Role Of LPG In Enabling A Just And Inclusive Energy Transition In Africa And The Arab Region

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Shared Prosperity Dignified Life

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About KAPSARC

KAPSARC is an advisory think tank within global energy economics and sustainability providing advisory services to entities and authorities in the Saudi energy sector to advance Saudi Arabia's energy sector and inform global policies through evidence-based advice and applied research.

About ESCWA

The Economic and Social Commission for Western Asia (ESCWA) is one of five United Nations regional commissions. Located in Beirut, it supports its Arab Member States in their efforts to ensure prosperity and equality. By analyzing regional and national economic, social and environmental trends in the light of global United Nations agendas, ESCWA provides Arab countries with innovative knowledge, fosters regional consensus and delivers transformational policy advice for a stable, just and flourishing Arab region.

The findings, interpretations, and conclusions expressed in this publication are those of the authors and do not necessarily reflect the official views or position of KAPSARC, the United Nations, or its officials or Member States.

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Abbreviations and acronyms

CFTs: Clean fuel technologies

LPG: Liquefied petroleum gas

Key Messages

- Globally, a concerning 2.3 billion people do not have access to clean cooking technologies. Approximately 52 million of these individuals reside in the Arab region.
- Less than 20% of residents in 29 sub-Saharan African countries have access to clean cooking facilities. In 2022, the region saw the number of individuals lacking this access rise to approximately 990 million. Though the Arab region has high access levels to clean, modern cooking fuels, with 88% of the population benefiting, access disparity is still prominent. This is particularly apparent in nations such as Sudan, Somalia, and Yemen.
- Considering the current pace of progress, meeting the Sustainable Development Goal (SDG) 7 of universal and modern energy remains a distant goal and will likely be unachievable by 2030 or even by 2050. Thus, to meet this target, there is an urgent need to accelerate the pace of progress.
- The use of biomass—unprocessed and processed—contributes to the deforestation rate. The selected countries depend heavily on charcoal, leading to rapid deforestation of around 3 billion kilograms of renewable wood, equivalent to **32 million tons** of greenhouse gas (GHG) yearly emissions.
- The health implications are equally severe. Exposure to particulate matter and pollutants from inefficiently burned biomass leads to serious health issues like respiratory infections, heart disease, and even death, with women and children being disproportionately affected. Cumulatively, in 2020, an estimated 3.2 million deaths occurred due to household air pollution, with over 237,000 of those fatalities involving children under the age of 5.
- Liquefied petroleum gas (LPG) is an integral part of the solution as it provides a modern, clean fuel alternative and supports renewable energy deployment. When adopted widely, it could trigger considerable benefits in emission reduction, gains in health, and time-saving for households, particularly women and children.
- Several countries are currently harnessing renewable energy sources on a large scale, including solar photovoltaics (PV), wind power, hydroelectric power, geothermal energy, ethanol, and biogas. Nevertheless, recent investigations indicate that LPG is a crucial clean cooking fuel for the transition due to its practicality, wide availability, and cost-effectiveness in this transition phase (Floess et al., 2023).
- Cumulatively, for all of our study countries, an important saving of over **1600 million hours per year** is observed when comparing the time spent on traditional fuel methods to using an LPG cookstove. Valuing this at the estimated minimum wage in these countries represents **nearly a billion dollars** (955 million) **of wasted potential each year.**
- Strategic enhancements in LPG infrastructure are crucial, especially in rural areas. Consideration should be given to factors like costs and distance from infrastructure. To make LPG more accessible in rural areas, refill stations should be established within 10 km of reach. Furthermore, allowing people to buy LPG in small quantities (for one-time cooking) can boost uptake.
- In countries facing economic, political, and conflict-related challenges, international and regional efforts should be intensified to resolve these challenges and create a more favorable environment for progress.
- Numerous other approaches can be instrumental in ensuring comprehensive access to clean cooking options. This entails amplifying health and environmental sustainability promotion via clean cooking awareness programs.
- This transition is imperative for reducing reliance on traditional cooking methods, emphasizing the necessity of mobilizing finance, fostering partnerships and collaboration, ensuring an appropriate policy and regulatory environment, and promoting capacity building. These key components are vital for addressing the access deficit and achieving sustainable development goals, including SDG 7, and enabling other SDGs.

1. Introduction

Globally, 2.3[1] billion people still lack access to clean fuels and technologies for cooking (CFTs) today, with an overwhelming majority residing in rural areas.

Without a dramatic increase in investment and action for scalable solutions, 1.9 billion people will remain without access to clean cooking in 2030.[2] This stark reality highlights the urgency for action, underlined by the Clean Cooking Alliance's (CCA) strategy, which emphasizes the need for annual investments of at least $10 billion to achieve universal clean cooking access by 2030, compared with the existing funding shortfall of less than 1.5% of that value ($130 million each year)[3]. This persistent underfunding places clean cooking as one of the most overlooked development challenges. In sub-Saharan Africa, 29 countries have under 20% of residents with access to clean cooking facilities. The region's number of individuals without such access has consistently increased, reaching about 990 million in 2022.[4] In the Arab region[5], around 52 million people[6] (12% of the population) did not have access to CFTs in 2021, albeit with significant sub-regional disparities. A large share of the access deficit is concentrated in Sudan, Somalia, and Yemen. The urban-rural divide is also evident, with a deficit in access to clean cooking in rural areas at around 21% compared with 6% among urban populations in the Arab region.[7]

In this pivotal decade of action aimed at accelerating the adoption of modern renewable sources for clean cooking, the imperative for cross-sectoral collaboration becomes paramount. LPG, as a crucial solution, stands out for bridging the transition gap, not only expediting progress but also playing a pivotal role in stimulating economic activities, particularly in vital sectors such as agriculture. This dynamic synergy promises a swift and effective resolution to address the access deficit, emphasizing the immediate establishment of effective partnerships, mobilization of finance, and cultivation of a cohesive and enabling policy and regulatory environment as pivotal components. Promptly implementing these measures is key, promising tangible benefits through enhanced economic growth, sustainability, and a reduction in negative impacts.

Clean cooking, including the use of LPG, must be an integral part of strategies for achieving the targets specified in Nationally Determined Contributions (NDCs) under the Paris Agreement on climate change and achieving SDGs 7 (Affordable and Clean Energy), 9 (Industry, Innovation, and Infrastructure), and 13 (Climate Action). New evidence on the climate, health, and social benefits of transitioning to clean cooking strengthens the argument for universal clean cooking as a way to accelerate the energy transition.[8]

Energy compacts that resulted from the High-Level Dialogue on Energy in 2021 intend to lead national clean cooking strategies and commitments as an important vehicle for countries to accelerate the transition to clean cooking. Numerous state and non-state actors, such as companies, regional and local governments, and nongovernmental organizations, have joined in the commitment to accelerate access to clean cooking. If realized, national targets to accelerate access to clean cooking, as spelled out in NDCs and energy compacts, have the potential to improve human health, livelihoods, the climate, and the natural environment at large. Promoting the use of a range of cleaner cooking fuel options such as electricity, LPG, ethanol, and biogas should thus be upheld as a critical implementable action for countries to use to advance development outcomes, preserve nature, and mitigate and adapt to the effects of climate change.[9] In this report, we discuss the role of LPG as a transition fuel to enhance access to clean cooking and reduce the burden of traditional cooking options while recognizing the role of other solutions.

While considerable attention has been directed toward the study of South and Southeast Asia, as well as sub-Saharan Africa, in the context of SDG 7, the Arab region is frequently overlooked due to its relatively robust progress in the area. Therefore, our focus is on Least Developed Countries (LDCs) within the Arab region, namely Comoros, Djibouti, Mauritania, Somalia, Sudan, and Yemen, as well as Madagascar (hereafter referred to as "focus countries"), to assess the necessary policy actions and business models needed to join other countries in the African continent in accelerating progress in achieving access to CFTs and thus SDG7 by 2030.[10]

[1] Tracking SDG 7 (2023).
[2] Ibid.
[3] https://climatechampions.unfccc.int/clean-cooking-named-as-a-critical-breakthrough-to-halve-emissions-by-2030/#:~:text=At%20COP27%2C%20the%20UN%20Climate,2.4%20billion%20people%20through%20at
[4] Ibid
[5] The Arab region here includes the Maghreb (Algeria, Libya, Morocco and Tunisia), Mashreq (Egypt, Iraq, Jordan, Lebanon, the State of Palestine and the Syrian Arab Republic), GCC (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates) and LDCs (Comoros, Djibouti, Mauritania, Somalia, the Sudan and Yemen).
[6] ESCWA (2023).
[7] Ibid.
[8] Tracking SDG 7 (2023).
[9] Ibid.
[10] Ibid.

Many households across the focus countries continue to rely on traditional cooking methods, such as open fires, inefficient stoves in rural areas, and charcoal in urban areas. Prolonged use of these inefficient technologies poses significant health, environmental, and economic risks to households and add up to considerable losses at national levels. Indoor air pollution from inefficient and polluting fuels and technologies in homes is harmful to health due to the high levels of fine particles. Women and children are particularly susceptible to exposure since they spend more time indoors. According to the World Health Organization (WHO), exposure to indoor air pollution from cooking fuels leads to millions of premature deaths annually, with women and children being disproportionately affected. In 2020, around 3.2 million fatalities were attributed to household air pollution globally, including more than 237,000 child deaths under five.[11]

The WHO classifies the following fuels and technologies as clean when it comes to household emissions: solar, electric, biogas, natural gas, LPG, and alcohol fuels, including ethanol (WHO, 2023). In low- and middle-income countries in 2021, gaseous fuels (LPG, natural gas, biogas) were used by 55% (49-60) of people (3.6 billion) as their main energy source for cooking.[12] This report focuses on the switch to LPG as a transition fuel as part of longer-term efforts to cut the access deficit gap and support the social and economic development of the most vulnerable in Africa and the Arab region.

LPGs are a group of hydrocarbon gases derived from crude oil refining or natural gas processing, primarily propane, normal butane, and isobutane. These gases may be marketed individually or mixed. They can be liquefied through pressurization (without requiring cryogenic refrigeration) for convenience of transportation or storage.[13] Although LPG is a sub-product of oil and gas, the associated GHG emissions are far less than those of traditional cooking technologies when accounting for efficient combustion and reduced deforestation and methane emissions. While there are cases where the transition to clean electricity is immediately viable, the success of this depends on policies targeting behavioral change, reliability of electricity supply, etc., which have shown limited success. India, Indonesia, and other Arab countries, which have seen very rapid and successful clean cooking uptake, have focused on LPG, which has been at least partly the reason for their success. Therefore, to address the CFT access gap following a people-centric transition pathway, we focus on LPG in this report with full recognition that there might be other cases where other fuels are better alternatives depending on availability and affordability and a just and inclusive energy transition pathway without leaving anyone behind.

The study offers important insights into the development of clean cooking access and its implications for the environment and well-being. First, it highlights the persistence of cooking inequality, particularly the disproportionate burden placed on women and children who spend more time at home. This insight calls for gender-responsive policies that address this disparity, empowering women and promoting gender equality in the context of clean cooking access. This study focuses on the degree of cooking inequality within the LDCs in the Arab region—along with Madagascar in Africa.

Second, the study delves into detailed discussions on the potential advantages and implications of adopting clean fuel technologies, primarily focusing on LPG. Along with highlighting the benefits and advantages of switching to cleaner cooking fuels, the study also critically examines the key impediments and driving factors concerning adopting cleaner fuel alternatives following integrated approach. It provides practical and actionable insights for policymakers, financial institutions, private sector, and other concerned stakeholders regarding implementing contextually relevant and effective interventions to mitigate the challenges and promote the adoption of clean cooking technologies. The analysis highlights the importance of understanding communities' unique social, cultural, and economic challenges when adopting cleaner cooking technologies. The report also provides case studies and examples of implementation of LPG and other clean cooking solutions to show case and support upscaling successful business models through regional and global collaboration.

The report is organized as follows: Section 2 provides the context by outlining the current state of clean cooking and highlighting the benefits of a shift to LPG; Section 3 outlines the challenges to LPG adoption; Section 4 provides the pathway forward by highlighting the opportunities, innovative use cases, and potential solutions; Section 5 provides policy recommendations, followed by the conclusion in Section 6.

This study was developed at the request of the Ministry of Energy of the Kingdom of Saudi Arabia to draw attention to the need to increase collaboration and financing flow to address the access gap in clean cooking and to use integrated approaches by using LPG as a clean cooking solution and transition fuel to expedite efforts in this decade of action.

[11] WHO (2022).
[12] Tracking SDG 7 (2023).
[13] EIA (n.d.).

2. Context Of Clean Cooking Access

2.1 Current State Of Clean Fuels And Technologies For Cooking

As per the International Energy Agency's 2023 report, to achieve Net Zero Emissions by 2050 in line with SDG 7, an estimated 300 million individuals each year must adopt clean cooking solutions. Specifically, a yearly transformation of 130 million inhabitants in Africa is essential to meet the stipulations outlined in SDG 7 (ADB, 2023). The costs required to support this are $25 billion annually, equivalent to setting up a Liquefied Natural Gas (LNG) terminal each year. Over the decade from 2010 to 2020, the African population requiring access to clean cooking solutions witnessed a sharp surge, increasing by 170 million to nearly 937 million. This rise is attributed to both population growth and the lack of adequate investment in clean cooking alternatives (UN, 2023b). Conquering this monumental task entails massive escalations in both policy development and monetary investments. Moreover, it will demand the utilization of diverse clean cooking technologies and fuels.

To keep a similar momentum in our selected countries, we would need to transition 10 million people each year[14]. Table 1 summarizes the percentage of the population with access to clean cooking in each of the focus countries back in 2021.

In sub-Saharan Africa, 29 countries have less than 20% of their population with access to clean cooking facilities. The number of those without this access has risen steadily, hitting around 990 million in 2022. Of the 52 million people without access in the Arab region, which is 12% of the population, there is a wide disparity between how this is spread. Figure 1 shows the relationship between income per capita and the percentage of population with access to clean cooking. The correlation between the two is not strong, implying that simply becoming wealthier as a country does not automatically lead to moving to better cooking technologies. This means that policies and regulations have an active role to play in providing better access to people. Another important thing to note is that our focus countries are all bunched at the less-than-$3000 mark but have varied degrees of access in the countries owing to differences in policy, as we highlight in Section 2.8.

