MARKET POTENTIAL:
BIOETHANOL FOR CLEAN COOKING

TANZANIA

pivot | GLOBAL BIOETHANOL COALITION

Contents

The *Market Potential: Bioethanol for Clean Cooking Tanzania* is the product of a research project initiated by Pivot Clean Energy Co. for the purposes of investigating target geographies in terms of their current state of energy access within household energy, potential rates of transition to bioethanol from current cooking trends, and projected future volumes and associated costs. This country specific report is intended to be used in conjunction with *Market Potential Methodology* in order to understand the conclusions and context.

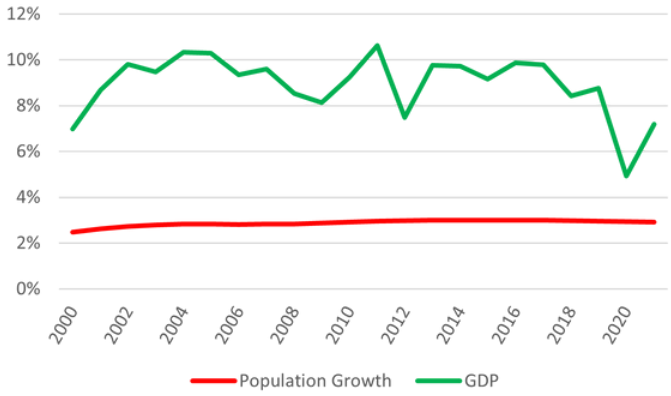
The country report was prepared by Adam Collins, Master's student at University of Colorado - Boulder (CU), under the overall guidance of Pivot's Executive Director Alicia ElMamouni. Pivot is grateful to Rita Klees for her facilitation of the CU Practicum program, and to the University of Colorado for providing such opportunities for their students. Special thanks to Mohammed Kadhi and Atupele Kilindu for their valuable contributions.

TANZANIA The Market Potential for Bioethanol as a Clean Cooking Fuel

Introduction | Tanzania at a Glance

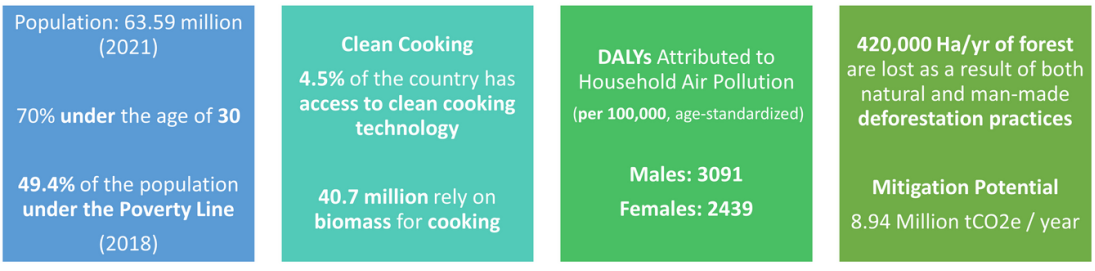
Tanzania has set itself apart from other sub-Saharan countries in economic terms, observing a higher-than-average GDP growth rate of 4% from 2012-2020, and national poverty rates that fell from 34.4% to 26.4%, with extreme poverty moving from 12% to 8%. Poverty fell much faster in rural areas, with the peak of this transition happening between 2007-2012, but slowing in the years since. In general, poverty reduction was driven by better access to basic services, assets, and infrastructure as well as more human capital, which helped raise household endowments and living standards. Even more, the expansion of education and increase in educational attainment paralleled changes in labor market requirements, so that the rewards for years of schooling below a certain level have actually declined. Despite these positive economic trends, per capita income growth remains modest in light of a quickly growing population, ranking 12th globally. The fastest growing economic sectors are in construction, ICT, real estate, non-market services, and mining, transport, and trade, with a shift toward more productive work in services and industry, primarily in urban centers. Self-employment has increased, but only in urban areas for those in "moderately poor" or "already better off" categories. The shift away from agriculture has been growing since 2012; national accounts show that agriculture is contributing far less value-add than services and industry, and has continued to decrease in percent of GDP from 40% in 1998 to 28% in 2017. About 80% of the heads of poor households work on their own farms or as unpaid family farm helpers; in these households, the poverty rate is more than double that of those in other employment categories. Considering Tanzania's remarkable economic growth, it is notable that poverty reduction has been slow. How much poverty reduction responds to economic growth depends on whether economic growth is defined based on changes in GDP per capita in the national accounts, or measured directly from household surveys. Household surveys in this case have a much larger impact on poverty reduction because the GDP deflator implies a slower rate of inflation than the Consumer Price Index (CPI), resulting in a higher "GDP growth per capita" compared to household consumption in the same period. In other words, the "poor" benefited less from economic growth from 2012 to 2018 due to worsening inequality.

Figure 1: Real GDP and Population Growth Rate



Note: Graphic made with data from the World Bank (n.d.).

Figure 2 - Quick Facts about Tanzania



Note: Data retrieved from the World Bank (n.d.), FAO (2020), CCA (2022), and WHO (2022) assessments.

