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Increasing Uptake of Liquefied Petroleum Gas in Uganda: Lessons from Morocco

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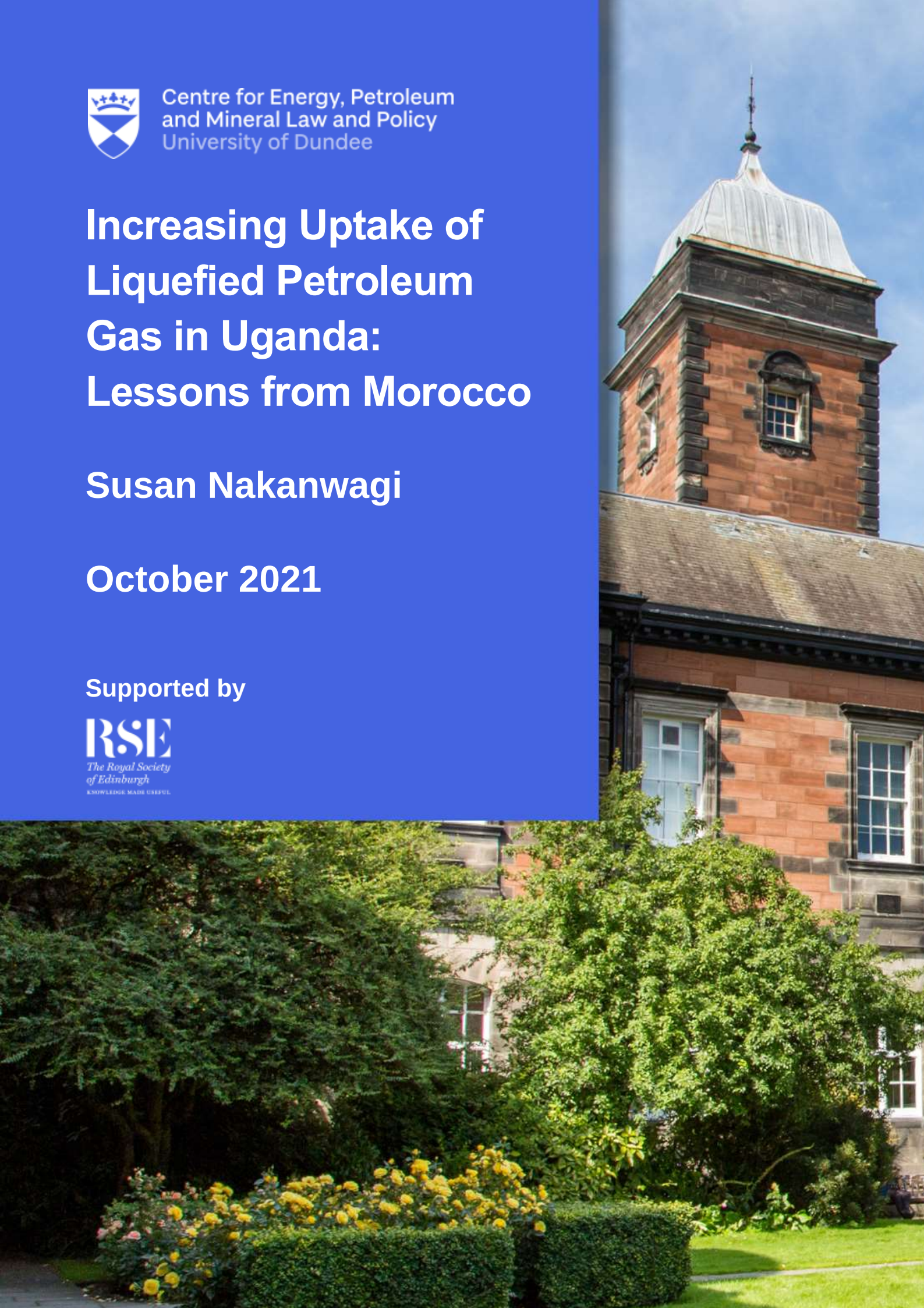

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Abstract

Uganda is currently promoting liquefied petroleum gas (LPG), particularly for cooking purposes in the domestic sector. Under the Draft Energy Policy of 2019, LPG is considered the sole option for clean cooking, with the Government undertaking to promote access to inexpensive, reliable, and clean LPG energy services. This Policy aims to assist the Government in meeting its obligations under the 2015 Paris Agreement and the Sustainable Development Goals (SDGs) on access to modern and affordable energy sources and climate mitigation and adaptation. Further, the country aims to cut down its aggregate national greenhouse gas emissions by approximately 22% by 2030. This study undertakes a case study analysis of Uganda and Morocco. It mainly examines how Morocco dealt with LPG supply bottlenecks such as affordability, safety, accessibility, and market regulation to increase LPG uptake in its urban and rural economy. As a result, this paper investigates the lessons drawn from Morocco's developed LPG markets and how they might be applied to Sub-Saharan Africa's growing LPG supply chains, particularly in Uganda. Finally, the research will assess the potential role of 'BioLPG' and how its production and uptake might be integrated into traditional LPG supply chains, promoting compliance with SDG 7 and climate change mitigation policy objectives.

Key Words: Liquified Petroleum Gas (LPG), Climate change mitigation and adaptation, clean energy, clean cooking

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1. Introduction

Liquefied petroleum gas (LPG) is expected to play a growing role as a "bridge fuel" or "transition fuel" alongside natural gas in the long-term transition to a truly sustainable global energy system.[1] There is now a consensus that the way we generate and consume energy today will have to shift fundamentally in the near to medium term. This is because most of the energy we consume now is derived from finite and non-renewable fossil-energy resources, even if they remain sufficiently vast to maintain rising production for many more years.[2] The current energy sources have also led to much damage to the environment, especially their contribution to climate change. How then might the world accelerate the transition to low-carbon energy sources and technologies while meeting the growing energy demands of a growing global economy and population? This dilemma is more challenging for the people living in developing countries, since the majority remain without access to modern energy sources. Moreover, these same states have abundant fossil fuel sources which they desire to exploit to promote growth. Indeed, countries like Uganda, Kenya, Tanzania, and Mozambique are nascent oil and gas producers.