[14] Assuming similar rates of progress in the selected countries

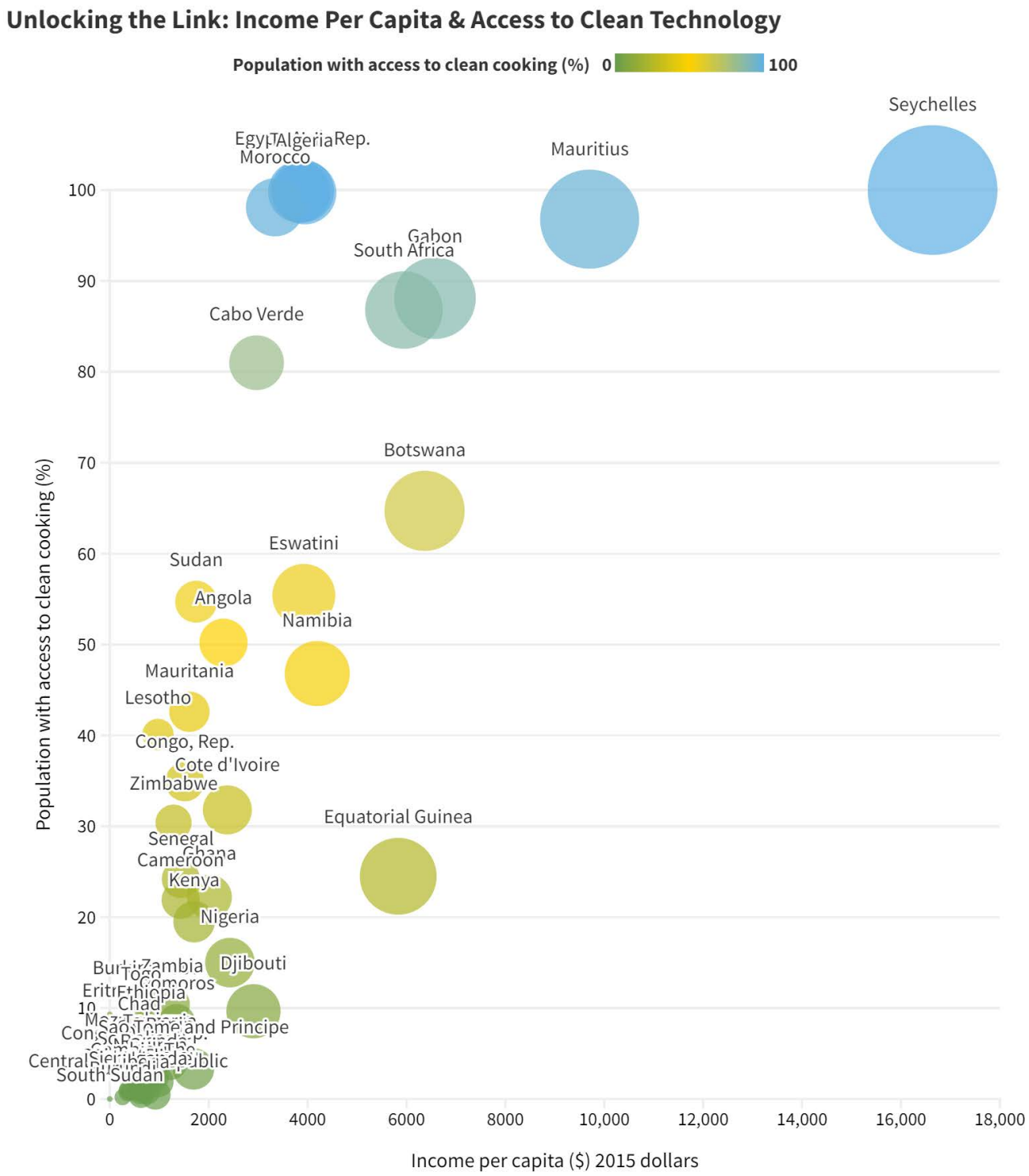
Table 1: Population with access to clean cooking and LPG

	Clean cooking access (%), 2021[1]
Comoros	11.3
Djibouti	9.65
Madagascar	1.4
Mauritania	48.3
Somalia	3.8
Sudan	62.8
Yemen	61.3

Source: Tracking SDG 7 (2023)

[1] Tracking SDG 7 (2023).

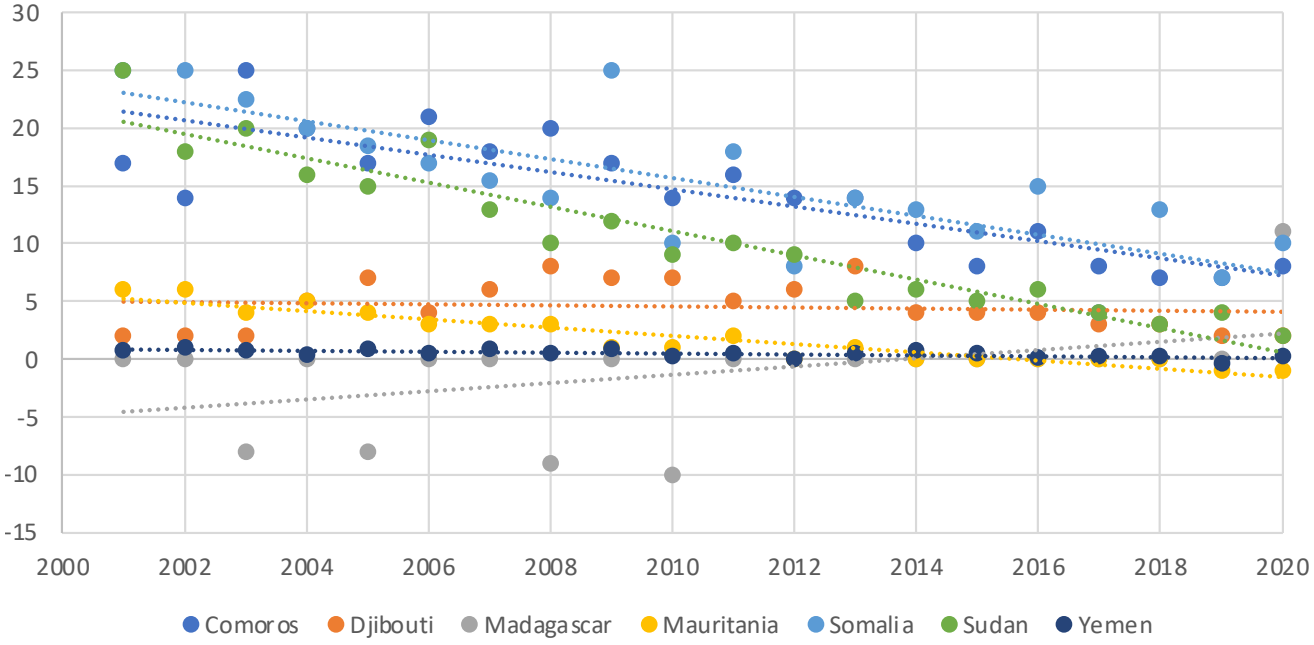
Figure 1: The relationship between income per capita (2015 dollars) and access to clean technology by % of the population



Source: Authors calculation using World Development Indicators data (World Bank, 2023).

2. Context Of Clean Cooking Access Cont.

Figure 2: Rate of progress on clean cooking

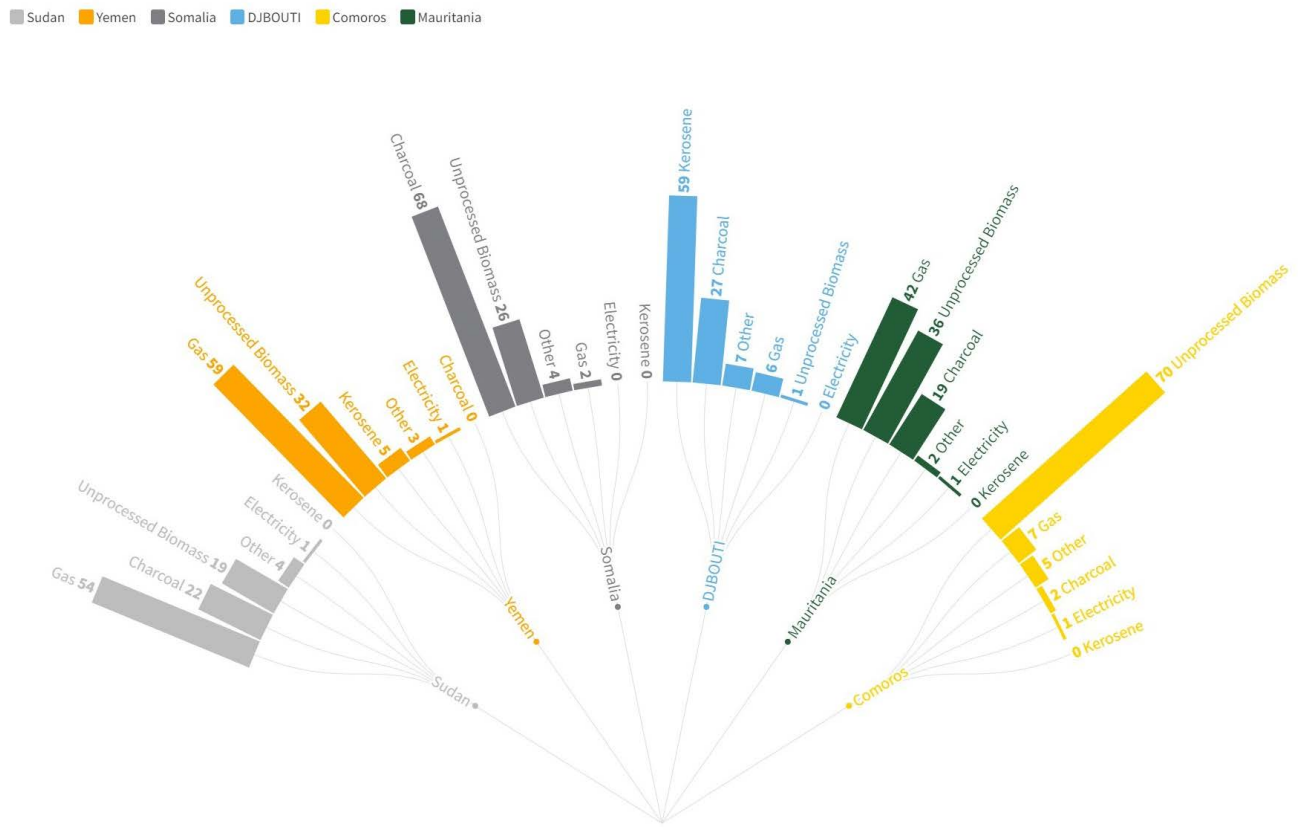


Source: Authors calculation using World bank data World Bank Data (World Bank, 2023). Note: The Y axis represent the percentage change in clean cooking access.

Figure 2 illustrates how access to clean cooking facilities is progressing in the designated countries. It's noticeable that, in most of these nations, there's palpable sluggishness in this improvement process. The evident downward trajectory in most cases is even more concerning, which suggests a decline rather than an ascent in improving clean cooking access. While this flattening may not seem significant, it has very real consequences in terms of people developing serious health problems, and increased deforestation, especially for women and children.

Figure 3 gives the share of cooking fuel used by people in the LDCs in the Arab region. For all the countries, the share of biomass—processed or unprocessed—is overwhelmingly large.

Figure 3: Cooking fuel used as a percentage of households for the Arab region LDCs



Source: Authors' design using data from the WHO-BAR tool (WHO-BAR tool, 2023)

2. Context Of Clean Cooking Access Cont.

2.2 Inequality in access

Most of the gains in access have been focused on urban areas, and the gains in rural areas are very slow. Access to clean cooking solutions is generally lower in rural areas of all the selected countries (Figure 4). In Djibouti, for example, only 0.4% of rural areas have access to such fuels, compared with around 12% of urban areas. Similarly, Mauritania has nearly 64% access in urban areas compared to 18% in rural areas.[15]

LPG has a better uptake in urban areas. In Sudan, about 8% of households in rural areas and about double that in urban areas use LPG as their primary cooking fuel (Figure 5).

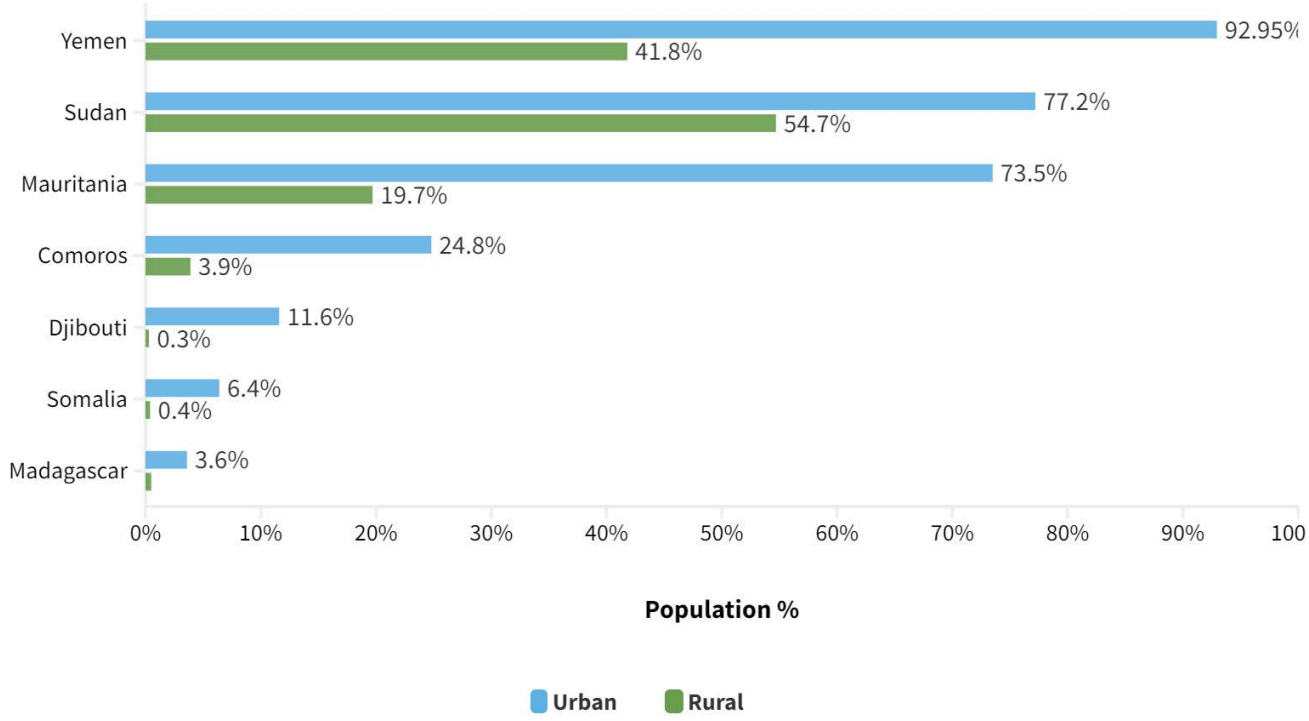
2.3 Cooking Exposure And Stove Stacking

Extensive research has consistently shown that cooking with LPG significantly reduces emissions, leading to reduced exposure to pollution for women who cook (Singh, Pachauri, and Zerriffi 2017; Li et al. 2020). However, the situation becomes less clear due to "fuel stacking," where multiple fuels are used simultaneously. In cases where households have upgraded to improved biomass stoves alongside LPG, emissions are lower compared to those using traditional stoves with LPG.[16]

As with electricity, cooking access is not a binary issue as people move from different types of fuels and often use many fuels together. Figure 6 shows the percentage of households that use a given fuel as their primary fuel in Comoros.

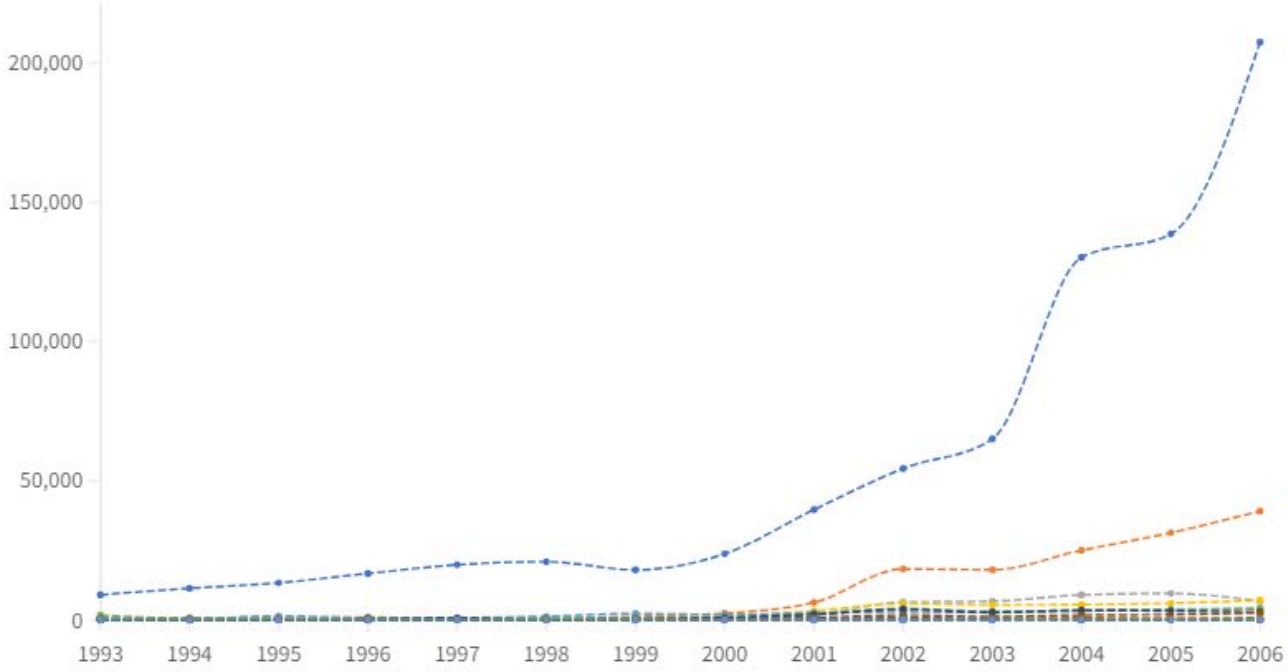
[15] Ibid.
[16] Cecelski, Bumboiu, and Yan (2019).