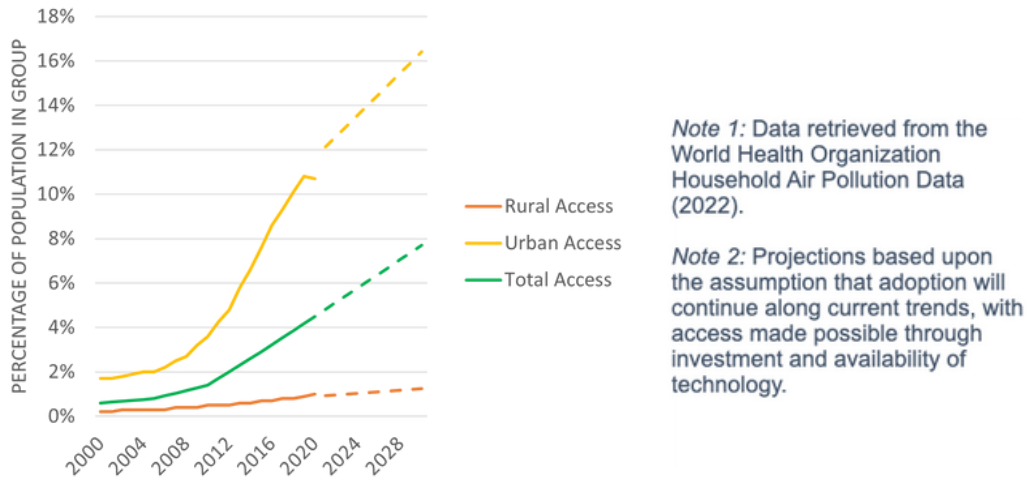
In Tanzania's largest city, Dar es Salaam, the Gini coefficient (level of inequality) reached 43% in 2018. The widening gaps between groups in education and employment were the primary cause of the increase in inequality. Due to rewards for wage employment increasing in industry and services, inequalities between the sectors widened. There is a demonstrated need to fortify the agricultural sector; the establishment of bioethanol economies can provide a demand for increased feedstock that supports small holder farmers, which in turn creates associated green jobs in stove manufacturing and fuel production, increasing the rate at which true economic growth can occur.

The Cooking Landscape

Cooking Fuels and Access to Clean Cooking Technology

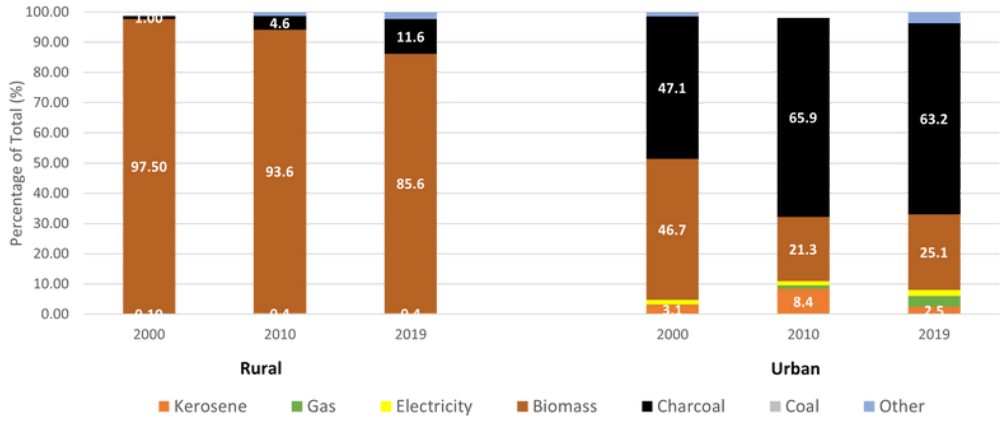
Rural access to clean cooking fuels and technologies has increased steadily, but urban access has grown exponentially. One reason for this is likely a result of the income differences between urban and rural areas, and the accessibility and affordability of fuel. In fact, 71% of the urban population is above the international poverty line compared to just 41% of the rural population (Ritter et al., 2022). There have, as well, been a number of projects and policies focused on improved cookstoves within the country since the 1980s that have helped somewhat to improve accessibility, but overall the shift has been slow (RECP, 2014).

Figure 3 - Projected Access to Clean Cooking Technology 2000 - 2030



Biomass and charcoal are by far the most dominant fuel types across both urban and rural populations. There has been a transition from biomass toward charcoal, which is most likely due to charcoal's use as a transition fuel. It is often more economical to buy, and also more efficient than conventional biomass. Additionally, rapid urbanization (increasing by a factor of 15 since 1967– currently 36% of total population) and relatively high prices or scarcity of energy substitutes like kerosene, electricity, biogas, or LPG have increased the demand for charcoal in general household consumption (RECP, 2014). While the practice of stove and fuel stacking is evident, it is more prevalent in urban areas, where a small percentage of the total energy demand includes electricity, gas, or kerosene to supplement household needs, as is seen in Figure 4 (Stanslaus, 2021, Choumert, 2018, Safari et al., 2022).

Figure 4 - Urban and Rural Cookstove Fuel Type Distribution 2000 - 2019



Note: Data retrieved from the World Health Organization Data (2021).

Existing Health and Environmental Impacts of Cooking Fuel in Tanzania

Continued dependence on polluting fuels carries with it serious health and environmental risks. A short analysis has been conducted to determine the impact in each of these categories using the assumptions noted in Appendix A. In general, the impact is calculated by looking at the projected number of households that could switch to bioethanol over the next 8 years and attributing the associated impacts to those respective populations.

The associated health impact is calculated using the HAPIT Household intervention tool. HAPIT currently uses background disease rates and relationships between exposure to PM2.5 and health outcomes to provide two outputs: disability-adjusted life years (DALYs) and deaths (HAPIT, 2022). DALYs for a disease or health condition are the sum of the years of life lost due to premature mortality (YLLs) and the years lived with a disability (YLDs) due to prevalent cases of the disease or health condition in a population (WHO, 2022).

Environmental impacts were calculated using the estimated fuel consumption and dry combustion CO2 emission factors for each fuel. The results of this analysis are shown in Table 1. It is important to note that both of these calculations do not consider the impacts of stove-stacking; the percentages of national fuel use per household only incorporate primary fuel use and do not include users who prefer the use of more than one fuel (ESMAP, 2020). This means that the impact in reality is likely even greater.

Table 1 - Potential Health and Environmental Impact of Dominant Fuels in Tanzania

IMPACT	*Firewood*	*Charcoal*	*Gas*
Health *(deaths and DALYs due to household air pollution from PM2.5)*	33,803 DALYs 793 Deaths	37,442 DALYs 910 Deaths	N/A
Environment & Climate *(GHG Emissions)*	145.6 Million kgCO2	184.6 Million kgCO2	231 Thousand kgCO2

Note 1: Assumptions are noted in Appendix A.

Note 2: Impact values are the cumulative totals from years 2022 to 2030.