The issue is how to accelerate the transition to low-carbon energy sources and technologies while also meeting the growing energy demands of a growing global economy and population, particularly the billions of people in developing countries who still lack access to modern energy services. Being a fossil fuel, LPG does not appear to have a substantial role in the future low-carbon energy system. However, LPG possesses unique qualities and benefits over other fossil and non-fossil fuels. It is exceptionally well-positioned to facilitate the world's environmental, economic, and social goals over the long period required to accomplish the energy transition.[3] For the transition to happen, it will require competitively priced low-carbon alternatives to be developed and commercialised on a broad scale worldwide; in the short-term the world will continue to rely on LPG and other fossil fuels.[4]

However, around 600 million people remain without access to power in Sub-Saharan Africa (SSA) alone.[5] Bringing modern energy to everyone in the African continent is a global problem that will require significant investments and a solid commitment to making the energy industry in individual countries more effective and efficient.[6] While most African countries have developed national energy policies, increased investment, and made steps to connect everyone to the grid, cooking is mostly absent from these plans. As a result, dirty

[1] Safari, A., Das, N., Langhelle, O., Roy, J. and Assadi, M., 2019. Natural gas: A transition fuel for sustainable energy system transformation?. *Energy Science & Engineering*, *7*(4), pp.1075-1094.
[2] WLPGA. 2015. LPG and the Global Energy Transition. A study on behalf of the World LPG Association. [online] Available at: <https://www.wlpga.org/wp-content/uploads/2015/05/LPG-and-the-Global-Energy-Transition.pdf> [Accessed 25 September 2021]
[3] WLPGA. 2015. Ibid
[4] Ediger, V.Ş., 2019. An integrated review and analysis of multi-energy transition from fossil fuels to renewables. *Energy Procedia*, *156*, pp.2-6.
[5] Ogundipe, A.A., Akinyemi, O. and Ogundipe, O., 2018. Energy access: pathway to attaining sustainable development in Africa. *International Journal of Energy Economics and Policy*, *8*(6), pp.371-381
[6] Hafner, M., Tagliapietra, S. and de Strasser, L., 2018. Energy Investments for Africa's Energy Transition. In *Energy in Africa* (pp. 77-96). Springer, Cham

cooking fuel is still widely used in many parts, particularly in SSA. For instance, about 900 million Africans rely on wood, charcoal, or kerosene for their daily cooking fuel requirements.[7] All of these fuels, regardless of how effectively they are managed, emit smoke, greenhouse gases, and particles that have been related to coughing and lung and respiratory diseases. Each year, an estimated 500,000 people die prematurely in Africa due to indoor air pollution, disproportionately women and girls, and infant respiratory illness rates remain high.[8] If packaged well as in bottles/cylinders, LNG is portable, convenient, and a scalable fuel that may be used for a variety of purposes, including household cooking[9]. LPG has the potential to contribute significantly to the achievement of sustainable development goals (SDGs), particularly SDG 7 (on access to affordable and modern forms of energy) as well as SDG 13 (on climate action), and other benefits like improved health, environmental protection, poverty reduction, and gender equality.[10]

Uganda is currently working to increase LPG consumption, particularly in the cooking industry.[11] The only clean cooking alternative officially listed in the Government's draft energy strategy is LPG, with the policy aim clearly stated: '*the Government shall promote access to affordable, reliable and clean LPG energy services*'.[12] This is intended to assist the country meet its obligations under the 2015 Paris Agreement and the SDGs. Given this ambition, the focus of the research in this paper is to examine what lessons may be learned from Morocco's developed LPG markets and how these might be applied to nascent LPG supply chains in SSA, notably Uganda. The paper also examines the general state of LPG use, both globally and regionally, the LPG supply chains and their bottlenecks or barriers. Finally, the research will provide an initial assessment of how to integrate 'BioLPG' production into traditional LPG supply chains, in this way advancing compliance with SDGs 7, 13 and the 2015 Paris Agreement climate change objectives.

[7] World Bank. 2011. *'Wood-Based Biomass Energy Development for Sub-Saharan Africa: Issues and Approaches, at p.8,* Energy Sector Management Assistance Program (ESMAP); World Bank, Washington, DC. © World Bank. <https://openknowledge.worldbank.org/handle/10986/26149> License: CC BY 3.0 IGO

[8] Langbein, J., 2017. Firewood, smoke and respiratory diseases in developing countries—The neglected role of outdoor cooking. *PloS one*, *12*(6), p.e0178631

[9] Bruce, N.G., Aunan, K. and Rehfuess, E.A., 2017. Liquefied Petroleum Gas as a Clean Cooking Fuel for Developing Countries: Implications for Climate. *Forests, and Affordability*, *44*

[10] Puzzolo, E., Cloke, J., Parikh, J., Evans, A. and Pope, D., 2020. *NATIONAL SCALING UP OF LPG TO ACHIEVE SDG 7: Implications for Policy, Implementation, Public Health and Environment*. Modern Energy Cooking Services (MECS). Working Paper

[11] Nakaweesi, D., 2021. *Government in bid to increase uptake of cooking gas*. [online] Daily Monitor. Available at: <https://www.monitor.co.ug/uganda/business/technology/government-in-bid-to-increase-uptake-of-cooking-gas--3542800> [Accessed 25 September 2021]

[12] Ministry of Energy and Mineral Development, 2019. Draft National Energy Policy. [online] Available at: <https://www.energyandminerals.go.ug/site/assets/files/1081/draft_revised_energy_policy_-_11_10_2019-1_1.pdf> [Accessed 22 September 2021]

2. Methodology

The central methodology of this paper is based on a case study analysis to help nations with low LPG uptake and those wishing to incorporate LPG into their energy mix establish appropriate strategies and policies based on local demands. According to Yin, case studies can be used to explain, describe, or investigate occurrences or phenomena in their everyday settings.[13] For example, these can help understand and explain causal connections and pathways that arise from a new policy initiative or service development. Although still a fossil fuel, LPG is a relatively cleaner fuel source, making it essential in the energy transition (in the short term at least), particularly for low-income countries. LPG for residential usage, particularly cooking, is the primary focus. This research looks at the LPG climates in Uganda and Morocco via the lens of a case study. It aims to identify solutions for Uganda to overcome the constraints that prevent LPG use, allowing the country to move to cleaner, more sustainable energy sources, with a focus on LPG use in domestic cooking. Uganda also has 173 billion cubic feet of natural gas and has identified 6.5 billion barrels of crude oil, with 1.4 billion barrels that are possibly commercially recoverable.[14] It plans to expand domestic refinery capacity and boost LPG's proportion of the energy mix.