Figure 4: Percentage of population with access to clean cooking technologies, broken by rural and urban, 2021.



Source: Authors using Tracking SDG 7 (2023) data.

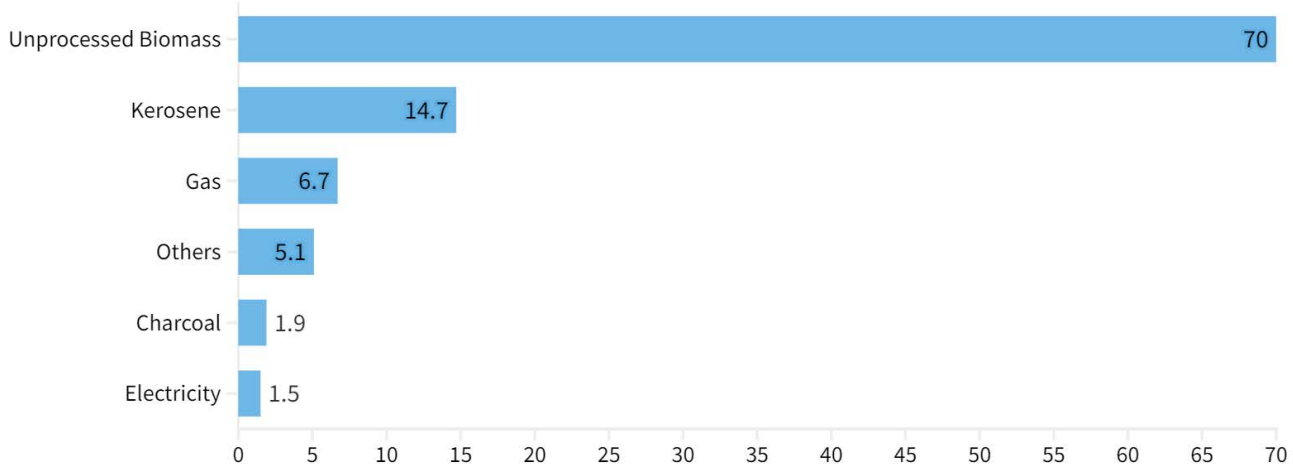
Figure 5: LPG consumption in different regions of Sudan, Metric Tons (before the current conflict)



Source: Authors' calculations using World Bank and UNEP[1] report data

[1] The use of LPG in Sudan, Hood (2010).

Figure 6: Fuel stacking in Comoros: Fuel stacking in Comoros



Source: Authors using data from WHO-BAR tool

2. Context Of Clean Cooking Access Cont.

We can see that most households still depend on biomass-based fuels such as charcoal, fuelwood, and other more toxic fuels like crop waste. A small percentage of households depend on cleaner fuels such as LPG and electricity. While more than 70%[17] of households use solid fuels as their primary cooking fuel in Sudan, Figure 7 shows that, most of the usage is a set of combinations of fuels people use. Therefore, a statistic on households owning LPG stoves would be an overestimate of the use of LPG because many households may not end up using LPG consistently, and rather may use it with combination of other fuels.

Furthermore, households that use multiple fuels and stove options can be exposed to high levels of particulate matter and have dangers of carbon monoxide poisoning. This can be managed if a household has a kitchen with a window. However, giving that cooking is primarily done by women with children close by, they run the risk of being exposed to dangerous pollutants.

2.4 Health Aspects

Traditional methods of using biomass lead to incomplete combustion and the generation of substantial particulate matter (Vicente et al. 2015). This type of combustion is inefficient and poses significant health risks. As depicted in Figure 8, the emission rate of particulate matter from traditional biomass burning is significantly higher compared to LPG. Traditional biomass exhibits an emission rate of approximately 844 µg/24 hours, while LPG registers a comparatively lower rate of around 41 µg/24 hours. This indicates that the emission rate of LPG is nearly 21 times lower than traditional biomass.

Long-term exposure to these particles leads to diseases like respiratory infections, lung cancers, and other heart diseases. In the context of the commonly practiced societal roles in the focus countries, women often bear the burden of cooking and child-rearing in the focus countries. This means that women and children are more exposed to particulate matter pollution. As a result, women and children tend to face a higher risk of developing these health conditions and end up disproportionately bearing the disease burden. Figure 9 depicts the evaluation outcome of the health expenses due to the absence of clean cooking technologies in the chosen countries.

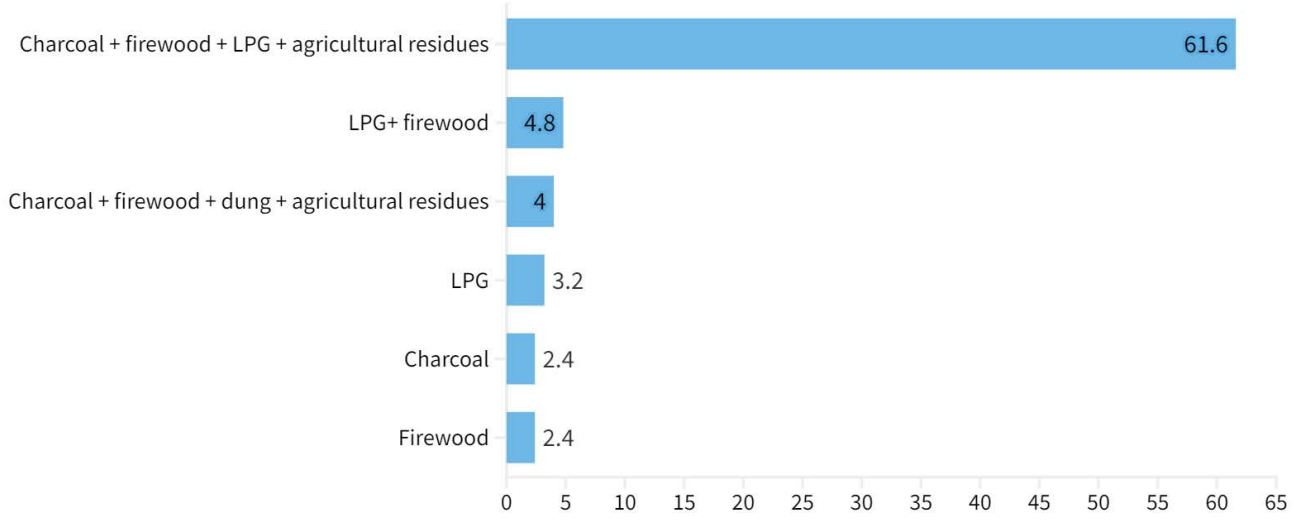
In 2020, these added up to just over 72,500 deaths[18] in our selected focus countries. These deaths are preventable if the households can transition to a more cleaner cooking technology. Most of these diseases are long-term illnesses that not only cause mental anguish but also put pressure on household budgets and national healthcare systems.

2.5 Economic Costs And Benefits

Financially speaking, LPG is still an expensive fuel for households in the focus countries. It is the most expensive

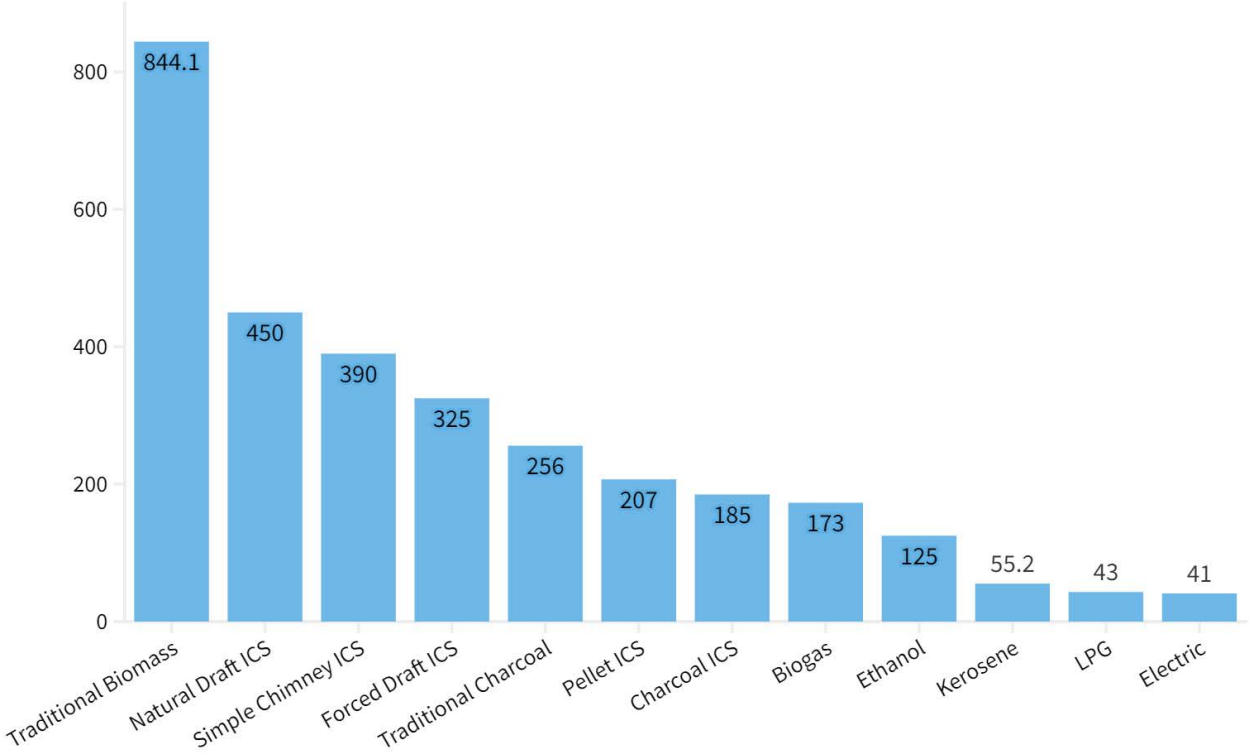
[17] Hood (2010).
[18] Authors' calculations using UN and WHO data (UN, 2023; WHO-BAR tool, 2023)

Figure 7: Fuel stacking in Sudan



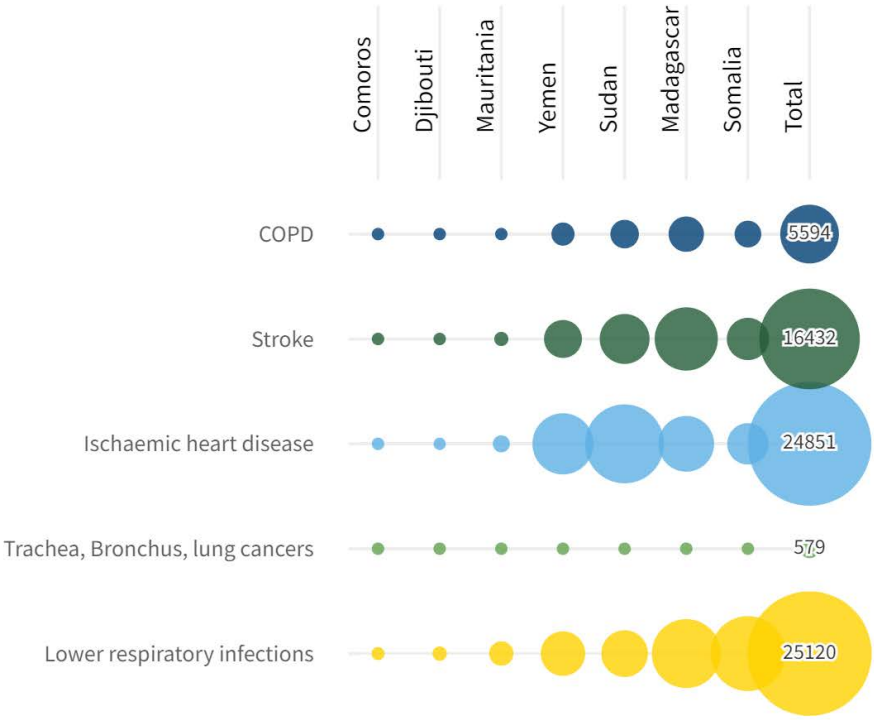
Source: Authors using Sudan Ministry of Energy and Mining 2001 data (Hood, 2010)

Figure 8: Particulate matter (PM 2.5) origination from various fuel stoves



Source: Authors' calculation

Figure 9: Summary of health costs of lack of access to clean cooking technologies



Source: Authors calculation using UN and WHO data (UN, 2022, 2023a; WHO-BAR tool, 2023).

2. Context Of Clean Cooking Access Cont.

fuel, only next to firewood bought from the market while other fuels, such as charcoal and kerosene work out financially cheaper than LPG, as shown in Figure 10. In Sudan, for example, the initial investment to purchase an LPG set was $71, and the annual refilling cost was estimated at $58.50 per household.

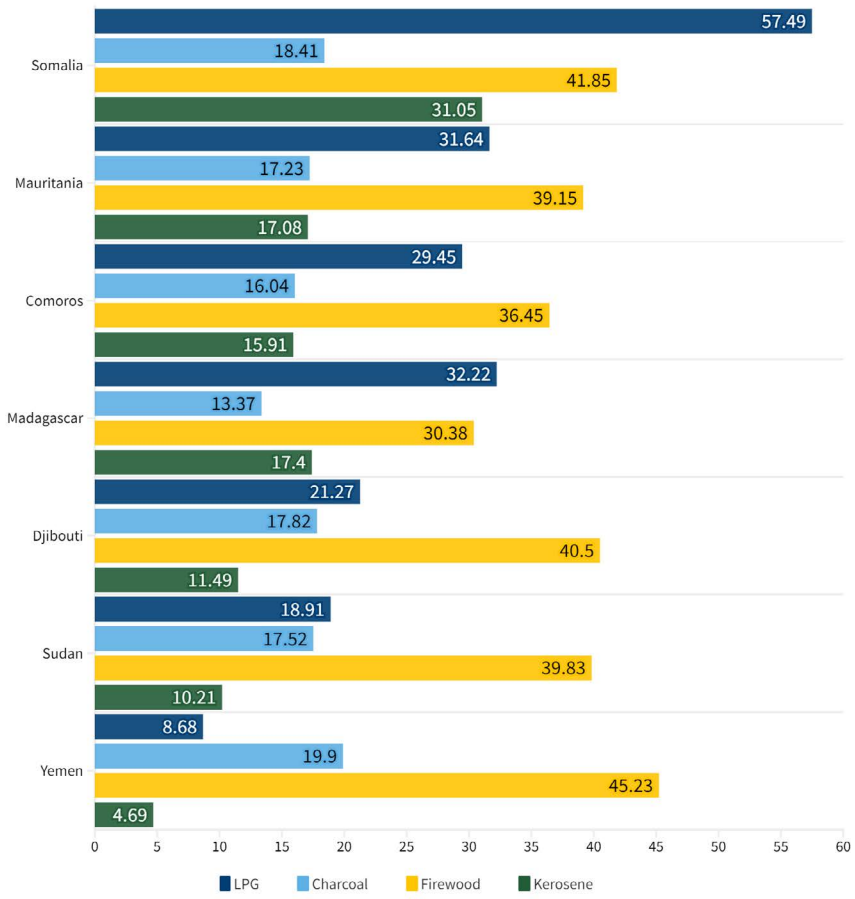
A study on LPG interventions found households predominately buy their wood and/or charcoal.[19] However, a significant barrier for these households to transition to LPG lies in the steep initial expenses, effectively demonstrating the financial impediment a household faces when considering a shift toward using LPG. In a survey on why households do not use LPG, 73% reported that they cannot afford it, and another 11% reported that they cannot afford to refill the cylinder (Practical Action, 2006; Hood, 2010). The average costs[20] for shifting to LPG, which includes the cost of stoves and refills, range from 37% of their monthly per capita income to nearly three times their per capita income (Figure 11).