A number of government and large donor-funded programs for clean cooking or cookstoves have existed in Tanzania that have positively impacted the existing availability and affordability of products today. However, while Tanzania on a broad level recognizes the health and environmental harm of the continued use of polluting fuels, there is still a gap in affordable and accessible clean fuel options that perpetuates existing trends of wood and charcoal use, particularly in rural areas (Table 2).

Table 2 - Availability and Affordability of Various Cookstoves and Fuel

Cooking Fuel	*Availability Assessment*	*Affordability Assessment*
Biomass	Fuelwood is collected locally around households or through informal markets. Widely available, particularly in rural areas, but contributing to deforestation as individuals harvest without discretion. Nearly 64% of the population uses this as their primary cooking fuel.	If collected on a household level, fuelwood or other biomass is typically free; this makes it favorable for families that cannot afford alternatives, even if they would want to switch fuels. Rural areas see 90% of households using fuelwood, compared to 20% in urban areas.
Charcoal	Charcoal is widely available in markets, particularly in urban areas. The existing high demand is likely to increase unless end users are offered other viable cooking choices, as ongoing rural to urban migration trends are expected to continue; at present approximately 26% of households use charcoal as their primary cooking source. (Doggart and Meshack, 2017).	Charcoal has a high price variability, and many policy tools have long been used to attempt to reduce its use, such as two unpopular and short-lived charcoal bans. Despite this, many people consider it the cheapest way to cook. Tanzania is strategically trying to reduce charcoal use, with additional policy initiatives expected in the upcoming National Charcoal Strategy.
Bioethanol	Initial offerings of bioethanol began in 2014-2015 through a pilot study. In 2018, a project run by United Nations Industrial Development Organisation (UNIDO) envisaged reducing the use of fossil fuels, which degrade the environment and aggravate climate change and its effects. The project's target was to sell 500,000 bioethanol-powered cooking stoves by 2025; as of 2022, they have sold approximately 10,000 stoves to Dar es Salaam households and are continuing to actively promote sales (Kamala, 2022). The provider of bioethanol was Consumer's Choice Ltd. - note discussion in Table 3.	Tanzania's subsidy program through UNIDO for ethanol cookstoves and fuel has positively impacted price, creating affordable products. The bioethanol stove starter pack retails at around $16.00 USD, which includes two liters of fuel. A liter of bioethanol fuel retails around $0.86 per liter and burns continuously for +3.5 hours or approximately two days of cooking needs (Motosafi, 2023).

Table 2 Cont - Availability and Affordability of Various Cookstoves and Fuel

Cooking Fuel	*Availability Assessment*	*Affordability Assessment*
Gas *(LPG & Biogas)*	In Tanzania, KopaGas offers PAYGO LPG, enabled by money services and smart meters. In 2015–2017, a KopaGas pilot was initiated comprising 148 households and two small-scale food stands, the results of which were encouraging for gender inclusion, affordability, and LPG expansion. Women accounted for 98% of customers. By late 2018, KopaGas had reached more than 500 customers. By 2021, it expects to have reached 200,000 customers in Dar es Salaam and Zanzibar. Among other organizations, Acumen and the Clean Cooking Alliance (through the Cooking Industry Catalyst program) are providing funding and support (ESMAP, 2020, Koranteng, 2020). The Tanzania Domestic Biogas Project (TDBP) ran from 2009-2017 and supported the construction of 20,700 new biogas plants in total; between 2009 and 2014, 11,103 biogas plants were created (SE4ALL). The scheme was targeted, largely, towards farmers with livestock who could use manure and other organic waste. A similar project supported the private sector development and market extension to reach 10,000 rural households. In general, these projects had a seemingly high rate of failure as a result of poor construction, sub-optimal feeding practices, maintenance, and knowledge erosion (Hewitt et al., 2022).	Two phases of a pilot scheme to supply LPG in the Nyarugusu refugee camp in 2017, and follow up research conducted by UNEP DTU Partnership, revealed a strong desire and willingness to pay (WTP) among refugee households for LPG as an alternative to traditional biomass for cooking (Rivoal et al., 2018). During the pilot, most customers spent $2.92 (USD) less per week on cooking, and nearly two-thirds had not previously used LPG for cooking. This demonstrates a competitive and attractive market product. Over 95% of refugees (from the DRC and Burundi) in this region use firewood or charcoal for cooking, heating or lighting, which is being collected from the forests in and around the camp. On average each person requires 1.2 kg of firewood per day for cooking, which, based on the present refugee population equates to a daily firewood demand of approximately 380 tons. This has led to rapid forest degradation in and around the camps, and a sharp increase in the prices of this basic resource. The aim for the project was not a 100% coverage of the refugees or host community during the first year of the intervention, but rather a progressive inclusion of all beneficiaries, as the price of LPG decreases and the economic opportunities increase.

Cookstove and Cooking Fuel Market

Tanzania is home to one of the larger bioethanol cooking enterprises in Africa currently, gaining support through a UNIDO initiative. As the business, and other like it, continue to expand, there will be an ongoing need for civic education to expand consumer awareness, increased efforts toward affordability, and particular attention to greater accessibility. Table 3 showcases a summary of the existing bioethanol market players and programs in country and existing barriers to scale that require attention.