On the other hand, Morocco has a lengthy track record of successful LPG adoption for household energy needs. According to the International Energy Agency, Morocco is reportedly considering the elimination of existing LPG subsidies and instead to focus assistance on disadvantaged consumer groups.[15] LPG accounts for more than 20% of total petroleum product use in Morocco. It is utilised mainly in the domestic sector for heating and cooking, and it accounts for approximately 63% of the sector's total energy demand.[16] By combining socio-legal dimensions, the work goes beyond doctrinal research. It uses search engines, books, and articles to gather data on LPG use's environmental, social, economic, legal, and regulatory implications. Finally, the study provides a summary of the long-term development of 'BioLPG'.

[13] Yin, R.K., 2009. *Case study research: Design and methods* (Vol. 5). Sage

[14] Republic of Uganda: Leveraging Oil and Gas Industry for the Development of a Competitive Private Sector in Uganda, March 25, 2015. at p.41 World Bank GTCDR AFRICA. [online] Available at: <http://documents.worldbank.org/curated/en/521361468302082824/pdf/ACS125280REVIS0itive0Private0Sector.pdf> [Accessed 2 September 2021]

[15] IEA 2019. Energy Policies Beyond IEA: Morocco. International Energy Agency, Paris. [online] Available at: <https://www.connaissancedesenergies.org/sites/default/files/pdf-actualites/Energy_Policies_beyond_IEA_Contries_Morocco.pdf> [Accessed 12 September 2021]

[16] Ibid

3. The Role of LPG in Driving Sustainable Development

Energy services were recognised as a crucial component of growth and human well-being during the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg. Concerning the challenges associated with heat, cooking, and household fuel use, the Johannesburg Plan of Implementation agreed that all stakeholders should support the transition to cleaner use of liquid and gaseous fossil fuels, considered more environmentally friendly and socially acceptable and cost-effective. LPG is one of the most economically feasible and scalable solutions available, ensuring access to basic necessities, stimulating economic activity, and providing more significant health and environmental benefits than traditional biomass alternatives.[17] North Africa provides a good example through its scaling of LPG use. Since 2000, around 20 million individuals have acquired access to electricity, with the most significant gains occurring in rural regions. The region has achieved near-universal access to electricity and clean cooking through grid extensions and LPG distribution networks under Goal 7 of the United Nations SDGs and the African Union Agenda 2063.[18]

The 2015 Paris Agreement's central component is the Nationally Determined Contribution (NDC) made by each of the parties to the United Nations Framework Convention on Climate Change (UNFCCC). NDCs are national climate plans that emphasise climate activities, such as policies, measures and climate-related measures that governments intend to adopt in response to climate change and aimed at supporting global climate action.[19] The UNFCCC's ambition mechanism is based on requiring all parties to submit increasingly ambitious NDCs every five years as part of a 'pledge and review' governance framework and to do so voluntarily.[20] NDCs made by countries are climate action promises aimed at limiting global warming to far below 2°C, preferably 1.5°C, over pre-industrial levels – by national determination.[21] While renewable energy is a mature and cost-effective climate change mitigation technology, its position in NDCs could be expanded to meet the landmark 2015 Paris Agreement's objectives. According to IRENA, if the NDCs' renewable energy commitments are implemented, global installed renewable energy capacity will exceed 3.5 terawatts (TW) in 2030. While this is noteworthy, it is far from sufficient to put the world on

[17] Rosenthal, J., Quinn, A., Grieshop, A.P., Pillarisetti, A. and Glass, R.I., 2018. Clean cooking and the SDGs: Integrated analytical approaches to guide energy interventions for health and environment goals. *Energy for Sustainable Development*, *42*, pp.152-159

[18] IEA 2020. *Clean Energy Transitions in North Africa*. IEA, Paris. [online] Available at: <https://www.iea.org/reports/clean-energy-transitions-in-north-africa> [Accessed 12 September 2021]

[19] Andresen, S., Bang, G., Skjærseth, J.B. and Underdal, A., 2021. Achieving the ambitious targets of the Paris Agreement: the role of key actors. *Int Environ Agreements* 21**,** 1–7 (2021). https://doi.org/10.1007/s10784-021-09527-6

[20] Weikmans, R., Asselt, H.V. and Roberts, J.T., 2020. Transparency requirements under the Paris Agreement and their (un) likely impact on strengthening the ambition of nationally determined contributions (NDCs). *Climate Policy*, *20*(4), pp.511-526

[21] Rajamani, L., 2016. Ambition and differentiation in the 2015 Paris Agreement: Interpretative possibilities and underlying politics. *International & Comparative Law Quarterly*, *65*(2), pp.493-514

the road toward meeting the Paris Agreement's targets, which call for renewable energy to reach 7.7 TW globally by 2030.[22]

Global summits such as the United Nations High-Level Energy Dialogue,[23] COP-26,[24] and the Africa-Europe Summit[25] provide a forum for the world to focus on green transitions and international development. IRENA thus notes that "*(t)he upcoming climate conference, COP26, represents a significant milestone for reducing energy-related emissions through enhanced and updated national climate pledges.*"[26]