This can make shifting to LPG a very costly affair, constraining households from using biomass, even if biomass scarcity implies that cooking a meal on biomass-based stoves is more expensive than LPG stoves. This is primarily because of the high efficiency of LPG as a fuel, as indicated in Figure 12.

On the other hand, using biomass-based stoves imposes considerable time costs on women and children, spending 1-5 hours per day foraging for firewood. These stoves are also inefficient; hence, cooking the food takes longer than

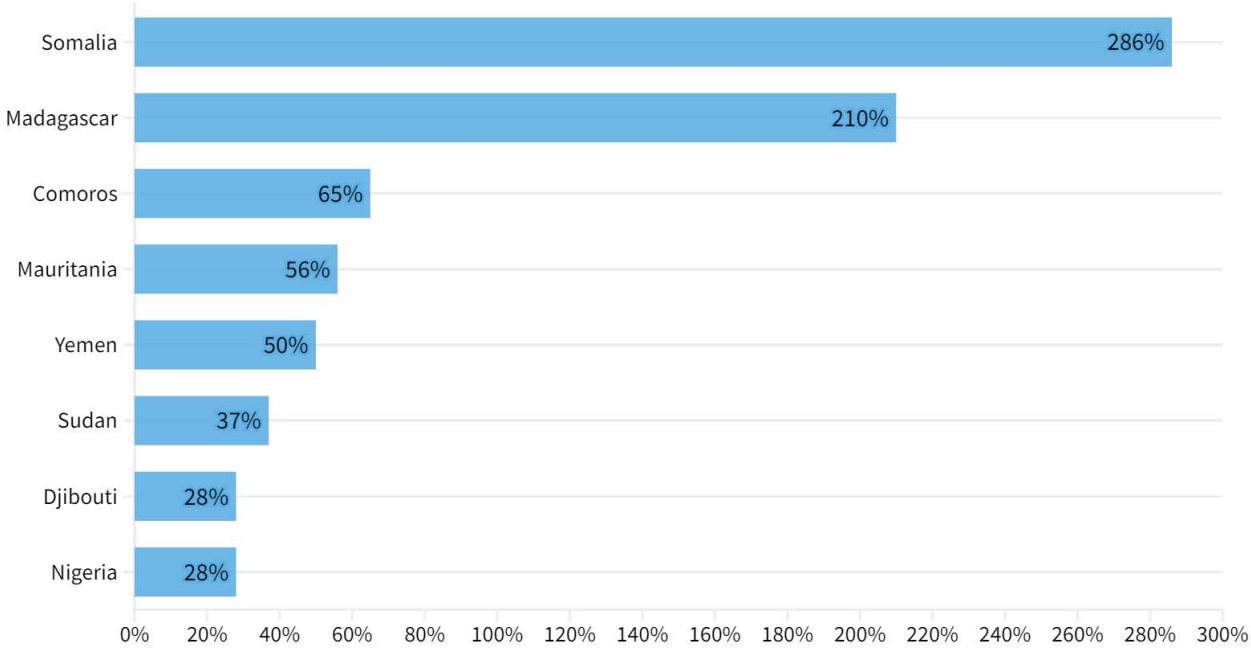
[19] Malla et al. (2011).
[20] These are estimates based on 2-3 refills per month based on the consumption data from India, adjusted for the respective average household size. We did not have data on household income and therefore we used per capita income as a substitute.

Figure 10: Comparative financial fuel cost for households |Data from WHO, MECS



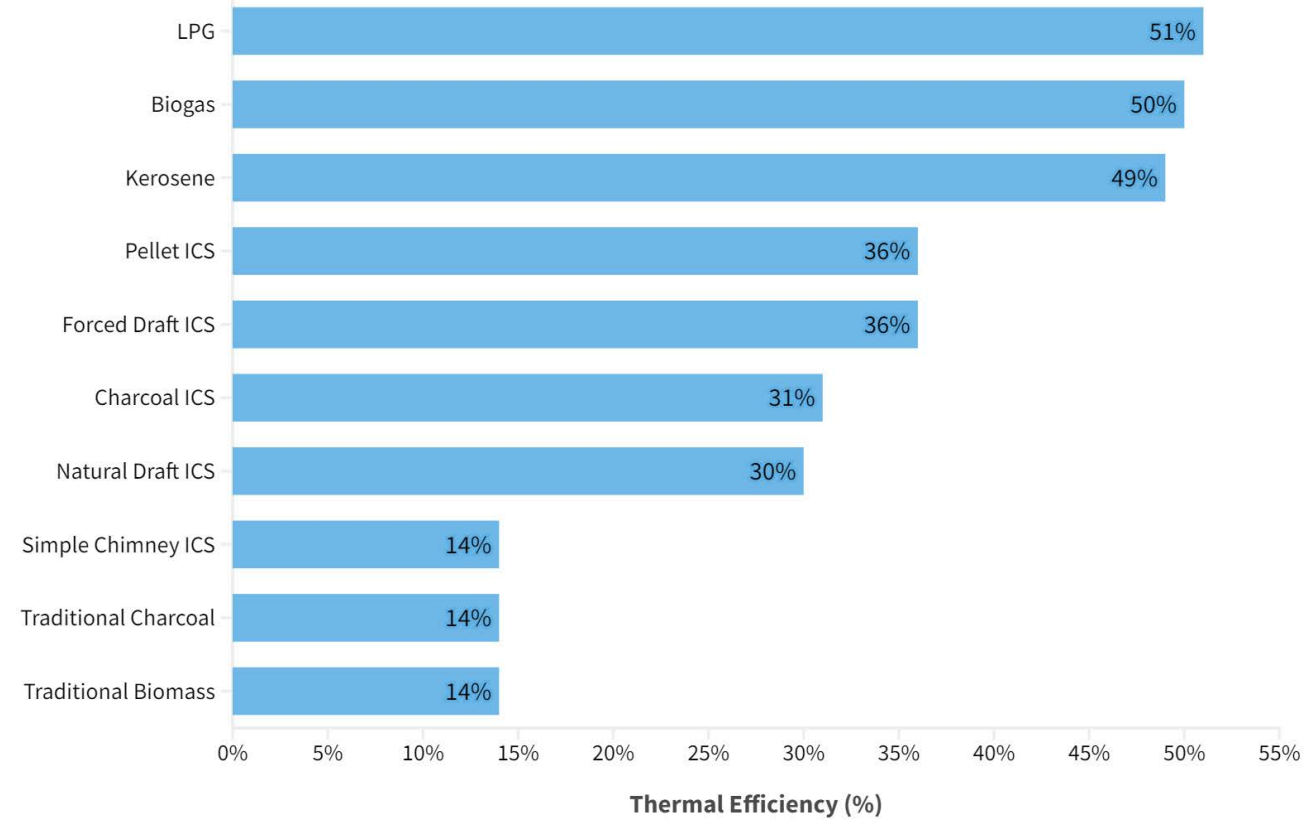
Source: Authors calculations| Note: we assume here that all firewood is bought at market price, but in reality, households do not buy all their firewood.

Figure 11: Financial costs of shifting to LPG for an average-sized family in select countries, including cost of stove and refills as a percentage of their monthly per capita income



Source: Authors calculations using data from the WHO-BAR tool (2023)

Figure 12: Thermal efficiency of LPG comparing to other fuels



Source: Authors calculations

2. Context Of Clean Cooking Access Cont.

an efficient electric or LPG stove would take. All these accumulated hours contribute to exhaustion, inhibiting women from seeking employment and, in some cases, preventing them from pursuing permanent jobs.

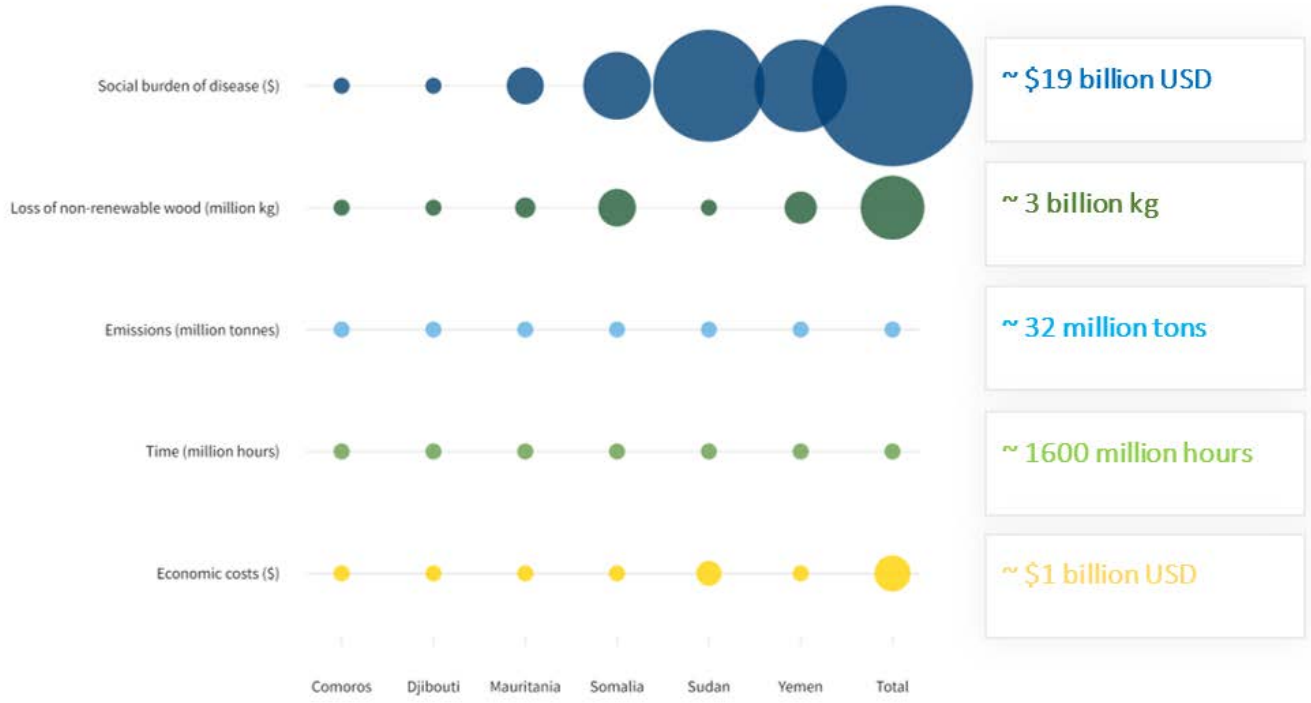
This illustrates the issue of time poverty, predominantly faced by women. By attributing a monetary value to this time based on each country's minimum wage, we can estimate the potential economic gain from shifting to modern, clean fuel technologies.[21] Cumulatively, across all countries in the study, over **1600 million hours** are spent yearly on less efficient methods, amounting to nearly **one billion dollars ($955 million)** of lost potential every year, given the minimum wage rates of these countries (as illustrated in Figures 13-14). Accounting for these potentials, a subsidy for LPG stoves and cylinders could result in significant economic benefits.

2.6 Environmental Benefits

Traditional biomass does not burn efficiently, so volumetrically, it requires significant quantities for the same heat production. This results in substantial time dedicated to

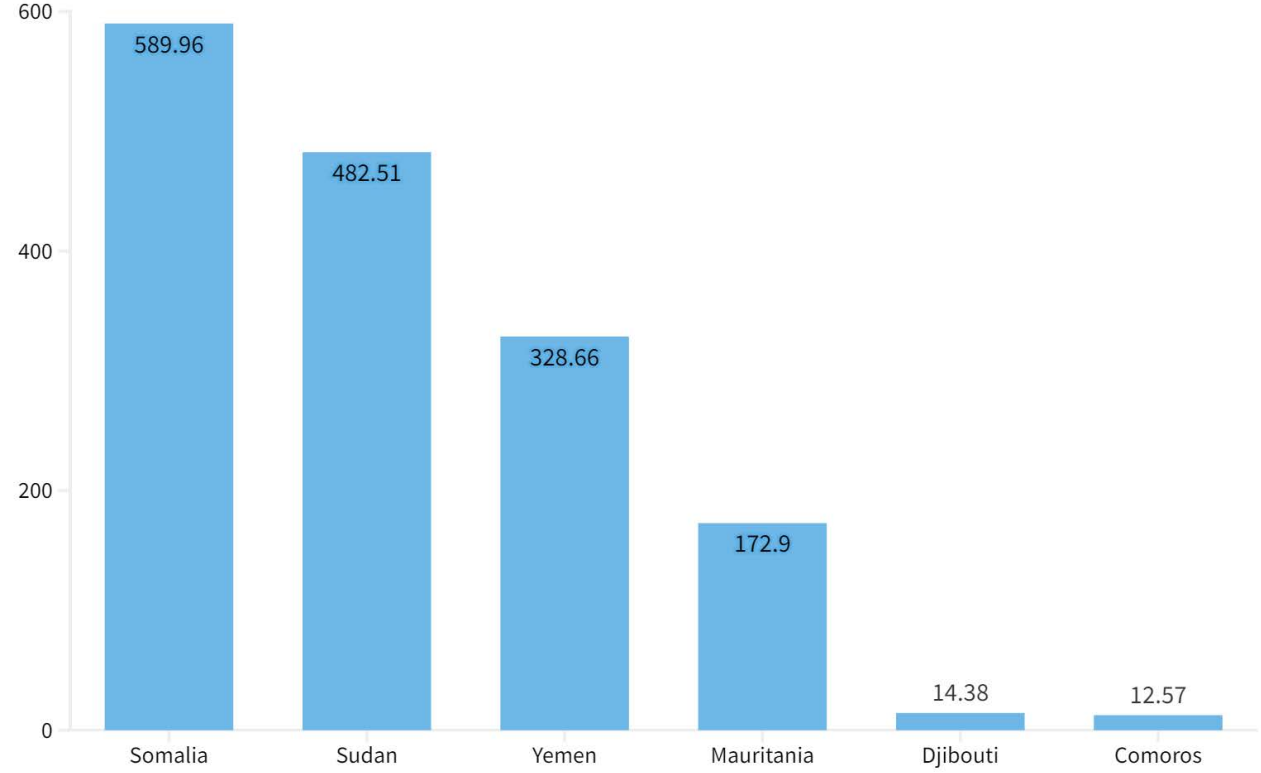
[21] This is because for this valuation we are assuming everyone is working at minimum wage. Of course, many people will be able to benefit from better jobs perhaps even investment in higher degrees but that analysis is outside the scope of our work.

Figure 13: Economic, time, environmental, and health costs of using traditional cooking fuels.