Table 3 - Bioethanol Cookstove and Fuel Market in Tanzania

Bioethanol Cookstove	Bioethanol Fuel
Motosafi - In 2018, the United Nations Industrial Development Organization (UNIDO) launched a five-year program in Tanzania to provide bioethanol for cookstoves, targeting half a million households while rapidly growing related local industries. The project, at large, is promoting and distributing bioethanol cookstove technology to an estimated 15% (160,000) of the households in Dar es Salaam as an alternative to charcoal, fuelwood, and kerosene (UNIDO, 2023). The project was initiated in June 2019. Consumer's Choice Ltd., who won the tender contract, began selling Cleancook stoves under the name “MotoSafi” and bioethanol fuel from existing distilleries, controlling the bottling and distribution. The stoves were imported from South Africa and assembled in Dar es Salaam. With such a large contract, Consumer's Choice gained the opportunity for competitive prices, as well as a partial subsidy to lower the cost of the stoves. **Tanzania Clean Cooking Project (TCCP)** - A project funded by the Swedish Government and implemented by the Africa Enterprise Challenge Fund (AECF). The project provides funding to private sector companies that deliver affordable, quality clean cooking solutions for low-income individuals in rural areas across Tanzania; more than 375 impact-focused Small and Medium Enterprises in 26 countries have benefited so far. This focus is outside of Dar es Salaam and especially focused on women, youth, and unserved markets in Tanzania (AECF, 2023). **Project Gaia** - Conducted a project from 2014 to 2015 as a small pilot study in Zanzibar. In general, families were pleased with the stove and saved on average 2.1 hours a day cooking compared to the alternatives and continue to recommend the stoves to family and friends even after the study (Gaia, 2015). They have continued to support with ongoing research efforts in Tanzania.	**Consumer's Choice Ltd.** - Winner of the UNIDO Tender Contract in 2019 to provide bioethanol cookstoves and fuel. Consumer’s Choice uses a more conventional fuel distribution modality using standard plastic bottles and paying retailers a margin of around 10% of the final price to stock and sell the fuel. In addition, the company has it's own trucking company subsidiary that is utilized to distribute bioethanol, which gives it a competitive advantage and keeps the model simple (USAID, 2021). Consumer's Choice currently sources bioethanol from Kilombero Sugar Factory and other domestic distilleries in Tanzania. **TIRDO** - The Tanzania Industrial Research and Development Organisation (TIRDO) provides technical assistance like research and energy audits within the industrial sector in Tanzania. They are currently undergoing discussions with local partners to facilitate the production of bioethanol from waste cashew apple fruit, which would help supplement local production of bioethanol from sugarcane or cassava to support existing clean cooking businesses.

Table 3 Cont. - Bioethanol Cookstove and Fuel Market in Tanzania

Key Barriers to Scale
• Most woodfuel or biomass for cooking is generally collected rather than bought, which means that clean cookstove business struggle to compete with low or even zero cost traditional cooking systems. • Even when local markets can provide relatively accessible, low-cost clean cookstoves, lower-income households often lack the upfront capital (Ritter et. al. 2022). • In a country with some of the strictest environmental laws across the African continent, the development of biofuels spurs fears about overall environmental degradation. Furthermore, while the aim of biofuels in Tanzania would be to empower small landowners, tensions currently exist between private companies, local citizens, and the government over property and land use rights. (Mitchell, 2018) • Historical cultural considerations that rely on cooking with biomass or charcoal and the perceived advantages; educational efforts and civic campaigns are necessary to help promote modern technologies.

There is potential for Tanzania to develop and expand crop production for bioethanol feedstock, two of the most important being sugarcane and molasses, and cashew apples. Tanzania is the third largest sugar producer in East Africa, but remains in a deficit and imports sugar to meet domestic demand. The government is looking to achieve self-sufficiency in this area by 2025 and has been increasing production since 2013, with a 16% increase between 2013-2019 (Asoko Insight, 2022). As of 2022, there were five different sugar producers with ongoing and planned projects: Kilombero Sugar Company Ltd., Tanganyika Planting Company Ltd., Kagera Sugar Ltd., and Mitbwa Sugar Estates Limited. Kilombero aims to double their production to 271,000 tonnes by 2025. Three additional production facilities are also in the planning stages; with the resulting molasses from these sugar facilities, local bioethanol production would become much more feasible and provide a market for the molasses which is often considered a waste product.

Atupele Kilindu is an Energy Engineer that works for the Tanzania Industrial Research and Development Organisation (TIRDO). In addition to providing technical services like research and energy audits, Mr. Kilindu is representing TIRDO in a partnership they have with Consumer's Choice Ltd. regarding the processing of cashew apple fruits into bioethanol; currently, hundreds of thousands of tonnes of this fruit are discarded after the cashew nut is harvested. This project, among others, has been identified as a key part of the clean cooking sector, and a proactive means to utilize another product that is currently discarded.

Clean Cooking Related Policy

Clean energy and clean cooking policy has recently garnered a great deal of attention, largely due to Tanzania's current President, Samia Hassan, and her focus on support for clean energy technologies. In November of 2022, she unveiled a plan to boost clean energy production within the country by over 90% in the upcoming ten years. The President hopes to change the reliance on charcoal by requiring most Tanzanian institutions – any group that provides services to more than 300 people – to switch to cleaner cooking technologies and fuels within by 2024 with a one year grace period (Ritter et al., 2022, IEA, 2019). While there is still a ways to go, particularly in terms of specific bioethanol policy, the country is headed in a positive direction. Table 4 summarizes key policies that align with or are focused on a specific clean fuel outcome for the future. Table 5 demonstrates the current tariffs and Value Added Tax (VAT), both of which are quite prohibitive, on bioethanol fuel and cookstoves for liquid fuel.

Table 4 - Summary of Policies Related to Clean Cooking

Policy	Coordinating Administration	Impacts on Clean Cooking Sector
Tanzania Nationally Determined Contribution Plan (NDC) 2021	United Republic of Tanzania, Vice President's Office	Builds upon the National Climate Change Response Strategy (2021) and the Zanzibar Climate Change Strategy (2014) with a main goal to reduce GHG emissions by 10-20% by 2030 compared to the business-as-usual scenario (IEA, 2019). It also aims at strengthening agricultural research, development, and knowledge services which is applicable to the production of biofuels and renewable energy.
National Energy Policy (NEP) 2015	United Republic of Tanzania, Ministry of Energy and Minerals (MEM)	Look to enhance fuel switching from wood fuel to modern energy, and facilitate the adoption of appropriate cooking appliances to promote alternatives to wood fuel.
Sustainable Energy For All (SE4ALL) 2015	United Republic of Tanzania, Ministry of Energy and Minerals (MEM) Tanzania Renewable Energy Association (TAREA) ICS Taskforce Global Village Energy Partnership (GVEP)	Aims to increase the percentage of the population with access to modern cooking solutions to greater than 75% by 2030. Also looks to support the increased use of ICS by engaging youth organizations in the production, dissemination, and distribution of these technologies. Working to define and scale up the certification processes for residential and commercial cookstoves. The GVEP has showcased a progression for accessing clean cookstoves with households, and added exponentially increasing cookstove targets from 2012 to 2030.