Additionally, these summits provide world leaders with an unprecedented opportunity to reconsider their perceptions of and priorities for cooking. Governments worldwide have now recognised the critical need for electrification, and aggressive targets have been accepted globally.[27] Numerous governments have committed to achieving SDG 7 on affordable and clean energy and ensuring that all people have access to affordable, dependable, sustainable, and modern energy by 2030 as part of their NDCs. Numerous NDCs now include renewable energy, demonstrating its importance in combating climate change.[28] For example, most of the parties to the UNFCCC that committed to the NDCs cited renewable energy generation, and energy efficiency improvement as critical components of climate change mitigation and have included measurable targets for renewable energy.[29] Although LPG is not a renewable energy source per se, it is seen as a medium-term option or transitional fuel in the energy transition[30]; more so in the cooking sector.[31]

LPG is a unique and efficient source of energy that could go to waste if not harnessed. It can become a critical component of Africa's off-grid energy mix, particularly in emerging oil

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[22] IRENA 2021. CLIMATE ACTION WITH RENEWABLES: Enhancing Nationally Determined Contributions. International Renewable Energy Agency. [online] Available at: <https://www.irena.org/-/media/Files/IRENA/Agency/Topics/Climate-Change/IRENAClimateActionBrochureV17.pdf?la=en&hash=685D0251C985320386932874EF06060A5DA5216C> [Accessed 15 September 2021]

[23] UN., 2021. HLDE 2021 | United Nations. [online] United Nations. UN High-Level Dialogue on Energy Nations Available at: <https://www.un.org/en/conferences/energy2021> [Accessed 25 September 2021]

[24] UN Climate Change Conference (COP26) at the SEC – Glasgow 2021. 2021. *UN Climate Change Conference (COP26) at the SEC – Glasgow 2021*. [online] Available at: <https://ukcop26.org/> [Accessed 25 September 2021].

[25] International Partnerships - European Commission. 2021. *Africa-EU Partnership*. [online] Available at: <https://ec.europa.eu/international-partnerships/topics/africa-eu-partnership_en> [Accessed 25 September 2021].

[26] IRENA 2021. CLIMATE ACTION WITH RENEWABLES: Enhancing Nationally Determined Contributions. International Renewable Energy Agency.

[27] Andresen, S., Bang, G., Skjærseth, J.B. and Underdal, A., 2021. Achieving the ambitious targets of the Paris Agreement: the role of key actors. *Int Environ Agreements* 21**,** 1–7 (2021). [online] Available at: <https://doi.org/10.1007/s10784-021-09527-6> [Accessed 23 September 2021].

[28] IRENA (2017), '*Untapped Potential for Climate Action: Renewable Energy in Nationally Determined Contributions*,' p.7, International Renewable Energy Agency, Abu Dhabi. http://irena.org/-/media/Files/IRENA/Agency/Publication/2017/Nov/IRENA_Untapped_potential_NDCs_2017.pdf

[29] UNFCCC, 2021. [online] Available at: <Nationally determined contributions under the Paris Agreement Synthesis report by the secretariat <https://unfccc.int/sites/default/files/resource/cma2021_08_adv_1.pdf> [Accessed 23 September 2021]

[30] Raslavičius, L., Keršys, A., Mockus, S., Keršienė, N. and Starevičius, M., 2014. Liquefied petroleum gas (LPG) as a medium-term option in the transition to sustainable fuels and transport. *Renewable and Sustainable Energy Reviews*, *32*, pp.513-525

[31] Astuti, S.P., Day, R. and Emery, S.B., 2019. A successful fuel transition? Regulatory instruments, markets, and social acceptance in the adoption of modern LPG cooking devices in Indonesia. *Energy Research & Social Science*, *58*, p.101248.

and gas-producing countries like Uganda, Senegal, Kenya, and Tanzania. According to a study undertaken by the WLPGA, LPG has no sulphur, making it a more environmentally friendly fuel source than other conventional alternatives. For example, it is a lower-carbon alternative to oil, with a carbon intensity around 20% lower.[32].= The significance of LPG and natural gas in meeting electrical demand while supporting the shift to greener fuel sources is major. Africa's vast natural gas reserves (221.6 trillion cubic feet of known reserves are concentrated in SSA alone) have the potential to meet global energy demand. Additionally, natural gas is seen as a good 'gateway fuel' to more environmentally friendly energy sources. Natural gas development and usage can help ensure socioeconomic growth by alleviating energy poverty and giving the renewable energy industry sufficient time to mature.[33]

Further, LPG has a significant role to play in socio-inclusion and gender equality. Access to clean cooking energy is a notably gendered issue, as women are almost universally responsible for cooking, most especially in the developing countries. Moreover, historically, energy access programmes and regulations have prioritised providing power connections over cooking energy.[34] The World Bank estimates that fuelwood collecting, and cooking take up roughly 5 hours each day on average for women in Sub-Saharan Africa and South East Asia.[35] The time spent collecting fuel, cooking with traditional biomass cookstoves, and related fuel preparation and food processing chores add up to 2–8 hours per day or around 5 hours per day on average.[36] The gendered implications for conventional cooking fuels are tremendous in developing countries, with the gender disparity gap widening between males and fuels. Girls and women aged 15 and over in Uganda, for example, spend an average of 3.8 hours per day cooking while men and boys, on the other hand, remain utterly uninterested in cooking.[37] Similarly, female household members in Uganda spend 7.5 times more time than men in procuring cooking fuels and preparing food.[38] This leaves little room for the women to engage in productive economic activities.

Therefore, access to clean cooking fuels and technology, particularly LPG, contributes significantly to several SDGs. The most apparent benefits are cleaner energy access, health, gender equality, environmental protection, and climate action. Still, developing a sustainable LPG sector may also help drive overall growth and development in other aspects of the economy. For example, it contributes to poverty reduction, job creation, reducing inequities, and making cities and communities more sustainable and reduce inequalities.