Source: Authors calculation using UN and WHO data (UN, 2022, 2023; BAR-HAP Tool, 2023) | Time, Health and Environment: WHO data (BAR-HAP Tool, 2023), Time cost is the excess time spent collecting firewood. Economic cost measures the loss to the economy from people not working for the excess of the time collecting wood and cooking relative to LPG. Health cost represents the costs for society directly or indirectly incurred by providing healthcare goods and services to maintain or recover a population's health caused by using traditional cooking fuels.

Figure 14: Excess hours cooking and collecting firewood and missing from the workforce



Source: Authors calculations

2. Context Of Clean Cooking Access Cont.

collecting firewood. The rapid increase in firewood collection has emerged as one of the leading causes of (illegal) deforestation. The highest rate of non-renewable biomass is in Mauritania, where nearly 70% of all the firewood harvested is non-renewable and is converted to charcoal, which is then bought by households. Similarly, half of all the biomass used in Somalia is unsustainably harvested.

When the unprocessed biomass undergoes combustion, it cannot be deemed carbon neutral due to the inherent nature of its extraction. In turn, it produces GHGs like methane and CO2, which escalate national-level emissions. For example, these emissions range from 6%-9% in countries like Sudan but can surge to a high range of 21%-40% for others, e.g., Somalia. Hence, adopting clean cooking methods emerges as an effective mitigation strategy, or, in other words, a more significant shift to LPG. This shift could prove advantageous, as it has the potential to improve indoor air quality and lead to a negative balance in net emissions.

2.7 Gender Dimension

The lack of access to clean fuels and modern energy systems for cooking affects livelihoods beyond just health, impeding quality of life for the most. The drudgery posed by reliance on inefficient stoves and fuels often falls disproportionately on women and children, particularly girls. The time loss from collecting fuel and preparing meals using inefficient methods keeps them from other social and productive activities like schooling or income generation, thus hindering the quest for quality education and gender equality for all (SDGs 4 and 5). Such tasks also put them at risk of violence.[22] A recent study in India (Sharma et al. 2023) highlights the significant role of reliable and clean cooking energy in improving social well-being, particularly in enhancing women's quality of life. It illuminates the positive impacts of transitioning to LPG, noting benefits such as cooking and cleaning time reductions, less physical strain, and minimized hardship linked to biomass collection and processing. Nevertheless, the study points out the continued need for strategically addressing the cost of LPG refills, and the importance of sustainable subsidy systems in promoting and maintaining clean energy usage.

[22] Tracking SDG 7 (2023).

Table 2: Fraction of non-renewable biomass used for cooking and contribution to total emissions in the focus countries

	Source of biomass used in cooking	Fraction of non-renewable biomass utilized (% of total)	Contribution of wood fuel in total CO2 emission (% of total)
Comoros	Firewood, agricultural residue	---	---
Djibouti	Charcoal, coal	---	---
Madagascar	Charcoal, coal	27	9-24
Mauritania	Charcoal, coal	69	3-8
Somalia	Firewood and charcoal	53	21-40
Sudan	Wood, charcoal, agri residue	26	6-9
Yemen	Charcoal, coal	---	---

Source: Data compiled from various sources, including country NDCs (Climate Watch, 2015)and CCA Report 2023 (Connors, Belopolsky, and Clarvis, 2022))
I Data from Comoros, Djibouti, and Yemen was unavailable.

Box 1: REGEND: An Integrated Business Model That Uses Renewable Energy As An Enabler

Arab countries are well positioned to develop renewable energy resources, which can greatly contribute to improving the living standards of rural communities, eradicating poverty, enhancing water and food security, improving health and environmental sustainability, and creating entrepreneurial skills, all of which will lead to poverty eradication and economic resilience. However, electricity access in most Arab countries is mostly based on centralized systems. Experiences from across the world show that centralized systems are driven by the demands of big industries and urban populations, while rural populations and small and medium rural enterprises are short-changed. Therefore, the provision of rural-based decentralized renewable energy systems as a powerful rural community development approach will enhance access to energy services in rural areas. Furthermore, when renewable energy applications are used to meet the needs of local communities in their daily lives, their multiple chores at home, and their income-generating activities, more entrepreneurial opportunities in productive sectors will be created.

It is this context that led to the inception of REGEND, a regional initiative designed and implemented based on an integrated approach to improve access to reliable, affordable, and modern sources of energy; supporting the empowerment of rural women; and to significantly improve the quality of life in rural communities of the Arab region. REGEND focused on three main pillars of interventions: field projects, capacity building, and policy development. Small-scale renewable energy systems and clean cooking solutions using LPG, along with productive equipment, were donated to rural beneficiaries, combined with capacity-building programs. The initiative targeted women entrepreneurs especially, and their capacity to play a greater role in their respective national economies by promoting pro-poor investments in clean energy in an environmentally adequate and affordable manner.

REGEND's integrated approach proved crucial in harmonizing the use of LPG and renewable energy by rural women in clean cooking. Existing and newly donated LPG cookers, coupled with newly donated electric cookers, solar energy systems, and energy-efficient productive equipment, were successfully and efficiently used by rural woman in their food and agri-food income-generating productive activities. In cooperatives and community-based organizations with on-grid solar PV and net-metering systems, rural women mainly used electric cookstoves for cooking thanks to a positive net balance of electricity injected into the grid. In cooperatives and community-based organizations with off-grid and/or hybrid solar PV systems with battery storage, rural women used electric cookstoves when irradiation levels and/or battery state of charge levels were high enough. On the other hand, they relied on LPG when irradiation levels and/or battery state of charge levels were not high enough to power the electric cookstoves. These use-case scenarios represent an optimized integration of LPG and solar electric cooking that ensure reliable and uninterruptable operation, minimize costs and emissions, and maximize affordability, efficiency, and productivity while ensuring access to clean cooking. In fact, REGEND's Social, Economic, and Environmental Impact **Assessment Report documented the benefits related to clean cooking:**

- 40% reduction in LPG consumption for cooking in Jordan
- 30-minute reduction in dairy products' cooking time
- 34 to 62 percent reduction in prices of agri-food products in Lebanon
- Increase in the number of agri-food products produced in Jordan from two to 10
- 37,000 kilograms CO2 annual reduction in GHG emissions from cooking activities in Jordan

Source: Sedaoui et al. (2022).

2. Context Of Clean Cooking Access Cont.

2.8 Current Policy Landscape

The focus countries have their own unique challenges while pursuing their clean cooking policies. For example, Comoros is a small island developing country and any discussion of providing LPG to households would be incomplete without a discussion of storage and delivery. Even though LPG is safe to store and transport, it is quite heavy and would add to costs. On the other hand, Sudan and Yemen are in different states of conflict, and therefore, questions of access would tend to take a back step in these situations, even though a conflict might potentially exacerbate the energy access crisis.

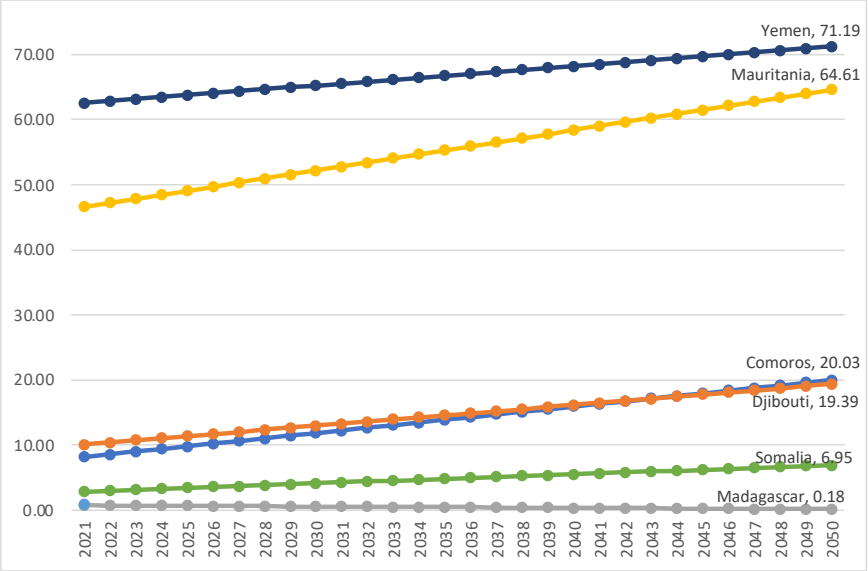
The Republic of Djibouti has already committed to reducing 56,100 tons of wood in their NDC and replacing it with LPG. The Federal Republic of Somalia, in the Horn of Africa, has also committed to "promoting clean and energy-efficient cooking" and estimates a cumulative cost of $1.3 billion[23] for the period of the NDC, i.e., until 2030.

A common theme underscoring the countries in focus is the need for financial resources and capacity building to achieve and enhance their objectives and targets on SDG 7. This is particularly alarming in the clean cooking space, where investments can make significant gains in health, labor productivity, emission reduction, and biodiversity protection. Apart from the 2030 SDG goal, these targets also set up countries to be successful in achieving the Africa 2063 goal seven of "environmentally sustainable, climate-resilient economies and communities." Harmonizing action and resources on these goals would help accelerate achieving clean cooking for all.

We conducted a basic linear projection based on historical data from 2000 to 2020 to predict the prospects of clean cooking access within these countries. The outcomes of this projection can be observed in Figure 15. The provided trend line foresees that if the current circumstances persist, these specified countries will be unable to achieve broad-scale access to clean cooking methods within the initially aimed target year of 2030 or even by the year 2050. Consequently, we anticipate a clean cooking access percentage of around 71% in Yemen by 2050. In contrast, Mauritania trails slightly behind with a projected access rate of 65%. On the lower end of the scale, Comoros, Djibouti, and Somalia are predicted to see access rates of 20%, 19%, and 7%, respectively. Tragically, Madagascar is forecasted to have virtually no significant improvement, with its projection showing a mere 0.2% access rate by 2050.

[23] Climate Watch (2015). Nominal prices, NDC was published in 2015.

Figure 15: Progress at current rates will not lead to achieving universal clean cooking even by 2050



Source: Authors calculations using World Bank data (World Bank, 2023).

This suggests that considerable action has to be undertaken to remedy this shortcoming. For substantial advancements to be made in this context, these nations could follow India's developmental trajectory with its annual progress. Reaching this level of growth and progress would undeniably be a noteworthy achievement, but it warrants considerable policy backing and financial investment in the region. In addition, as previously mentioned, adopting LPG could provide numerous economic, environmental, and health benefits.

This forecast summarizes the prediction of the future status of clean cooking access, using available historical data from 2000 to 2020. Since the prediction model is simple, its results may not account for all the complexities that could arise in real-world situations.

3. Challenges

Many challenges may hinder LPG's widespread adoption and replacement of solid fuel combustion. These hurdles can limit LPG's capacity to enable a just and inclusive energy transition in Africa and the Arab region by supplanting more contaminating solid cooking fuels and mitigating their health and economic externalities.

3.1 Access To LPG

Lack of availability is one of the significant barriers to the uptake of LPG cylinders. Urban settings generally exhibit higher LPG adoption rates due to population density, accessibility of distribution points, and increased income levels. In contrast, rural areas face barriers such as higher LPG prices, long distances to refilling stations, and limited access to credit. The affordability and accessibility of traditional fuels like wood and charcoal in rural areas can further hinder LPG adoption.

Inefficient supply chains and customer service/delivery management contribute to operational inefficiencies and increased costs. Delays in supply, inadequate infrastructure, and suboptimal delivery routes can lead to higher expenses for LPG distribution companies. These inefficiencies are often passed on to consumers through higher prices, further discouraging adoption.

Where LPG supply chains exist, they do so at higher prices (as outlined earlier) and with lower safety standards. Instead, many remote households would need to travel long distances to obtain LPG. If the household is below the poverty line, as defined locally, the accessibility of fuel will impact the wage they have to forego to acquire it and, therefore, is a part of the decision-making. For example, in a rural setup, if the household runs out of LPG fuel and they have to travel 10 km to refill, it would be disruptive. The cylinders are heavy (between 5 and 15 kilograms) and may require two people to travel by bus or a motorized two-wheeler. This could easily take away half a day of work, for which two people might have to forego wages. The household can decide that this is not worth their time, and they might continue to cook with biomass.

In urban areas, this challenge is less severe since the distance to be traveled to refill is less, and biomass is not procured but bought. The incentive structures for the households would change. Therefore, affordability would be a more significant barrier than availability in an urban setup where LPG competes with biomass like charcoal.

3.2 Affordability

Affordability is a multidimensional concept, and there is no universal definition of affordability for clean cooking. Some studies consider only stove or fuel costs, while others use expenditure on cooking as a percentage of the total expenditure or disposable income. The formula under consideration depends on local circumstances and policy support. Price of the stove, price of the fuel, and accessibility of the fuel, including the distance and time required to procure it, are key components of affordability.

The countries under discussion are all low-income countries, and hence, any discussion on the transition to clean fuel would be incomplete without a discussion on affordability, which, according to the Energy Sector Management Assistance Program (2020), is the most significant barrier to the uptake of clean cooking technologies. This means that policies designed to address the affordability of LPG need to consider the affordability of compatible cooking stoves and other related needs.

As well as low incomes, the nature of employment is also a major challenge. Many families have irregular or seasonal incomes, which can make it challenging to budget for recurring LPG expenses. This inconsistency in cash flow can hinder their ability to maintain a steady supply of LPG.

The other aspect to consider on the supply side is the volume of LPG available. It is generally viable if procured in bulk quantities, typically in full cylinders weighing around six kilograms or more. Buying in bulk is unaffordable for many households, especially those with lower incomes. The high upfront cost of purchasing a full cylinder can deter potential users from adopting LPG as their primary cooking fuel.

A recent study analyzing the possible accessibility to clean cooking under various scenarios until 2050 concluded that slow post-COVID-19 recovery and extreme climate mitigation measures could impede clean cooking accessibility unless

Box 2: Lessons Learned In India

India's access to CFTs stood at 71% in 2021 (World Bank 2023). It achieved this by gradually shifting its cooking fuel strategy by using piped LNG in the cities and releasing all the LPG for the rural areas. The primary reliance was on providing clean cooking technologies to households with the hope that exposure and familiarity with the modern stoves (LPG/LNG with stove) would spur further uptake. In 2016, India introduced the Pradhan Mantri Ujjwala Yojana[1] (PMUY 2.0, 2023). The scheme enables underprivileged households to apply for an LPG cylinder (also known as a canister in other parts of the world). The cylinder has a 15 kilogram capacity, and households can also claim a refill under either the 15 or 5 kilograms scheme. Between 2016 and 2020, the scheme released 80 million connections to deprived households. To ensure women's active participation, the connection can only be made in the name of a woman (Ranjan and Singh 2020).

The jury is still out on the success of the scheme and the Indian experience overall, but a report indicating that more than 70% of Indian households use LPG as their primary cooking fuel and 85% have LPG connections at the same time, more than half of Indian households still use traditional cooking fuel. While it has achieved its stated goal of providing access to LPG technology for households, there has not been a significant increase in LPG consumption, implying that households may be reverting back to traditional means.

Furthermore, the Government of India has recently removed subsidies for low-income households using LPG, recognizing the financial burden on the exchequer. The India Modern Energy Cooking Forum in September 2022 emphasized the consensus among top-level delegates that eCooking, using electric pressure cookers and induction stoves, could be the way forward. The India eCookbook developed by Finovista supports this, highlighting that electric cooking is not only feasible but also cost-effective, providing significant savings for consumers.[2]

Another key factor in the scheme was managing the distance traveled by people to get an LPG refill. Since these are heavy (15 kilograms for large or five kilograms for small canisters), it is a big hassle for people to change the cylinder. This is such a big barrier that according to a report by the Council on Energy, Environment and Water think tank, reduction in distance traveled to buy the cylinder is the most effective solution to increase the uptake of LPG. The median distance for a rural household to buy a cylinder is about 4 km in one day. The report also found that even though the connections were made out to women, only 14% of households orders for new cylinders were placed by women.