Table 4 Cont. - Summary of Policies Related to Clean Cooking

Policy	Coordinating Administration	Impacts on Clean Cooking Sector
Country Action Plan for Clean Cookstoves and Fuels 2014	Tanzania Renewable Energy Association (TAREA) Clean Cookstoves and Fuels Alliance of Tanzania (CCFAT)	Outlines the foundations and cornerstones for all future clean cooking interventions and is the basis for clean cooking strategies noted within S4ALL. They include but are not limited to: • Supporting and lobbying government for the development and implementation of the biomass energy policy & strategy through stakeholder involvement • Establish Standards working group with the Tanzania Bureau of Standards (TBS) • Advocates for policy frameworks that support tax relief and incentives for clean cookstoves and fuels producers in Tanzania
Biomass Energy Strategy (BEST) Tanzania 2014	United Republic of Tanzania, Ministry of Energy and Minerals (MEM)	Yet to be fully adopted, it recommends the development of ICS with quantitative targets in Tanzania specifically aimed at reducing fuel-wood and charcoal consumption within the country overall; cooking is a major aspect of the strategy for 2030 targets.
Guidelines for Sustainable Liquid Biofuels Development in Tanzania 2010	United Republic of Tanzania, Ministry of Energy and Minerals (MEM)	Defines 'energy crops' which are grown specifically for energy use and that can produce biofuels (biodiesel, bioethanol) in Tanzania. They include: Sugarcane, cassava, maize, sorghum, millet, sisal, and rice for bioethanol and jatropha, oil palm, cashew nut, coconut, sunflower, castor bean, soybean, groundnut, cotton, sunflower and croton megalocarpus, among others for biodiesel. While this does not outline a strategy, it sets the basis for liquid biofuels.

Table 5 - Bioethanol Fuel Tariffs and VAT

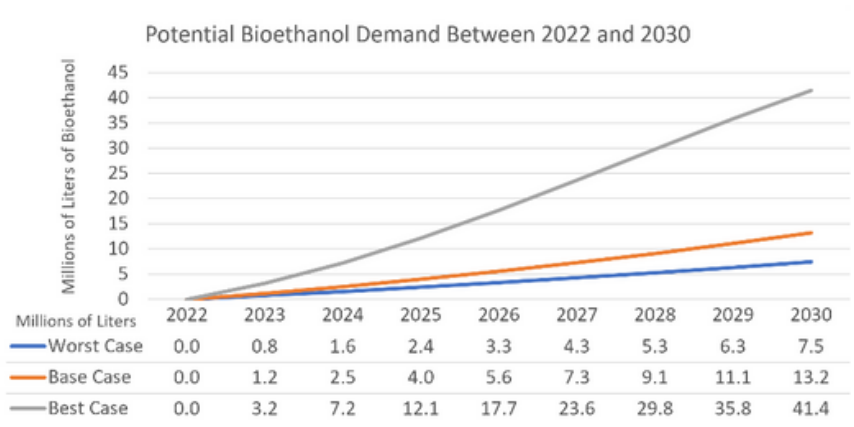
Product Type	WTO Code	Tariffs	VAT	Total
Bioethanol Fuel	220720	25%	18%	43%
Cookstoves for Liquid Fuel	732112	25%	18%	43%

Bioethanol Cooking Fuel Projections and Cost Comparison

Based on the methodology referenced, as well as population, fuel use, and urbanization trends, the following projections were calculated for potential bioethanol cooking fuel demand across three different scenarios (Figure 5). Three scenarios were created to showcase the variability of transitioning from kerosene, charcoal, or gas fuels to bioethanol. Both preference - wanting to use a different fuel despite being able to afford bioethanol fuel - and growth of access, possible uptake, and infrastructure growth are dependent not only on the location, but also on the market conditions in the future.

Figure 5 - Potential Bioethanol Demand for Low, Base, and Best Case Scenarios 2022 - 2030

Scenario	Preference to switch to ECF (% of Total HHs by 2030)	Access to Clean Cooking Technology (% Increase from Baseline by 2030)
Worst Case	5%	0%
Base Case	20%	Projected Values
Best Case	40%	35%



Given the conditions above, the uptake of bioethanol as a cooking fuel seems promising. In fact, compared to the cost of conventional fuels like charcoal and gas, bioethanol is sometimes more cost-effective for the consumer — just lacking in available infrastructure (Figure 6). While bioethanol has a lower calorific value (27.00 Mj/kg) compared to LPG (46.60 Mj/kg) and Kerosene (43.10 Mj/kg), bioethanol stoves generally have higher efficiency (60% vs. 55% and 35% respectively). On a national level, the same can be seen; overall, the cost for households that may shift to bioethanol is slightly more economical compared to the existing cost of other available clean fuels (Figure 7), and this advantage can continue to widen with appropriate policies.

Figure 6 - Average Annual Fuel Consumption to Meet 3,500 MJ Household Consumption