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[32] WLPGA 2019. *Supporting Businesses in the Energy Transition: The role of LPG and bioLPG in Europe*. World LPG Association. https://www.wlpga.org/wp-content/uploads/2020/03/The-Role-of-LPG-Bio-LPG-in-Europe-The-2019-Report.pdf

[33] Gürsan, C. and de Gooyert, V., 2020. The systemic impact of a transition fuel: Does natural gas help or hinder the energy transition?. *Renewable and Sustainable Energy Reviews*, p.110552

[34] WLPGA 2014. Cooking with Gas: Why women in the developing world want LPG and how they can get it. World LP Gas Association. [online] Available at: <https://www.esmap.org/sites/default/files/resources-document/WLPGA%20-%20Cooking%20with%20LP%20Gas%20Report%20-%20FINAL%20%20PbP_OPTIMIZED.pdf> [Accessed 21 September 2021]

[35] Energy Sector Management Assistance Program (ESMAP). 2020. The State of Access to Modern Energy Cooking Services. Washington, DC: World Bank. License: Creative Commons Attribution CC BY 3.0 IGO. [online] Available at: <https://cleancookingalliance.org/wp-content/uploads/2021/07/598-1.pdf> [Accessed 23 September 2021]

[36] Ibid

[37] Ibid

[38] Ibid

4. LPG in a Global and Regional Perspective

LPG is a by-product of oil and natural gas and oil refining production and must be disposed of appropriately wherever it is produced. Where LPG is not recovered and retained during operations, it is burnt or 'flamed' into the environment as a waste product, adding to the production of greenhouse gases. Approximately 30% of global LPG output is now used as feedstock for plastics and chemicals consumed by high-income countries, rather than being fully utilised as a clean, efficient, and highly scalable cooking fuel.[39] LPG, or bottled gas, is a lightweight, clean-burning fuel ideal for cooking and heating and comparable to both natural gas and electricity in terms of end-user experience when cooking.[40]

The International Energy Agency (IEA) estimates that over 2.5 billion people in resource-poor settings and many more in high-income countries rely on LPG for part or all of their cooking needs.[41] LPG is a highly portable fuel that has become a residential clean fuel choice in several low- and middle-income countries and high-income countries. LPG offers significant current potential for developing countries to wean themselves off harmful solid fuels such as firewood, charcoal, and kerosene. Recent successful national-scale LPG conversion efforts, such as those undertaken in Morocco, Nigeria, Algeria, and Ghana, attest to this. The IEA's World Energy Outlook Special Report, 'From Poverty to Prosperity', promotes LPG as a feasible clean cooking solution for more than half of the 2.8 billion people who still lack access to clean cooking fuels and technologies by 2030.[42]

LPG is primarily utilised for cooking and heating in industry and households. In 2018, the residential sector accounted for nearly half (44%) of global LPG consumption, making it the most prominent user alongside the petrochemical sector (28%).[43] LPG is currently in abundant supply worldwide, and production has recently been expanding at a high rate. Global output was projected at 317 million tonnes in 2018, up around 3.6% from 2017, while consumption was estimated at 313 million tonnes, up 3.8% from 2017.[44] Since 2009, this rise has mainly been driven by the development of U.S. shale gas, which produces LPG as

[39] MECS., 2020. *NATIONAL SCALING UP OF LPG TO ACHIEVE SDG 7: Implications for Policy, Implementation, Public Health and Environment*. Modern Energy Cooking Services (Policy Brief) . [online] Available at: <https://www.mecs.org.uk/wp-content/uploads/2020/02/MECS-LPG-Briefing-Paper_Jan-2020.pdf> [Accessed 23 September 2021]
[40] Ibid
[41] IEA 2017. *Energy Access Outlook 2017: From Poverty to Prosperity*, International Energy Agency, Paris. [online] Available at: <https://doi.org/10.1787/9789264285569-en> [Accessed 13 September 2021]
[42] Ibid
[43] Argus 2019. *Argus White Paper: Statistical Review of Global LPG*. [online] Available at: <https://www.argusmedia.com/-/media/Files/white-papers/statistical-review-of-global-lpg-2016.ashx> [Accessed 13 September 2021]
[44] Ibid

a by-product.[45] When the excess gas is vented or flared at oil and gas production sites, the associated benefits are lost yet again with a worsening in the pollution of the atmosphere.[46]

The global LPG market was worth USD 116.41 billion in 2019 and is forecast to expand at a compound yearly growth rate of 4.4% between 2020 and 2027.[47] This growth is partly attributed to rising awareness of the benefits of using LPG as a substitute for fossil fuels and increasing the acceptance of clean and green energy sources in both developed and developing countries. On a worldwide scale, Africa's LPG use is minor, as seen above. On the other hand, LPG can play an essential role in developing countries, as evidenced by recent data showing LPG penetration in several new markets. For the urban and rural poor in several nations, LPG has long been an aspirational fuel choice.[48] In 2018, SSA growth was robust at about 9%, with Nigeria setting the pace with approximately 780,000 tonnes per year. In the coming years, the country is anticipated to become the first in SSA to consume more than 1 million tonnes of LPG per year.[49] Economic growth in many countries and increased imports (primarily from the Middle East Gulf) resulted in increased LPG use in many countries in the region in 2018. Moreover, primary infrastructure projects in countries like Kenya and South Africa are expected to increase the trajectory.[50]

LPG consumption in Africa has risen year after year, owing to the fuel's growing importance in the cooking industry, not just in the more developed North African region but also in East, West, and Southern Africa. Traditionally, the primary impediments to increased LPG use in underdeveloped nations have been affordability and availability. LPG has traditionally been used by the upper half of the income distribution in low- and lower-middle-income countries, predominantly urban and suburban families.[51] In countries like Morocco, Senegal, and Ghana, government intervention has increased LPG consumption, especially among lower-income households. The interventions include deliberate governmental initiatives to promote the creation of LPG infrastructure and pricing and equipment packages that make LPG affordable to middle-income and occasionally even lower-income homes in urban, suburban, and even rural locations.[52]

Nigeria's growth has been incredibly rapid, with the country presently using around 1 million tonnes per year. The Government and industry plan to significantly expand this amount in

[45] Chen, Y. and Xu, J., 2019. The shale gas boom in the US: Productivity shocks and price responsiveness. *Journal of Cleaner Production*, *229*, pp.399-411