The Indian experience sheds light on the complexity of achieving a transition to sustainable and clean cooking. Nevertheless, the social, environmental, and economic benefits remain significant enough to warrant a temporary transition. For example, even though biomass is still a large part of overall cooking fuels in India, in the decade of 2001-2011, studies estimate that the displacement of biomass by LPG caused a net emission reduction of 6.7 Mt of Co2e with positive gains in terms of women's employment and health (Singh, Pachauri, and Zerriffi 2017).

[1] Which translates to Prime Minister's prosperity scheme
[2] https://mecs.org.uk/blog/key-partners-working-to-make-ecooking-at-scale-a-reality-in-india/

Source: PMYY2.0 (2023). Pradhan Mantri Ujjwala Yojana 2., https://www.pmuy.gov.in/

3. Challenges Cont.

paired with energy access and poverty reduction policies (Pachauri et al. 2021). It further suggests that rising fossil fuel prices under these policies might increase reliance on biomass and push LPG out of reach of many, indicating that price effects could exceed income effects in determining fuel choices.

For some consumers, upfront costs of buying a cook stove are also prohibitive for the LPG transition. The World Bank reports that 70%-90% of the households in sub-Saharan Africa can afford $3-$7 for a stove while less than half can afford it at $15-$40 per stove. However, this is a rare case, for households that cannot afford a clean cookstove are also hard-pressed to purchase fuel.

3.3 Access To Finance

The challenge of accessing finance is multifaceted, impacting various stakeholders, from end users to suppliers and governments. Low-income households, constrained by affordability, often face limited access to formal financial services, hindering their ability to secure funds for acquiring LPG equipment and refills. For LPG distributors, effective operational management demands substantial working capital covering procurement, transportation, storage, and distribution infrastructure. However, the scarcity of affordable working capital can constrain overall supply volumes and hinder distributors from offering consumer credit, thereby limiting LPG accessibility.

Box 3: Cost Perception In Uganda

Throughout 2018 and 2019, Fenix International, an off-grid solar company, conducted a pilot initiative called Fumba, which distributed LPG cylinders with integrated smart meters to 750 customers in Kampala, Uganda. While customer feedback was positive, one of the challenges faced was that due to the fact that LPG was perceived as expensive, customers saved rather than used their fuel despite having access to a subsidized or even free supply. This resulted in Fenix being stranded with immobilized assets for a considerable period of time.

Fenix reported that they saw great market traction for their product, and customers largely appreciated being able to access LPG at an affordable cost. However, they flagged that a majority of their customers in Kampala only used LPG to quickly cook small meals, which resulted in little gas consumption and long repayment periods. Hence, efforts and initiatives need to be ramped up to educate and increase the awareness of consumers and potential consumers on the affordability of LPG as well as to its health and environmental benefits relative to other non-clean fuels. The concept of cost opportunity also needs to be covered, where it will be highlighted that time spent on collecting traditional fuels is more profitable when better spent on income-generating activities while relying on the readily available, clean, and reliable LPG.

Source: Avi (2021).

Box 4: Case Study From Madagascar

Madagascar is grappling with a substantial deficit in clean cooking with control over the import terminal and minimal (VITOGAZ is the sole owner of import terminal) competition. This has resulted in stagnant LPG consumption at just 0.3 kilograms per capita, significantly below the desired 2 to 3 kilograms per capita target.

Limited investment in LPG cylinder infrastructure exacerbated the issue, with approximately 250,000 cylinders available for a population of 27 million. This is far off achieving a 40% penetration rate, especially considering that marketers bear the financial burden. The prevailing pricing structure led to high LPG prices, with the cost of maintaining infrastructure for a small volume of LPG users further contributing to this affordability challenge. Infrastructure limitations meant that extending LPG access beyond the capital, Antananarivo requires comprehensive logistics planning and potentially a second import terminal, a project previously abandoned by LPSA (a common logistic facility involved in liquid fuels).

As a result, the deficit in Madagascar has had far-reaching consequences. Traditional cooking methods not only contributed to environmental pollution but also had adverse health effects on the population. High LPG prices placed an additional financial burden on households and deterred many from adopting this cleaner cooking option.

Moreover, the financial strain on many countries with constrained budgets complicates their ability to finance or subsidize LPG, let alone incentivize private sector involvement or infrastructure development. Governments increasingly rely on crucial support from international organizations and development institutions to navigate these challenges.

The intricacies of securing finance are deeply rooted in perceived risks, a critical consideration for investors and financial institutions. The perception of risk associated with populations in LDCs and rural areas often hampers the availability and cost of financing. This challenge arises from the limited capacity to thoroughly evaluate, assess, and mitigate perceived risks.

Overcoming these challenges demands a comprehensive approach involving clear communication, transparency, and credible risk assessments. Multilateral and development finance institutions can play a pivotal role in this process by providing concessional loans, technical assistance, and risk-sharing mechanisms. Their involvement becomes especially valuable in areas where private investors may exhibit caution due to these perceived risks. This collaborative effort not only addresses financial barriers but also fosters an environment conducive to the flourishing of the combined smaller, decentralized energy solutions tailored to the specific needs of rural and underserved communities.

3.4 Education And Consumer Awareness

Negative customer perceptions of LPG are another hurdle to its adoption. Many consumers may view LPG as an unreliable and/or expensive fuel source due to market supply and distribution fluctuations. Safety concerns related to gas leaks and accidents can also discourage potential users from switching to LPG for cooking, even though it is a cleaner and more efficient option compared to traditional solid fuels like wood or charcoal.

Box 5: Striving For Clean Cooking Solutions In The Sahel Region Of Sub-Saharan Africa

About 90 million people in the Sahel region still rely on traditional biomass for cooking, making up a tenth of the 900 million African households without clean cooking access.[1] Despite efforts to transition to cleaner cooking methods, progress has been slow due to rapid population growth and income disparities.

Senegal and Mauritania stand out as exceptions, having surpassed the sub-Saharan average for access to clean cooking solutions. Senegal has made considerable progress in reducing solid biomass consumption through the promotion of improved stoves and Mauritania's clean cooking strategy focuses on LPG promotion, underpinned by strong planning frameworks and awareness programs since 1991.

Universal access to clean cooking by 2023 requires deploying over 2 million modern cooking devices annually. While biomass-based stoves will serve remote populations, LPG and electricity will be more accessible in densely populated areas.

Government intervention is crucial for infrastructure development and fuel supply. Maintaining sustained public action and averting supply disruptions, especially in unstable regions, is vital for long-term progress.

This case study highlights the importance of building capacities and awareness through policy and planning and provides insights into the complexities of expanding access to clean cooking methods in the Sahel region of sub-Saharan Africa, a region that lags behind the global average for access to clean cooking solutions. Highlighting the experiences of Senegal and Mauritania, the case underscores the role of transitional fuels like LPG in improving public health and mitigating environmental impact. The lessons from the Sahel can serve as valuable indicators for other regions facing similar challenges, especially for policymakers looking to bridge the gap between electricity access and clean cooking solutions.

[1] CFT and electricity access figures for the Sahel Region of Sub-Saharan Africa: Burkina Faso 12% CFT, 19% electricity; Chad 8% CFT, 11% electricity; Eritrea 12% CFT, 53% electricity; Niger 3% CFT, 19% electricity; Senegal 29% CFT, 68% electricity; South Sudan NA CFT, 8%; Sudan 63% CFT, 62% electricity.

Source: IEA (International Energy Agency). 2022. Transitions énergétiques au Sahel

3. Challenges Cont.

Moreover, the absence of effective regulation both supporting and enforcing strict safety standards, does little to rectify these negative perceptions.

3.5 Other Barriers

The multifaceted crises encountered in the societal, environmental, political, technological, health, price volatility, and geopolitical fronts form a complex, intricate matrix that poses challenges and impacts the global LPG ecosystem.

Societal factors such as rapid population growth pose enormous pressure on existing energy resources, while cultural barriers prevent the adoption of modern cooking methods like LPG stoves. Furthermore, women's lack of social empowerment solidifies the continued usage of detrimental cooking practices.

The environmental scale weighs heavy with climate change, which can jeopardize LPG production and supply due to extreme weather conditions. Moreover, the constant depletion of natural resources questions the sustainability of LPG production.

Political instability and policy incoherence contribute to volatile energy regulations, while trade restrictions or subsidy cutbacks can create financial barriers for households adopting LPG.

From a **technological standpoint**, unequal access to advanced, safe, and efficient LPG technologies can result in continued harmful cooking methods. Cybersecurity risks pose another challenge, potentially endangering the LPG supply chain's digital infrastructures.

In terms of health, pandemics, like COVID-19, can fracture the LPG supply chain, impair accessibility, and affect its affordability.

On the **geopolitical** front, conflicts and wars showcase their disruptive nature, disturbing LPG production facilities and transportation routes, thus making supply unstable. Certain countries exhibit compounded issues due to instability and conflict, critically impacting government finances, policy stability, and effectiveness of LPG measures. Despite the apparent demand, this discourages the private sector's domestic and international engagement in the LPG markets of conflict-prone regions.

Finally, cultural factors can hinder the wide acceptance of LPG as a cooking fuel. These barriers include loyalty to traditional cooking methods, attributed to ancestral respect and skepticism about change.

These hurdles result from allegiance to traditional cooking methods, motivated by reverence for forebears and reluctance towards change. As per a survey conducted in Nigeria by Akintan et al., (2018), 'ethnic-specific' conventional norms and prohibitions exert a more substantial impact on fuel selection, wood fuel procurement, and cooking procedures than the tangible effects of indoor air pollution exposure. Additionally, the perceived improved taste of food cooked with traditional fuels can limit LPG adoption despite its clear benefits, like reduced smoke and quicker cooking. The cultural fondness for the taste of food prepared on wood fuel is deeply ingrained. According to a study by Ruiz-Mercado et al., (2011), people's identities and beliefs, molded by their culture, can make overcoming these barriers a daunting task, possibly impeding the mass-market commercialization of LPG. Since culture shapes people's identities and beliefs, overcoming these obstacles is challenging, potentially hindering LPG's large-scale commercialization. Therefore, successful promotion strategies must understand, respect, and address these cultural nuances while showcasing the benefits of LPG.

4. Toward Addressing The CFT Access Gap

Recognizing the obstacles to LPG adoption, particularly among vulnerable populations in low-income countries and the current uptake status, exploring a holistic approach to fostering change is imperative.

Key considerations include the need to mobilize inclusive finance, awareness and capacity building, promoting innovative business models, and gender empowerment to unlock the vast benefits of greater uptake of LPG compared with traditional cooking methods. Additionally, fostering regional collaboration and engaging diverse stakeholders are imperative steps.

4.1 Mobilizing Finance

In addressing the significant clean cooking fuel deficit and advancing policy recommendations for a sustainable transition, it is imperative to recognize that financing stands out as one of the most critical and indispensable means of tackling the existing gaps in LPG adoption. Its multifaceted role extends to infrastructure development, supply chain optimization, affordability enhancement through subsidies, market expansion efforts, consumer education campaigns, and, ultimately, the elimination of financial barriers hindering the widespread adoption of LPG as a transitional solution for cleaner and safer cooking. In the quest for accessible, efficient, and environmentally friendly cooking fuels, strategic financing mechanisms emerge as the cornerstone for shaping a brighter, cleaner future.

First, distributors need access to larger amounts of working capital or credit lines at a cheaper cost to unlock greater procurement volumes of LPG downstream. Second, marketers need access to cheaper financing to offer affordable consumer credit—or a financial partner to extend consumer credit for LPG retail procurement. Third, traders need access to commoditized technology and models to better package fuel and track and trace cylinders to optimize sales to low-income customers while ensuring safety and regulatory standards are met. While the market is seeing progress related to this last lever—as a result of technological innovations such as pay-as-you-go (PAYG) cylinder smart meters and incremental refilling of cylinders—the first two levers remain constrained at varying degrees of gridlock across priority country markets, preventing low-income access at the necessary scale.

With a squeeze on government budgets, high levels of debt, and an ongoing recovery from the impacts of different economic and financial crisis, governments will increasingly rely on external funding sources. However, these funds rarely reach the most vulnerable and in the appropriate form. In the Arab region, for example, nations received a meager $34.5 billion in public international climate finance from 2010-2020, representing less than 6% of their total needs. Furthermore, most of this assistance came in the form of loans rather than grants, exacerbating the region's debt burden. Additionally, there's a concerning shift toward non-concessional climate finance, with only a fraction of the funding coming from climate funds. Accessing these funds proves challenging due to complex accreditation processes and resource-intensive project development procedures, leaving these countries struggling to secure the necessary financial support.[24]

4.2 Innovative Business Models

Achieving universal access to clean cooking, much like electricity, requires tailored solutions. PAYG LPG is emerging as a potential remedy, particularly addressing affordability concerns. In the PAYG system, households receive a full LPG tank, often with a deposit. A "smart meter" controls gas flow and facilitates remote monitoring. Customers pay for gas via mobile money, enabling flexible payments, similar to prepaid mobile phones or off-grid solar solutions.

This model offers several advantages. It transforms companies into service providers, providing free delivery, safe installations, and cylinder ownership, thereby eliminating upfront costs and enhancing customer safety. With remote monitoring, users only pay for the gas they consume, making clean cooking accessible and affordable. Additionally, financing options for stoves and accessories further enhance affordability, bringing cleaner cooking within reach for more households.

However, several challenges hinder the widespread adoption of PAYG. The necessity for last-mile distribution, especially in densely populated areas, places a significant logistical and financial burden on providers. In regions with lower population density, the model becomes less economically viable. Moreover, many households continue to use multiple fuels interchangeably, impacting the turnover rate for service providers. Lastly, the business model's overall viability remains unproven, demanding substantial capital investment for rapid expansion and scale.

[24] ESCWA. 2022. Climate finance needs and flows in the Arab region. https://www.unescwa.org/publications/climate-finance-needs-flows-arab-region

4. Toward Addressing The CFT Access Gap Cont.

4.3 Building Capacities

Navigating the path forward involves a strategic focus on capacity building. Overcoming the perceived risks associated with financing barriers is pivotal in this journey. Capacity-building initiatives are essential in equipping financiers with the requisite knowledge and tools, thereby facilitating increased access to affordable credit for communities situated at the "last mile." This transformative process encompasses various stakeholders, ranging from government and policymakers to microfinance institution lenders and national-level bankers, staff members of international development organizations, development finance institutions, fund managers, and other financing stakeholders involved in supporting clean cooking technologies.

To bolster these efforts, strategies should be devised to incorporate guarantee mechanisms, establish robust track records for both households and enterprises and devise mechanisms adept at handling smaller ticket sizes. By fortifying the capabilities of those involved in the financing landscape, we can systematically dismantle the perceived risks, paving the way for more inclusive and sustainable access to clean cooking fuel technologies in our focus countries.

Box 6: Case Study: PAYG LPG For Clean Cooking In Nairobi's Informal Settlements

In Nairobi's informal settlements, the affordability of clean cooking solutions like LPG has been a significant barrier to reducing household air pollution, which poses severe health risks. Traditional fuels like wood and charcoal are the primary sources for cooking, contributing to indoor air pollution and climate change.

A breakthrough came with the introduction of PAYG smart meter technology. This allowed residents to make incremental fuel payments via mobile banking, eliminating the need for a large upfront investment in an LPG cylinder. Anita's family was among the early adopters, transitioning from polluting fuels to clean LPG stoves.

The use of PAYG LPG stoves remained stable despite economic hardships and the COVID-19 pandemic. The technology not only made clean fuel accessible but also improved safety by reducing risks of burns and gas explosions. Direct cylinder delivery and dual burners further enhanced the user experience. This initiative also aligns with achieving SDGs related to health, food, and energy.