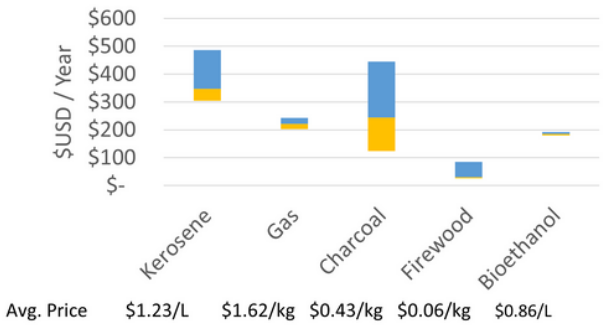
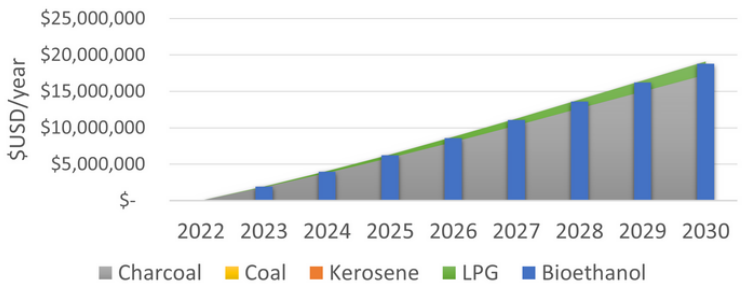
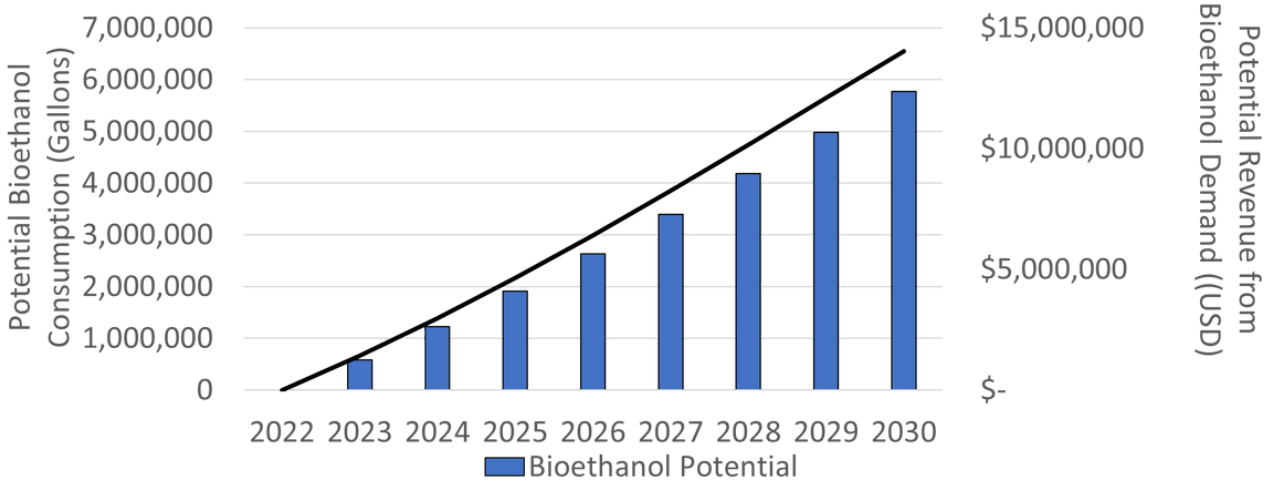


Figure 7 - Dominant vs Bioethanol Fuel Costs for Households Transitioning to Bioethanol



As has been observed in other focus countries like Nigeria and Mozambique, the combined benefits from a lower cost fuel and high potential demand could provide a revenue opportunity for producers. Using Trading Economics, the potential revenue has been calculated over the years (Figure 8). The revenue is based on the existing bioethanol price and base case scenario for potential demand; revenue and potential are calculated in gallons and USD.

Figure 8 - Potential Bioethanol Demand and Revenue



Recommendations and Conclusions

As Tanzania continues to make strides toward clean energy solutions within the household space, the following recommendations or observances should be considered:

1. In markets where people are already familiar with the idea of installment payments, **PAYGO cooking solutions do not represent a significant constraint to the uptake of modern cooking solutions**. KopaGas in Dar es Salaam has set up LPG canister meters that allow users to pay for customized amounts of fuel depending on the need or financial capacity.

   Recommendation 1: Encourage solutions that account for consumer preference and economic ability to realize full access to modern fuels and technologies.

   Recommendation 2: When possible, equip technology with options for installment payments, PAYGO, or mobile money capabilities, both for monitoring as well as ease of use.

2. Recent national program experience suggests that **nearly all clean fuel and stove programs involve some form of performance-based incentive or subsidy**.

   Recommendation: Create programs that can leverage Results-Based Financing, support co-finance opportunities with government or multi-lateral partnerships, or provide assistance utilizing carbon finance as a mechanism to apply a subsidy within the private sector.

3. **Increasing the value-added output per worker within the agriculture sector may limit the need to switch entirely to a services and industry-based economy**

   Recommendation 1: Look at providing support or subsidies for farming households that sell cash and staple crops. It is noted in the 2017 Systematic Country Diagnostic (SCD, World Bank) where high-value activities in agriculture, manufacturing, and tourism could encourage job creation.

Recommendation 2: Include enabling measures to the agricultural and manufacturing sectors that include tax reduction and increased license availability for land.

4. While there is some availability of bioethanol stoves and fuel in country, the **cultural preference, affordability, and accessibility of woodfuels and charcoal weigh heavily** in consumer decisions.

Recommendation 1: Leverage the use of subsidies or cost reductions through programs like Results-Based Financing, when possible, to reduce the cost on initial cookstove and ongoing fuel purchases.

Recommendation 2: Engage appropriate entities such as the Ministries of Finance, Energy, Health, Environment, etc to implement mechanisms such as reductions on import duties and taxes that can facilitate lower operational and consumer costs.

Recommendation 3: Implement civic campaigns emphasizing the co-benefits related to the adoption of bioethanol cookstoves such as health, safety, the environment, ease of use, etc.

5. **Addressing the human capital gap is critical for structural transformation** and would be especially important for the agricultural sector in order to improve productivity, quality, quantity, and relevance of skills. The 2019 Global Competitiveness Report ranked Tanzania's skills at 126 out of 141 countries. In fact, more than 45% of firms identified shortages in the skilled workforce as a major constraint.

Recommendation 1: Focus on capacity building that can equip workers with knowledge and resources to enter the workforce; bioethanol economies are well positioned to deliver green jobs that offer trainable positions in agriculture, manufacturing, fuel production, and sales.

Recommendation 2: Leverage agricultural and technical knowledge from international groups that can inform on appropriate farming techniques and inputs to utilize farmland more efficiently, as well as training in optimized production and manufacturing facility operation.