[46] IEA, 2021. Driving Down Methane Leaks from the Oil and Gas Industry. IEA, Paris. [online] Available at: <https://www.iea.org/reports/driving-down-methane-leaks-from-the-oil-and-gas-industry> [Accessed 22 September 2021]

[47] GVR 2020. LPG Market Size, Share & Trends Analysis Report By Source (Refinery, Associated Gas, Non-associated Gas), By Application, By Region, And Segment Forecasts, 2020 – 2027. Ground View Research. [online] Available at: <https://www.grandviewresearch.com/industry-analysis/liquefied-petroleum-gas-industry> [Accessed 16 September 2021]

[48] Van Leeuwen, R., Evans, A. and Hyseni, B., 2017. Increasing the use of liquefied petroleum gas in cooking in developing countries

[49] Argus 2019. *Argus White Paper: Statistical Review of Global LPG*

[50] Ibid

[51] Norad. 2020. Final Report Study on the Potential of Increased Use of LPG for Cooking in Developing Countries, September 2020. [online] Available at: <https://www.multiconsultgroup.com/assets/LPG-for-Cooking-in-Developing-Countries_Report-by-Multiconsult.pdf> [Accessed 3 September 2021]

[52] Ibid

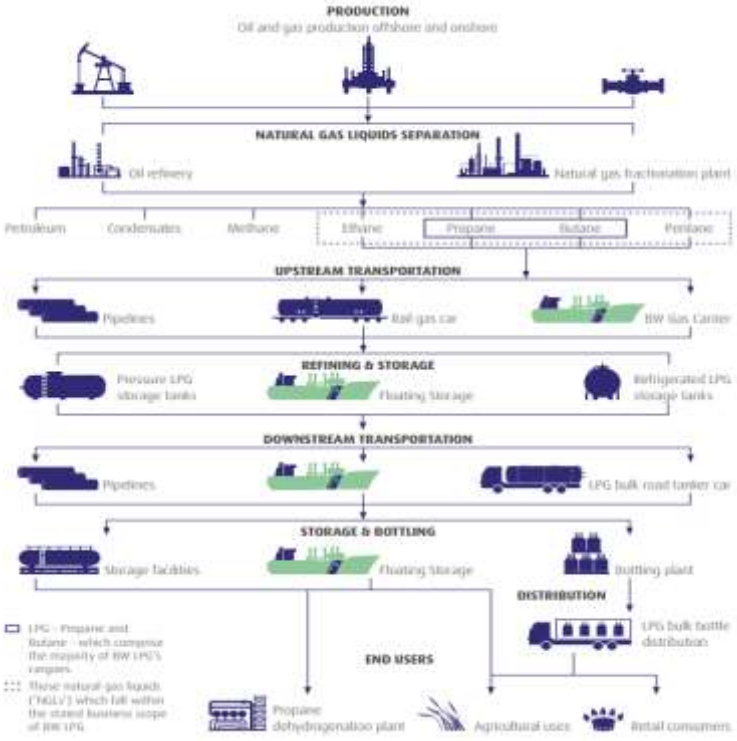
future years. New or forthcoming storage and terminal facilities in East and Southern Africa are expected to drive increased consumption in the region for the next decade. LPG use in SSA has increased dramatically over the last ten years, with a compound annual growth rate of 9.6%. Since 2010, consumption has more than doubled, reaching 4.0 million metric tonnes in 2019.[53] However, consumption in SSA is still swamped by North Africa, which has a much more developed market.

[53] CITAC 2020. LPG uptake strategies in Sub-Saharan Africa. [online] Available at: <https://www.citac.com/2020/01/20/lpg-uptake-strategies-in-sub-saharan-africa/> [Accessed 22 September 2021]

5. The LPG Value-Chain

LPG is a generic term that refers to two different forms of natural gas: Propane and Butane. LPG is derived commonly from natural gas and oil extraction but is increasingly produced from renewable sources.[54] Due to its unique characteristics, it is a very adaptable energy source that may be used in over 1,000 various applications. Both gases have similar qualities, yet each has a distinct purpose. While Butane is primarily utilised indoors in portable heaters, Propane has a broader range of applications due to its lower boiling point, making it more suitable for outdoor use. Propane is utilised chiefly in central heating (in colder climates), cooking, transportation, and commercial operations. Interventions aimed at increasing the uptake or consumption of LPG in a country require a comprehensive understanding of the supply chain, which consists of multiple steps from the raw LPG to the ultimate customer. Details fluctuate from market to market, depending on the context and applicable legislation, but the value chain is generally made up of the elements shown in *Figure 1* below.

Figure 1: A Summary of the LPG Value Chain



Source: LPG, B., 2021.[55]

Figure 1 shows that LPG is produced directly from natural gas wells or as a by-product of crude oil processing. It is liquefied and transported from supply locations to primary bulk

[54] WLPGA. 2021. *What is LPG? - WLPGA*. [online] Available at: <https://www.wlpga.org/about-lpg/what-is-lpg/> [Accessed 25 September 2021]

[55] LPG, B., 2021. *Our Business | BW LPG*. [online] BW LPG. Available at: <https://www.bwlpg.com/about-us/our-business> [Accessed 24 September 2021]

storage facilities where it is kept under refrigeration or pressurization.[56] Bulk storage facility owners/operators may also be importers and have the appropriate transportation infrastructure. LPG is transported to cylinder filling operations for use in cooking. The bottling business, distributors, or consumers own the cylinders. The filled cylinders are delivered through a network of intermediaries that manage depots and transportation infrastructure.[57] The cylinders are distributed to retail locations for sale to customers. Empty cylinders are either returned to the filling factory via the chain or carried directly to a filling station by the client. There are currently two primary cylinder distribution methods on the market, each of which can act as an enabler or a barrier to LPG adoption:[58] (1) Consumer Controlled Cylinder Model (CCCM); and (2) Branded Cylinder Recirculation Model (BCRM). *Table 1* below shows the major differences between these two models.