As a result and beyond affordability, residents reported benefits like the ability to cook multiple dishes simultaneously and increased safety due to less risk of burns and gas explosions. During COVID-19 lockdowns, 95% of households enrolled in the PAYG program maintained their LPG usage despite income declines.

The PAYG smart meter technology represents a scalable solution to the affordability challenge in transitioning to clean cooking solutions. It can significantly impact public health, climate change, and contribute to achieving multiple SDGs.

Source: WHO. 2021. Transitioning to cleaner cooking. https://www.who.int/news-room/feature-stories/detail/transitioning-to-cleaner-cooking

4.4 Gender Empowerment

Empowerment and mentorship programs for women entrepreneurs in the clean cooking value chain have effectively promoted a more gender-inclusive workforce. Better representation of women in energy sector policy and decision-making and more active participation of women entrepreneurs in the clean cooking value chain are important ways to advance gender equity and ensure that efforts to expand access meet the needs of cookstove users (Connors, Belopolsky, and Clarvis 2022). For example, in Nepal, where a transition to e-cooking is underway, a lack of availability of after-sales services was becoming a challenge. To address this gap, the Women's Network for Energy and Environment, with the support of the Gender and Energy Innovation Facility, trained women who owned or worked in electrical appliance stores to provide maintenance and repair services for electric stoves. Such innovation promotes clean cooking and women's participation in the energy value chain, all the while providing women with additional income and customers a place to go for appliance repair (ENERGIA 2022).[25]

Subsidy-based intervention has been adopted in the countries that have made very rapid transitions recently, for example, India and Indonesia. In India, the stove and first refill were subsidized, and in Indonesia, both stove and subsequent refills were subsidized. As we discussed in the Indian case study, this leads to a rapid uptake, but sales data shows that households do not continue to use LPG, presumably because of the costs, as we demonstrated in Figure 8. Therefore, the Indonesian model of ensuring continued support through LPG stove and fuel subsidies along with reducing subsidies for the competing fuel, kerosene, is a more viable option but would still depend on the government's long-term ability to support implementing subsidies with growing populations and energy needs.

[25] Tracking SDG 7 (2023)

Box 7: Synergies Of Merging LPG And Solar Home Systems In The Democratic Republic Of Congo (DRC)

Bboxx, a next-generation utility and leading off-grid solar company, has been developing its strategy for LPG distribution, with pilots implemented in the DRC, where there is significant overlap between LPG and solar home systems (SHS) customers. Bboxx also announced a new partnership with the U.S. Agency for International Development in 2020 to scale up PAYG clean cooking access in the DRC, where only 4% of the population has access to clean and affordable cooking. The pilots test two offerings: bundling LPG with SHS by leveraging the PAYG capabilities of the SHS and a stand-alone smart meter solution. These solutions allow upfront equipment financing in order to increase affordability among target customers.

These pilots explore synergies associated with merging solar and clean cooking solutions, including the reduction of overheads and investment needs for expansion. Furthermore, in 2021, the Multilateral Investment Guarantee Agency (MIGA), a member of the World Bank Group, issued guarantees of up to $37.1 million to cover loan investments in Bboxx subsidiaries in Rwanda, Kenya, and the DRC for up to 10 years where Bboxx operations there will continue bundling LPG with SHS. These guarantees on bundled products primarily aim to mitigate risks associated with currency and political instability. The objective is to enhance the attractiveness of investments for financiers while simultaneously maximizing carbon emission reductions.

Source: Avi (2021)

Box 8: Training Women In Nepal To Maintain Electric Cookstoves

Nepal's access to clean cooking technologies stood at 35%, with access to electricity at 90% as of 2021.

Electric cooking (e-cooking) technologies have been deployed to tackle this clean cooking gap, but the ongoing transition to e-cooking in Nepal has been hindered by limited after-sales services, a challenge that needs to be addressed for successful adoption. In response, the Women's Network for Energy and Environment, in partnership with the Gender and Energy Innovation Facility, launched a project to tackle this issue. They trained women who either owned or were employed in electrical appliance stores to become skilled in maintenance and repair services for electric stoves.

This approach had multiple beneficial outcomes. Firstly, it empowered women by providing them with valuable skills and additional income opportunities, enabling their active participation in the clean energy value chain. Secondly, it improved the consumer experience by offering reliable after-sales service, which is critical for the success of any clean cooking initiative.

The project not only elevated the roles of women in the workforce but also had tangible economic benefits. Women who participated in this initiative found supplementary income opportunities, thereby improving their economic resilience.

Ultimately, the project contributed to enriching the overall ecosystem around clean cooking and sustainable energy in Nepal. Ensuring reliable after-sales services encouraged the broader adoption of cleaner and more efficient cooking technologies, which is an essential step toward achieving energy sustainability.

While not specific to LPG, Nepal's case shows that investing in women's skills and entrepreneurship can be pivotal in driving social and environmental change. The program's dual focus on gender inclusion and sustainable energy makes it a compelling model for other nations working to advance these critical goals.

Sources: (ENERGIA 2022). Tracking SDG 7 (2023).

Box 9: Algeria's Investment And Policy Support For LPG Domestic Use And Beyond

Algeria's access to clean cooking technologies stood at 99.7%, with access to electricity at 100% as of 2021.

In an effort to further improve the distribution of LPG, particularly in western and central Algeria, Naftal and Sonatrach TRC (Transport par Canalisation) have joined forces to construct a 424-kilometer LPG pipeline along the Mediterranean coast, costing an estimated $364 million. The project is a part of Algeria's broader strategy to diversify its energy portfolio and will substantially reduce the high costs associated with LPG transport by sea or road.

The pipeline is designed to have an annual transportation capacity of 1.2 million tons of LPG. Slated for completion in 2026, the pipeline will run from the port city of Arzew to the capital, Algiers, crossing several major administrative divisions. Additional filling centers are planned in various strategic locations to facilitate distribution.

In terms of investment, Sonatrach announced significant investments in various energy sectors for the period from 2022 to 2026. For 2022 alone, the budget allocation is $8 billion, with a notable part of this fund targeted at projects in the LPG sector aimed at meeting national fuel demand.

Algeria has also been proactive in promoting LPG as a fuel for vehicles. With rising global oil prices and environmental concerns, the country has looked to LPG as a cheaper and cleaner alternative. Several fuel stations now offer LPG and conversion centers have been established to retrofit existing vehicles to run on LPG. This not only diversifies Algeria's energy consumption but also serves as an example for other countries looking to transition their energy sectors in line with SDG7 targets.

Algeria's expansion of its LPG infrastructure for both domestic and vehicle use, completed with energy subsidies and incentives, presents one of the models for how substantial investment and strategic planning with a people-centric approach can bring about tangible benefits in energy diversification but also a just and inclusive approach for addressing the CFT access gap.

Sources: Christelle Moraes. 2022. Algeria's Naftal – Sonatrach team up to construct an LPG pipeline https://www.constructafrica.com/news/algerias-naftal-sonatrach-team-construct-lpg-pipeline. Tracking SDG 7 (2023).

5. Policy Recommendations

As the Arab region moves toward a more sustainable energy future, the role of clean cooking fuels and technologies is increasingly critical for public health and environmental well-being.

According to WHO Guidelines, future policies should prioritize the scaling up of clean cooking solutions that offer maximum health benefits. In contexts where these solutions are affordably and reliably available, government policies and investments should aim to enable their widespread adoption by supporting enterprise growth.

While the ultimate objective is to achieve universal access to the cleanest cooking fuels and technologies, transitional options also have a role to play. These transitional fuels, such as LPG, offer immediate health and environmental benefits and serve as stepping stones toward cleaner solutions. Promoting the uptake of LPG as a transition fuel for clean energy technologies in LDCs and in rural areas requires a comprehensive and integrated approach that addresses various economic, social, and environmental factors based on the optimal use of available natural resources.

This sets the stage for the following policy recommendations aimed at making LPG a viable transition fuel for cleaner cooking. Combined with a renewable integration solution, it is expected to bring significant benefits to the countries included in this study.5.1 Introduce targeted subsidies.

5.1 Introduce Targeted Subsidies

Improving access to clean fuels is a crucial step, but it does not guarantee a complete shift from polluting fuels. Subsidized LPG recipients, in some cases, may continue to use traditional fuels due to affordability and accessibility barriers. Achieving full transitions may require larger subsidies, behavioral change intervention, or other complementary efforts. Specific strategies to realize this transition may include:

- Identifying and mapping out demand alongside vulnerable populations more likely to rely on polluting cooking fuel sources.
- Implementing targeted subsidies for LPG to ensure that cost variations do not inhibit its use.
- Providing subsidies for the purchase of clean cooking stoves to make them more affordable to the masses.
- Gradually phasing out subsidies on competing polluting fuels to promote cleaner cooking sources.
- Develop a clear roadmap for the gradual phasing out of LPG subsidies to guarantee a timely transition to renewable energy sources and electric stoves in the long-run.
- Provide customs tariff exemptions and tax credits to encourage LPG cooking stove imports, making them more affordable and attractive for consumers.

5.2 Regulation

Robust regulatory measures, coupled with rigorous control mechanisms, are indispensable in addressing supply gaps, affordability, and in addressing LPG safety. This can be achieved by nurturing a private sector-driven industry with regulations that can unlock extensive job creation and entrepreneurship opportunities. Indeed, these opportunities will essentially be the downstream segment of the LPG value chain, concentrated on a local scale. As a result, LPG can evolve into a safer, more accessible, and environmentally friendly choice for clean cooking that not only aids in environmental conservation but also stimulates economic growth and employment opportunities. To accomplish this, policymakers may consider taking the following actions:

- Strengthen legal frameworks and enforce competition laws to prevent anti-competitive practices and protect consumer interests.
- Enforce anti-monopoly regulations to prevent price manipulation and unfair competition practices. This may involve creating or strengthening regulatory bodies responsible for monitoring market behavior.
- Enforce mandatory safety standards, conduct regular inspections, and bolster regulatory agencies to ensure safe LPG stove usage.
- Conduct continuous market surveillance to remove substandard stoves, and establish feedback mechanisms for consumer concerns.
- Encourage third-party safety certifications for LPG stoves and mandate compliance reporting by manufacturers and importers.

5.3 Financing Solutions And Investment

To achieve equitable outcomes, investments beyond subsidies are also essential. Quite often, national subsidies tend to disproportionately benefit better-off populations, especially those in urban settings where existing LPG networks exist or can be more easily implemented. Subsidies might also be not targeted and might benefit rich and poor populations alike. Coupling targeted subsidies with financing mechanisms and infrastructure investment will help de-risk LPG. Potential options to mitigate financing and investment challenges could encompass:

- Embedding LPG as part of NDCs and national strategies on climate action to provide a signal to the private sector and to gain accessto climate finance.
- Providing innovative financing mechanisms such as concessional loans instead of an outright subsidy.
- Facilitating access to microfinance and credit schemes for low-income households and entrepreneurs to invest in LPG equipment and infrastructure.
- Investing in supply and distribution network expansions, including the capacity of LPG cylinders, accounting for current deficits expected with growing demand.
- Providing innovative payment solutions, as sometimes the actual cost of LPG is not the primary concern. Therefore, exploring options for a more flexible payment arrangement, perhaps installment-based, would be highly beneficial to accommodate occasional usage, making it convenient and financially manageable.
- Collaborating with private sector entities to develop solutions and maintain LPG infrastructure, storage facilities, and distribution networks.
- Assisting LPG providers in creating home delivery plans for cylinder distribution to boost usage in rural regions.

5. Policy Recommendations Cont

5.4 Building Capacities And Awareness

Addressing the current LPG deficit requires a comprehensive capacity-building strategy across the supply chain involving policymakers and users. Increasing awareness about the benefits of LPG is paramount. Given the informal and minimally-trained nature of the charcoal production workforce, programs aimed at reskilling the workforce, for example, will not only equip them for alternative livelihoods that align with cleaner and more sustainable energy but also contribute to the mitigation of unregulated deforestation. To do this effectively, policymakers may rely on the following strategies:

- Develop capacities of governments in articulating and estimating financing needs, and access greater levels of funding from international finance institutions, development banks, and climate finance in general.
- Develop comprehensive training programs for LPG technicians, distributors, and users. This should include safety protocols, equipment maintenance, and efficient usage.
- Implement comprehensive reskilling programs to equip the informal sector with the necessary skills.
- Promote consumer education on safe stove use, strengthen emergency response infrastructure, collaborate with international safety organizations, and certify and train LPG users for safe storage, transportation, and distribution.
- Launch extensive awareness campaigns to inform communities about the benefits of LPG, safety measures, and its environmental advantages and to ensure that targeted measures such as subsidies and grants reach marginalized and vulnerable communities.
- Organize local workshops and seminars in collaboration with community leaders, local authorities and civil society to address concerns about LPG safety.
- Educate users about the environmental benefits of LPG compared to traditional fuels, emphasizing how LPG reduces indoor air pollution and deforestation, supports productive sectors and entrepreneurship development which would encourage behavioral change.

5.5 Partnerships And Collaboration

Governments ought to foster collaborative efforts and coordination across the health, climate, and energy sectors. Embracing a multi-sectoral approach is essential for driving progress toward achieving universal clean cooking access. Integrating clean cooking solutions into mainstream practices will not only amplify their impact on these critical domains but also make significant contributions to women's empowerment and livelihood enhancement.[26]

Trade-offs between different mitigation policies also need to explicitly bring in people's need for clean cooking and fuel price stability.

Policymakers considering a comprehensive regulatory framework to promote access to clean cooking should consider implementing the following strategies:

- Fostering partnerships between governments, NGOs, private sector stakeholders, and international organizations to leverage resources and expertise for capacity-building efforts.
- Coordinating policies related to LPG adoption with other sectors like health, environment, and education.
- Engaging in international cooperation and trade agreements to access LPG from global markets, diversifying supply sources, and reducing dependency on monopolistic domestic suppliers.
- Addressing the deficit in data and pinpointing the socio-cultural determinants that motivate cooking practices. This aids in enhancing our understanding and provides valuable insights, which can significantly contribute to formulating more informed and effective policies.

[26] UNDESA (2018).

Box 10: The Kingdom Of Saudi Arabia's Clean Fuel Solutions For Cooking Initiative

The Kingdom of Saudi Arabia has announced its commitment to provide Clean Fuel Solutions for Cooking initiative provides cleaner cooking fuels, including LPG, solar power, and biodigesters, to 750 million people worldwide during the Middle East Green Initiative summit held in October of 2021. This initiative offers solutions to vulnerable populations globally, many facing dire consequences due to traditional and hazardous cooking practices, such as coal and wood usage. These clean cooking solutions have the potential to save countless lives by mitigating the health risks associated with these cooking fuels.

The Oil Sustainability Program has been the leading entity to execute this initiative and has been actively working on implementing multiple global projects, alongside key local and international stakeholders. The initiative is based on a set of strategic pillars that include:

1. **Raising awareness and increasing clean cooking solutions access to end users.**
2. **Supporting sustainable market growth for clean cooking solutions.**
3. **Removing barriers to clean energy in emerging markets.**

The initiative will ultimately lead to:

- Improving the quality of life for disadvantaged people and supporting gender equality.
- Reducing CO2 emissions from traditional cooking methods by providing access to clean cooking solutions.
- Supporting targeted countries' economic growth, job creation, and infrastructure development.
- Scaling up international cooperation to prevent and mitigate climate change impacts and support a sustainable future.

The initiative also provides off-grid solar power systems to empower households to use electric stoves as clean cooking solutions.

The countries selected for intervention on LPG are Ethiopia, Ivory Coast, South Africa, South Sudan, Sudan, and Tanzania. The countries selected for LPG and renewable are Cameroon, Ghana, Kenya, Madagascar, Nigeria, and Senegal. The countries with renewable projects potential location are Chad, Mali, Mozambique, Namibia, Niger, Zambia, and Zimbabwe.