6. **State-owned enterprises (SOEs) tend to negatively affect access and service delivery** and put constraints on growth in private sector enterprises; regulatory quality and effectiveness has dropped since 2012.

Recommendation 1: Develop and implement policies that create enabling environments for private sector to flourish, such as tax exemptions or fiscal policy that incentivizes new or expanding business.

Recommendation 2: Continue to work with relevant government ministries to reduce taxes and duties on clean fuels and technologies, which will encourage local production and manufacturing to grow private sector investment, and result in more economical products for consumers.

References

AECF. (2023). Tanzania Clean Cooking Project. Africa Enterprise Challenge Fund. Retrieved from: https://www.aecfafrica.org/approach/our-programmes/renewable-energy/tanzania-clean-cooking-project-tccp/#geography

CCA. (2022). Accelerating Clean Cooking as a Nature-based Climate Solution. Clean Cooking Alliance. Retrieved from https://cleancooking.org/reports-and-tools/accelerating-clean-cooking-as-a-nature-based-climate-solution/#:~:text=Accelerating%20Clean%20Cooking%20as%20a%20Nature%2Dbased%20Climate%20Solution%20examines,to%20advancing%20nature%2Dbased%20solutions

Choumert, J., Motel, P. C., & Le Roux, L. (2018). Stacking up the ladder: A panel data analysis of Tanzanian household energy choices.

Dalberg. (2020). Kenya Ethanol Cooking Fuel Masterplan - SouthSouthNorth. Retrieved September 26, 2022, from https://southsouthnorth.org/wp-content/uploads/2020/06/ECF-Kenya-Masterplan_23-June-2020.pdf

Dalberg. (2018). Scaling up clean cooking in urban Kenya with LPG & Bio-ethanol - Dalberg. Retrieved September 26, 2022, from https://dalberg.com/wp-content/uploads/2018/06/Dalberg_Long-form-report_FINAL_PDF_0.pdf

Energy Sector Management Assistance Program (ESMAP). (2020) The State of Access to Modern Energy Cooking Services. Washington, DC: World Bank. License: Creative Commons Attribution CC BY 3.0 IGOHAPIT, 2022 https://householdenergy.shinyapps.io/hapit3/#

FAO. (2020). Global Forest Resources Assessment 2020. Food and Agriculture Organization of the United Nations. Retrieved September 26, 2022 from https://www.fao.org/forest-resources-assessment/2020/en/

HAPIT. (2022). Household Air Pollution Intervention Tool. https://householdenergy.shinyapps.io/hapit3/#

Hewitt, J., Holden, M., Robinson, B. L., Jewitt, S., & Clifford, M. J. (2022). Not quite cooking on gas: Understanding biogas plant failure and abandonment in Northern Tanzania. Renewable and Sustainable Energy Reviews, 165, 112600. Retrieved from: https://www.sciencedirect.com/science/article/pii/S1364032122004968

IEA (2019), Africa Energy Outlook 2019, IEA, Paris. Retrieved from: https://www.iea.org/reports/africa-energy-outlook-2019

Komala, J.. (2022) Tanzania: Unido Friendly Stoves Fail to Make Headway. Tanzania Daily News. AllAfrica. Retrieved from: https://allafrica.com/stories/202206070193.html

Koranteng, K.. (2020) Understanding the complexities to successfully intervene in informal settlements: A clean cooking case study from Tanzania. Local Governments for Sustainability. Retrieved from: https://africa.iclei.org/understanding-the-complexities-to-successfully-intervene-in-informal-settlements-a-clean-cooking-case-study-from-tanzania/

MECS. (2022). Tanzania eCooking Market Assessment. Modern Energy Cooking Services. EnDev. Retrieved from: https://mecs.org.uk/wp-content/uploads/2022/08/Tanzania-eCooking-Market-Assessment-2022-Final.pdf

MEM. (2010). Guidelines for Sustainable Liquid Biofuels Development in Tanzania. United Republic of Tanzania Ministry of Energy and Minerals. Retrieved from: http://www.tzonline.org/pdf/LIQUIDBIOFUELSeng.pdf

Mitchell, H.. (2018). Biofuel in Tanzania. Stanford University Coursework. Retrieved from: http://large.stanford.edu/courses/2018/ph240/mitchel1/

Motosafi. (2023). The Impact. Motosafi. Retrieved from: https://motosafi.com/the-impact/

NEP. (2015). Tanzania National Energy Policy. Retrieved from: https://www.fao.org/faolex/results/details/en/c/LEX-FAOC205656/

RECP. (2014). Biomass Energy Strategy Tanzania (BEST): Tanzania Biomass Energy Strategy and Action Plan. Africa-EU Renewable Energy Cooperation Programme. Tanzania Forest Conservation Group. Retrieved from: https://www.tfcg.org/wp-content/uploads/2018/05/BEST-Biomass-Energy-Strategy-Tanzania_Final-Version-April-2014.pdf

Ritter, B. & Karl, K.. (2022). Traditional Cookstoves: Fueling a Health and Climate Crisis?. Columbia Climate School. Retrieved from: https://news.climate.columbia.edu/2022/11/14/traditional-cookstoves-fueling-a-health-and-climate-crisis/

Rivoal, M., & Haselip, J. A. (2018). Delivering market-based access to clean cooking fuel for displaced populations the Kigoma region, Tanzania: a business plan. Retrieved from:https://backend.orbit.dtu.dk/ws/files/144864187/LPG_market_creation_plan_for_refugees_in_Tanzania.pdf

SADC. (2018). SADC Energy Monitor 2018 – Enabling Industrialization and Regional Integration in SADC. SADC, SARDC.

Safari, J. G., Mwongerezi, J. K., & Hyandye, C. B. (2022). Patterns and predictors of household fuel choices in Maswa District, Tanzania. Cogent Social Sciences, 8(1), 2137963.