Table 1: The Key Differences between Consumer Controlled Cylinder Model (CCCM) and the Branded Cylinder Recirculation Model (BCRM)

	Consumer Controlled Cylinder Model (CCCM.)	Branded Cylinder Recirculation Model (BCRM.)
Ownership of Cylinder	Consumer owns the cylinder	Government-licensed L.P.G. marketers invest in and own the cylinders.
Initial refill	The consumer may refill the cylinder at any refilling station	Typically: the consumer pays a deposit for the first cylinder from approved distributors, less than the cylinder's cost plus the LPG purchase price
Refiling	The consumer may refill the cylinder at any refilling station	Consumers may refill the cylinder only at authorised marketing business locations. With the refill charge, empty cylinders are replaced for a full cylinder of the same brand
Cylinder Safety	The consumer is totally responsible for the maintenance of the cylinder	LPG marketing company entirely responsible for the safety of cylinder (including inspection, maintenance, and replacement)

Source: Author's elaboration, Extracted from Clean Cooking Alliance 2020.[59]

Because the consumer is in total control of the cylinder, the primary downside of the CCCM is that it may decrease cylinder safety, increasing the likelihood of fire and explosion incidents[60]. Additionally, CCCM is vulnerable to black market LPG activities conducted by

[56] Norad. 2020. Final Report Study on the Potential of Increased Use of LPG for Cooking in Developing Countries, September 2020
[online] Available at: <https://www.multiconsultgroup.com/assets/LPG-for-Cooking-in-Developing-Countries_Report-by-Multiconsult.pdf> [Accessed 24 September 2021]
[57] Norad. 2020. Final Report Study on the Potential of Increased Use of LPG for Cooking in Developing Countries, September 2020
[58] Ibid.
[59]Clean Cooking Alliance. 2020. *LPG Safety, Innovation, and Market Growth*. [online] Available at: <https://www.cleancookingalliance.org/binary-data/RESOURCE/file/000/000/586-1.pdf> [Accessed 24 September 2021]
[60] Norad. 2020. Final Report Study on the Potential of Increased Use of LPG for Cooking in Developing Countries, September 2020

unregistered and uncertified refilling enterprises that violate safety standards. On the other hand, in terms of safety, commercial capital mobilisation, affordability, and accessibility, the BCRM model is preferred. However, BCRM's primary disadvantages include the frequently higher end-user cost of the cylinder and refilling, as well as the exclusion of small businesses from the LPG sector.[61] Further, the legislative and enabling framework must be adjusted to attract commercial actors to invest and operate in the market. Customers must acquire an LPG stove, have access to an LPG cylinder, either owned or rented, a tube to connect the stove to the cylinder, and a guarantee of refilling the cylinder.[62]

[61] Ibid
[62] Ibid

6. Barriers to LPG Uptake

Several barriers may hinder the uptake of the LPG in any given country. These relate to the critical issues of affordability and accessibility, safety, market organisation, and equipment considerations, as elaborated in *Table 2* below:

Table 2: Schematic Representation of Major Challenges to LPG Uptake

	Challenge/ Issue	**Intervention**
Affordability and availability, especially for low-income households	Associated equipment, including stoves and cylinders, is prohibitively expensive for low-income families, making the entire LPG delivery system unaffordable	Deliberate governmental initiatives to promote the creation of LPG infrastructure and pricing and equipment packages that make LPG affordable to middle-income and occasionally even lower-income homes in urban, suburban, and even rural locations; Use of subsidies (e.g. Morocco, India). In just 5 years, a large-scale subsidised programme in Indonesia moved nearly 50 million homes from kerosene to LPG for cooking, resulting in 31% lower greenhouse gas emissions than in 2007[63]
Safety **(Safe handling, cylinder refilling, and transportation)**	Small-scale independent re-fillers and distributors that operate outside of the government's ability to inspect and enforce safety laws, ostensibly undermining the market for all bottlers; Insufficient regulatory frameworks to oversee all aspects of the bottling, distribution, and cylinder-refilling chains	Routine Safety and inspection measures. Developing relevant health and safety-related legislation Sensitisation campaigns
Government Leadership and Policies	Lack of government will in establishing the basic conditions for effective market expansion of modern fuels; setting up transparent pricing systems	An integrated approach to energy services in general, particularly the role of energy in promoting local development and commercial activity; Government commitment to expanding LPG use to rural households and low-income

[63] Thoday, K., Benjamin, P., Gan, M. and Puzzolo, E., 2018. The Mega Conversion Program from kerosene to LPG in Indonesia: Lessons learned and recommendations for future clean cooking energy expansion. *Energy for Sustainable Development*, *46*, pp.71-81

		households (e.g. in South Africa, Morocco)
Market Organisation	Maintaining of standards by both small scale and large-scale distributors; new entrants; competition	New entrants must adopt the same safe storage, distribution, and refilling standards as established segments of the supply market
Equipment Consideration	Availability of smaller canisters to make home cooking cheaper, as well as locally produced stoves and equipment	Establishing a common market facility for the sale of gas, cylinders, and appliances. (e.g. "integrated energy centres" in South Africa and "maisons d'énergie" in Morocco); Boosting domestic production of equipment

Source: Author's elaboration; Information extracted from Norad, 2020.[64]