In 2022, the initiative kicked off efforts to provide LPG for clean cooking in Ghana, Madagascar, and Nigeria.

Expanding initiatives like this would help to accelerate progress in addressing the access gap on CFT in the most vulnerable countries and ensure that no one is left behind for a just and inclusive energy transition.

Source: OSP. 2023. Oil Sustainability Program Announces 'Empowering Africa' with Several Saudi Ministries https://www.spa.gov.sa/en/N1977071; ARDA Week 2023. Kingdom of Saudi Arabia's Clean Fuel Solution for Cooking and Opportunities for Africa https://arda.africa/wp-content/uploads/2023/03/Mohammad-Al-Tayyars-Presentation-in-ARDA-Week-v10.pdf, Authors, OSP, Ministry of energy of Kingdom Saudi Arabia

6. Conclusion

Clean cooking is a critical element of sustainable development. Scaling it up saves lives, enhances well-being, and protects the climate. Regrettably the world is falling behind in attaining the goal of universal access by 2030. Putting the world back on track will require an immediate boost in cross-sectoral collaboration and action. The need is urgent for public, private, and nongovernmental actors working in health, energy, environment, finance, and social development to come together to elevate political commitment, dramatically increase investment, and step up cross-sectoral coordination. Advancing the transition to clean fuels and technologies is a guaranteed win-win for human health and well-being and protection of the natural environment and the climate. The greater the investment, the quicker the benefits materialize.[27]

Within this context, the study attempted to underscore the critical role of LPG as a transition fuel for enhancing access to clean cooking solutions in LDCs within the Arab region and Madagascar in Africa. This transition is imperative for reducing reliance on traditional cooking methods emphasizing the necessity of mobilizing finance, fostering partnerships and collaboration, ensuring an appropriate policy and regulatory environment, and promoting capacity building. These key components are vital for addressing the access deficit and achieving sustainable development goals, including SDG 7.

LPG offers a significant yet partial solution for the millions who need access to clean and modern cooking solutions in LDCs in the Arab region and sub-Saharan Africa. Beyond addressing the access deficit, LPG provides a multifaceted array of social, economic, and environmental benefits. LPG reduces indoor air pollution, leading to improved health outcomes and reduced respiratory illnesses, which disproportionately affect women and children, and creates opportunities for income generation through its distribution and usage, empowering local communities. Moreover, LPG mitigates deforestation by curbing the reliance on biomass fuels and decreases GHG emissions, contributing to a more sustainable future. In regions where the continued use of biomass is unavoidable in the medium term, LPG plays a crucial role in achieving a cleaner, healthier, and more environmentally friendly cooking solution.

An integrated approach to policy planning and implementation is necessary to effectively address the interlinkages between clean cooking and other sustainable development goals. This approach should consider climate, land, energy, and water in an integrated way and include a set of indicators that reflect the potential synergies between clean energy and sustainable land use.

To support the transition to clean cooking technologies and fuels, greater public and private investment is needed. Publicly supported technology innovation accelerators can drive private and public investment in companies producing and distributing clean cookstoves and fuels that can deliver measurable climate benefits. Additionally, clean cooking should be integrated into climate and renewable energy funds such as the Green Climate Fund to ensure that financing is flexible, accessible, and meets the needs of organizations that can reach the last mile and make sustainable impacts.

At the national level, LPG should be promoted through national strategies and global commitments as a solution that delivers multiple benefits for addressing the access gap, inequality, air pollution, and other development goals to spur more ambitious commitments. By taking a comprehensive and integrated approach, governments can effectively deliver on their targets for net-zero emissions and achieve sustainable development goals, including SDG 7.

Concerns about LPG being a fossil fuel for clean cooking in LDCs in Arab and African regions are unfounded, whereas the focus should be on the imperative for scaling up the technology to accelerate the lagging progress toward SDG 7. Not only can this transition provide substantial health benefits but it also has minimal global warming impact and aids in forest preservation. Compared to biomass cooking, LPG causes much lower amounts of GHG emissions. A dual approach, promoting the uptake of LPG in conjunction with the development of renewable technologies, can accelerate access to clean energy and achieve SDG 7 goals without compromising targets for net-zero and global warming.

[27] Tracking SDG 7 (2023).

References

ADB (African Development Bank). 2023. Africa's 2030 Universal Electricity Access Goal. https://www.afdb.org/fr/news-and-events/press-releases/africas-2030-universal-electricity-access-goal-clock-running-out-says-adesina-berlin-60170

Akintan, Oluwakemi, Sarah Jewitt, and Mike Clifford. 2018. "Culture, tradition, and taboo: Understanding the social shaping of fuel choices and cooking practices in Nigeria." *Energy research & social science* 40: 14-22.

Avi, Shrikant. 2021. "Leveraging Off-Grid Solar Infrastructure for Modern Cooking." *Clean Cooking Alliance,* January 8. Accessed on July 30, 2023.https://cleancooking.org/news/01-08-2021-leveraging-off-grid-solar-infrastructure-for-modern-cooking/

BAR-HAP Tool, 2023. World Health Organization. https://www.who.int/publications/m/item/bar-hap-tool-updates-march-2022

Cameron, Colin, Shonali Pachauri, Narasimha D. Rao, David McCollum, Joeri Rogelj, and Keywan Riahi. 2016. "Policy Trade-Offs Between Climate Mitigation and Clean Cookstove Access in South Asia." *Nature Energy* 1, (January): 1-5. https://doi.org/10.1038/nenergy.2015.10.

Cecelski, Elizabeth, Raluca Bumboiu, and Yilun Yan. 2019. *Cooking with Gas: 2018 Update*. The World Liquefied Petroleum Gas Association. https://www.wlpga.org/wp-content/uploads/2019/07/Cooking-with-Gas-Why-Women-in-Developing-Countries-Want-LPG-and-How-They-can-Get-It.pdf.

Climate Watch. 2015. *Planned Contributions Determined at the National level of the Comoros Union.* Union of Comros: Climate Watch. https://www.climatewatchdata.org/ndcs/country/COM/full?document=first_ndc-EN&query=cooking&searchBy=query.

Coldrey, Olivia, Christine Eibs Singer, Chavi Meattle, Morgan Richmond, Valerie Furio, Federico Mazza, Jolly Sinha, Jakub Linstaedt and Caroline Dreyer. 2020. *Energizing Finance: Understanding the Landscape 2020.* Sustainable Energy for All. https://www.seforall.org/publications/energizing-finance-understanding-the-landscape-2020.

Connors Belopolsky, Jillene, and Margot Clarvis. 2022. *Accelerating Clean Cooking as a Nature-Based Climate Solution*. Clean Cooking Alliance. https://cleancooking.org/wp-content/uploads/2022/08/Accelerating-Clean-Cooking-as-a-Nature-Based-Climate-Solution.pdf.

Das, Ipsita, Jessica J. Lewis, Ramona Ludolph, Melanie Bertram, Heather Adair-Rohani, and Marc Jeuland. 2021. "The Benefits of Action to Reduce Household Air Pollution (BAR-HAP) Model: A New Decision Support Tool." *Plos one* 16, no. 1 (January): PP 1-22. 10.1371/journal.pone.0245729.

EIA (U.S. Energy Information Administration). n.d. "Liquefied Petroleum Gases (LPG)." In *U.S. Energy Information Administration Glossary.* U.S. Energy Information Administration. https://www.eia.gov/tools/glossary/index.php?id=Liquefied%20petroleum%20gases%20%28LPG%29

Energy Sector Management Assistance Program. 2020. *The State of Access to Modern Energy Cooking Services.* World Bank. https://doi.org/10.1596/34565

ESCWA (The United Nations Economic and Social Commission for Western Asia). 2022. *Social, Economic, and Environmental Impact Assessment Report of REGEND.* https://www.unescwa.org/publications/regional-initiative-promote-small-scale-renewable-energy-applications-rural-areas-arab.

——— 2023. *Review of Progress in the Arab Region under the Decade for Sustainable Energy.* https://www.unescwa.org/sites/default/files/pubs/pdf/progress-arab-region-decade-sustainable-energy-english.pdf.

Floess, Emily, Andrew Grieshop, Elisa Puzzolo, Daniel Pope, Nicholas Leach, Christopher J. Smith, Annelise Gill-Wiehl, Katherine Landesman, and Rob Bailis. 2023. "Scaling Up Gas and Electric Cooking in Low- and Middle-Income Countries: Climate Threat or Mitigation Strategy with Co-Benefits?" *Environmental Research Letters,* 18, 034010. https://doi.org/10.21203/rs.3.rs-2011721/v3.

Hood, Ahmed Hassan. 2010. *The Use of Liquified Petroleum Gas (LPG) in Sudan.* United Nations Environment Programme. https://wedocs.unep.org/bitstream/handle/20.500.11822/22454/Use_LPG_Sudan.pdf?sequence=1&isAllowed=y.

References cont.

Jewitt, Sarah, Peter Atagher, and Mike Clifford. 2020. "'We Cannot Stop Cooking': Stove Stacking, Seasonality, and the Risky Practices of Household Cookstove Transitions in Nigeria." *Energy Research & Social Science* 61, (March): 101340. https://doi.org/10.1016/j.erss.2019.101340.

Jones, Tom, Nigel Scott, and Anna Clements. 2021. *A2EI Mini-Grid Cooking Diaries Data Analysis: Bezi & Mavota (Tanzania).* Modern Energy Cooking Services. https://mecs.org.uk/wp-content/uploads/2021/03/Bezi-Mavota-Phase-1-2-Cooking-Diaries-Analysis-v8-formatted-clean.pdf.

Kar, Abhishek, Shonali Pachauri, Rob Bailis, and Hisham Zerriffi. 2019. "Using Sales Data to Assess Cooking Gas Adoption and the Impact of India's Ujjwala Programme in Rural Karnataka." *Nature Energy* 4, no. 9 (July): 806-14. https://doi.org/10.1038/s41560-019-0429-8.

Khavari, Babak, Camilo Ramirez, Marc Jeuland, and Francesco Fuso Nerini. 2023. "A Geospatial Approach to Understanding Clean Cooking Challenges in Sub-Saharan Africa." *Nature Sustainability* 6, (January): 1-11. https://doi.org/10.1038/s41893-022-01039-8.

Li, Hui, Xianneng Ai, Lulu Wang, and Ruining Zhang. 2022. "Substitution Strategies for Cooking Energy: To Use Gas or Electricity?" *Journal of Environmental Management* 303, (February): 114135. https://doi.org/10.1016/j.jenvman.2021.114135.

Malla, Min Bikram, Nigel Bruce, Elizabeth Bates, and Eva Rehfuess. 2011. "Applying Global Cost-Benefit Analysis Methods to Indoor Air Pollution Mitigation Interventions in Nepal, Kenya and Sudan: Insights and Challenges." *Energy Policy* 39, no. 12 (December): 7518-29. https://doi.org/10.1016/j.enpol.2011.06.031.

Pachauri, Shonali, Miguel Poblete-Cazenave, Arda Aktas, and Matthew J. Gidden. 2021. "Access to Clean Cooking Services in Energy and Emission Scenarios After COVID-19." *Nature Energy* 6, no. 11 (October): 1067-76. https://doi.org/10.1038/s41560-021-00911-9.

Patnaik, Sasmita, and Sunil Mani. 2019. "Realising the Ujjwala dream." In *Ujjwala 2.0: From Access to Sustained Usage*, edited by Santosh Harish, and Kirk R. Smith. New Delhi: Collaborative Clean Air Policy Centre. https://www.ceew.in/publications/realising-ujjwala-dream.

PMYY2.0 (2023). Pradhan Mantri Ujjwala Yojana 2., https://www.pmuy.gov.in/

Ranjan, Rahul, and Sudershan Singh. 2020. "Household Cooking Fuel Patterns in Rural India: Pre- and Post-pradhan Mantri Ujjwala Yojana." I*ndian Journal of Human Development* 14, no. 3 (December): 518-26. https://doi.org/10.1177/0973703020975045.

Ruiz-Mercado, Ilse, Omar Masera, Hilda Zamora, and Kirk R. Smith. 2011. "Adoption and sustained use of improved cookstoves." *Energy policy* 39, no. 12: 7557-7566.

Saudi Middle East Green Initiative (MGI), 2023. *MGI Initiatives*. Retrieved from: https://www.greeninitiatives.gov.sa/mgi-initiatives/.

Sedaoui, Radia, Jessica Obeid, Samer Zawaydeh, Mohamed Zied Gannar, Jil Amine, and Omar Kaaki. 2022. *Social, Economic, and Environmental Impact Assessment Report of REGEND*. The United Nations Economic and Social Commission for Western Asia. https://www.unescwa.org/publications/regional-initiative-promote-small-scale-renewable-energy-applications-rural-areas-arab.

Sharma, Ashutosh, Chandrashekhar Singh, and Saumya Vaish. 2023. "Gender Aspects of Transition to Clean Cooking Energy: Evidence from Two States of India." In *Axes of Sustainable Development and Growth in India: Essays in Honour of Professor Jyoti K. Parikh*, edited by Piyush Tiwari, and Kirit Parikh, 171-96. Singapore: Springer Nature Group. https://doi.org/10.1007/978-981-19-9756-3.

Singh, Devyani, Shonali Pachauri, and Hisham Zerriffi. 2017. "Environmental Payoffs of LPG Cooking in India." *Environmental Research Letters* 12, no. 11 (November): 115003. http://dx.doi.org/10.1088/1748-9326/aa909d.

Sudan household health Survey (SHHS) (2006), http://www.irinnews.org/pdf/pn/SHHSreport.pdf.

Tracking SDG 7 (Tracking Sustainable Development Goal 7). 2023. T*he Energy Progress Report.* Tracking Sustainable Development Goal 7. https://trackingsdg7.esmap.org/.

UN (United Nations). 2021. Theme report on energy access: Towards the achievement of SDG 7 and net-zero emissions. https://www.un.org/ohrlls/sites/www.un.org.ohrlls/files/technical_working_group_1_energy_access_report_2021.pdf

UN (United Nations). 2023a. World populations prospects. https://population.un.org/wpp/

UN (United Nations). 2022 . Household size and composition. https://population.un.org/Household/index.html#/countries/840

UN (United Nations). 2023b. Policy briefs in support of the un high-level political forum 2023 advancing SDG7 in Africa. https://sdgs.un.org/sites/default/files/2023-06/2023%20Advancing%20SDG7%20in%20the%20Africa-062923.pdf

UNDESA (The United Nations Department of Economic and Social Affairs). 2018. *Accelerting SDG7 Achievement Policy Briefs in Support of the First SDG7 Review at the UN High-Level Political Forum 2018*. The United Nations Department of Economic and Social Affairs. https://sustainabledevelopment.un.org/content/documents/18041SDG7_Policy_Brief.pdf

Vicente, Estela, Márcio Alexandre Correia Duarte, Ana I. Calvo, Teresa Nunes, Luis Tarelho, and Célia Alves. 2015. "Emission of Carbon Monoxide, Total Hydrocarbons and Particulate Matter during Wood Combustion in a Stove Operating Under Distinct Conditions." *Fuel Processing Technology* 131, (March): 182-192. https://doi.org/10.1016/j.fuproc.2014.11.021.

WHO (World Health Organization). 2021. I*ncreasing Access to Clean Cooking Through Subsidies*. World Health Organization. https://www.who.int/publications/i/item/WHO-HEP-ECH-AQH-2022.1.

———. 2022. *Household Air Pollution and Health*. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health.

———. 2023. *Defining Clean Fuels and Technologies*. World Health Organization. https://www.who.int/tools/clean-household-energy-solutions-toolkit/module-7-defining-clean.

World Bank. 2023. *Access to Clean Fuels and Technologies for Cooking (% of Population).* World Bank. https://data.worldbank.org/indicator/EG.CFT.ACCS.ZS.

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