SE4ALL. (2015). Tanzania's SE4ALL Action Agenda. Retrieved from: https://www.seforall.org/sites/default/files/TANZANIA_AA-Final.pdf

Stanslaus, M. (2021). Fuel-stacking behaviour among households in Dar es Salaam, Tanzania. Retrieved from: https://www.diva-portal.org/smash/get/diva2:1588582/FULLTEXT01.pdf

TAREA. (2014). Tanzania Country Action Plan for Clean Cookstoves and Fuel. Retrieved from: https://tarea-tz.org/storage/app/media/Blog/ICS%20Country%20Action%20Plan.pdf

UNFCCC. (2021). United Republic of Tanzania: Nationally Determined Contribution. United Nations Framework Convention for Climate Change. Retrieved from: https://unfccc.int/sites/default/files/NDC/2022-06/TANZANIA_NDC_SUBMISSION_30%20JULY%202021.pdf

UNIDO. (2023). Promotion of Bio-Ethanol as Alternative Fuel for Cooking in the United Republic of Tanzania. UNIDO. Retrieved from: https://open.unido.org/projects/TZ/projects/150208

WHO. (2021). Database: Cooking fuels and technologies (by specific fuel category). World Health Organization Publications. Retrieved September 26, 2022, from https://www.who.int/publications/m/item/database-primary-reliance-on-fuels-and-technologies-for-cooking

WHO. (2022). Disability-adjusted life years (DALYs). World Health Organization Indicator Metadata Registry List. Retrieved September 26, 2022, from https://www.who.int/data/gho/indicator-metadata-registry/imr-details/158

WHO. (2022). Household air pollution attributable death rate (per 100 000 population, age-standardized). World Health Organization Indicators. Retrieved September 26, 2022 from https://www.who.int/data/gho/data/indicators/indicator-details/GHO/household-air-pollution-attributable-death-rate-(per-100-000-population-age-standardized)

WHO. (2022). Proportion of population with primary reliance on clean fuels and technologies for cooking (%). World Health Organization Indicators. Retrieved September 26, 2022, from https://www.who.int/data/gho/data/themes/air-pollution/household-air-pollution

World Bank. (n.d.). Open Data. Retrieved from September 26, 2022, from https://data.worldbank.org/

World Bank. (2020)(a). Tanzania Mainland Poverty Assessment; Tanzania Mainland Poverty Assessment : Part 1 - Path to Poverty Reduction and Pro-Poor Growth. World Bank, Washington, DC. Retrieved from: https://openknowledge.worldbank.org/entities/publication/132c2957-1fd2-5d40-983d-cc86682e3687

World Bank. (2020)(b). Tanzania Mainland Poverty Assessment; Tanzania Mainland Poverty Assessment : Part 2 - Structural Transformation and Firms Performance. World Bank, Washington, DC. Retrieved from: https://openknowledge.worldbank.org/entities/publication/6dde07d8-a130-5728-96f4-5dda7c117f0a

World Bank. (2022). Tanzania Country Program Evaluation. World Bank Independent Evaluation Group. Retrieved from: https://ieg.worldbankgroup.org/sites/default/files/Data/reports/ap_tanzania_cpe.pdf

Appendix A

Projected Number of Households that may Switch to Bioethanol Cooking Fuel

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel	Charcoal	Charcoal	Charcoal	Charcoal	Charcoal	Charcoal	Charcoal	Charcoal	Charcoal
Yearly HHs	0	7,467	15,524	24,098	33,099	42,420	51,934	61,492	70,925
Total HHs	0	7,467	22,991	39,622	57,197	75,519	94,354	113,426	132,418

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel	Coal	Coal	Coal	Coal	Coal	Coal	Coal	Coal	Coal
Yearly HHs	0	-	-	-	-	-	-	-	-
Total HHs	0	-	-	-	-	-	-	-	-

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel	Kerosene	Kerosene	Kerosene	Kerosene	Kerosene	Kerosene	Kerosene	Kerosene	Kerosene
Yearly HHs	0	-	-	-	-	-	-	-	-
Total HHs	0	-	-	-	-	-	-	-	-

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel	LPG	LPG	LPG	LPG	LPG	LPG	LPG	LPG	LPG
Yearly HHs	0	569	1,266	2,098	3,067	4,175	5,418	6,789	8,272
Total HHs	0	569	1,835	3,364	5,164	7,242	9,593	12,207	15,061

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fuel	Biomass	Biomass	Biomass	Biomass	Biomass	Biomass	Biomass	Biomass	Biomass
Yearly HHs	0	3,509	7,784	12,912	18,990	26,119	34,408	43,969	54,925
Total HHs	0	3,509	11,293	20,696	31,902	45,109	60,527	78,377	98,895

Fuel Characteristic Assumptions

Fuel Type	Unit	Low Fuel Cost (USD) per Unit	High Fuel Cost (USD) per Unit	Average Fuel Cost (USD) per Unit	Net Calorific Value (MJ/kg)	Stove Efficiency	kg/L
Kerosene	Liter	$ 1.23	$ 1.23	$ 1.23	43.10	35%	0.817
LPG	kg	$ 1.62	$ 1.62	$ 1.62	46.60	55%	
Charcoal	kg	$ 0.43	$ 0.43	$ 0.43	28.20	22%	
Coal/Firewood	kg	$ 0.06	$ 0.06	$ 0.06	26.70	28%	
Bioethanol	Liter	$ 0.86	$ 0.86	$ 0.86	27.00	60%	0.783

Note 1: Fuel costs are sourced from local experts.

Note 2: Fuel Net Calorific and Efficiency Values are sourced from Dalberg, 2018.

HAPIT Health Impact Calculator Assumptions

Country	Tanzania		
Possible HHs (by 2030)	147,479	% Using Intervention	100%
Average HH	5	Intervention Useful Life	1
Kids <5 per HH	1		
Adults per HH	4		
Total Individuals	737,394		

Fuel	PM2.5 Emissions (micrograms/m3)
Kerosene	100
LPG	47
Charcoal	160
Coal	82.3
Bioethanol	50
Biomass	500

Appendix A

Environmental Assumptions

Stove	Avg. gCO2/kg Fuel
Charcoal	2740.0
Kerosene	71.3
Gas (LPG)	55.9
Coal	98.3
Ethanol	64.9