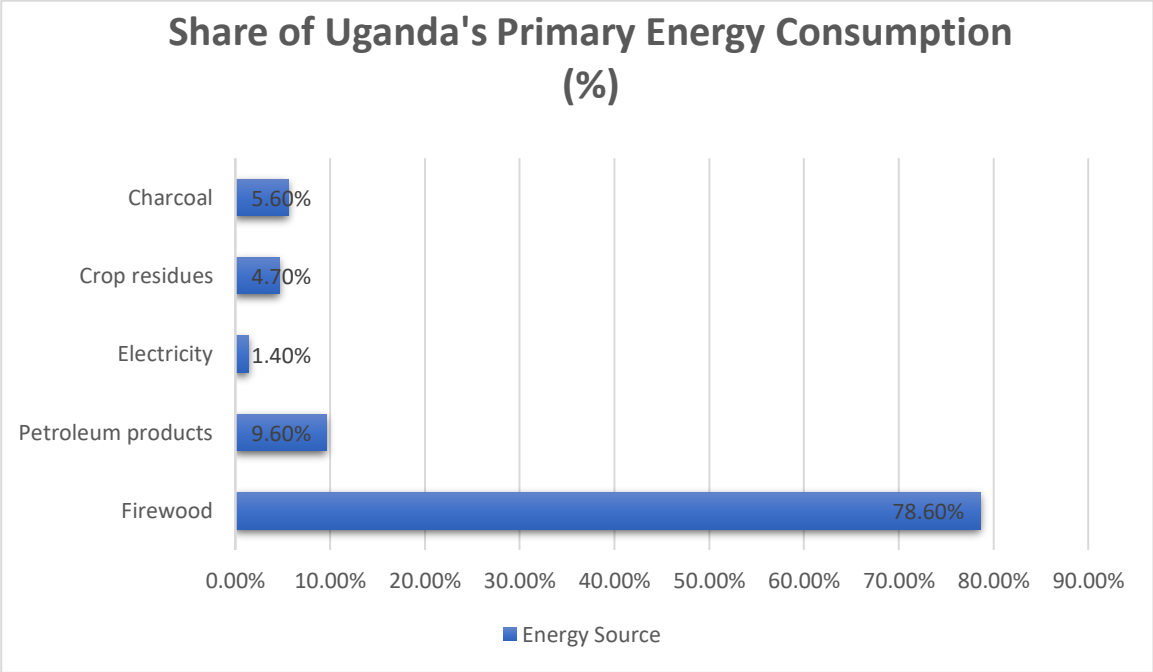
[64] Norad. 2020. Final Report Study on the Potential of Increased Use of LPG for Cooking in Developing Countries, September 2020. [online] Available at: <https://www.multiconsultgroup.com/assets/LPG-for-Cooking-in-Developing-Countries_Report-by-Multiconsult.pdf> [Accessed 21 September 2021]

7. LPG: Ugandan Case Study

7.1 Overview

According to the World Bank, Uganda has approximately 45.7 million people, with 75% of these living in rural areas, and only 41.3% of the entire population has access to electricity.[65] As *Graph 1* shows, Uganda's energy sector is heavily reliant on wood fuel (charcoal and firewood), accounting for up to 93% of the country's overall energy requirements.[66] Other energy sources include petroleum products, crop residues and hydroelectricity. In rural and urban regions, wood fuel is the primary source of heating and cooking. Increased demand for wood fuel has resulted in forest degradation and exacerbates land degradation. Uganda possesses significant renewable energy resources, including biomass supply, hydropower potential (over 2000 MW), sunlight, and agricultural biomass wastes. On the other hand, renewable resources are not fully tapped, which adds to the increased need for wood fuel. The transportation sector is the largest consumer of fossil fuels, accounting for approximately 75% of the total cost of fossil fuel imports.

Graph 1: Uganda's Energy Consumption



Source: Authors Illustration: Information extracted from, Muwanguzi, JBBA, *et al.,*2021.[67]

Several energy generation projects sponsored by the public and private sectors have been completed and commissioned in the power sector, while others are still in the implementation stages. With assistance from the World Bank, the Government of Uganda is developing the Uganda Energy Access Scale-up Project (EASP). The proposed EASP

[65] Data.worldbank.org. 2021. *Access to electricity (% of population) - Uganda | Data*. [online] Available at: <https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=UG> [Accessed 26 September 2021]
[66] MEMD. 2015. *Biomass Energy Strategy (Uganda)*. Ministry of Energy and Minerals Development. Uganda
[67] Muwanguzi, J.B.B.A, Kaggwa R, Werikhe A, Ajidiru R, Kandwanaho J, Guloba A, and Muvawala J., 2021. Evaluating the Energy Requirements for Uganda: Case for Natural Gas. *International Journal of Energy and Environmental Science, 6*(4), p.68

will assist the Government of Uganda to expand access to electricity for households, industrial parks, commercial enterprises, refugee and host communities, and public institutions to spur socioeconomic transformation consistent with Uganda's 'Vision 2040' and other Government policies.[68] The Government is expanding the transmission and distribution infrastructure by building transmission lines and substations. At the same time, wind, solar, and geothermal energy generation are also being promoted to diversify the energy mix and boost the level of renewables.[69] The commercialisation of oil and gas resources is underway in the oil and gas subsector, with the final investment decision regarding the East African Crude Oil Pipeline reached in April 2021. LPG is one of the products expected from the refinery, and the Ministry of Energy and Minerals Development (MEMD) recognises the importance of the Uganda National Oil Company (UNOC) in planning for its use and handling in Uganda from the onset[70]. As such, an LPG detailed feasibility study was undertaken in 2019-2020. The LPG standards and codes of practice are still in draft form to cover LPG installations, grills, burner, and bulk transportation by rail.[71]

7.2 Uganda's Climate Ambition and Action

Uganda is a signatory to the UNFCCC and has ratified the Paris Agreement. In 2016, the country submitted its first NDC under the Paris Agreement. It emphasised the devastating effects of climate change in the country, including rising mean annual temperatures, decreased annual and seasonal rainfall, an increase in the frequency and severity of extreme events, such as droughts, floods, and landslides. Further, it negatively impacted various sectors, including agriculture, water, health, and human settlements. As such, Uganda's NDC emphasised the importance of reducing the economic vulnerability of the population and the environment to climate change through adaptation actions.[72] The primary strategy is to "implement strategies, plans, and actions for low-carbon development" to achieve its development goals. This is accomplished by ensuring that all stakeholders appropriately address the impacts and causes of climate change while also promoting sustainable development and green growth.

Uganda's first NDC places a premium on balancing climate action and economic growth and development. Several actions have been identified, including building on existing Clean Development Mechanism (CDM) projects and programmes and promoting low-carbon development in critical priority sectors, such as energy, forestry, wetlands, and agriculture.

[68] MINISTRY OF ENERGY AND MINERAL DEVELOPMENT 2019. Uganda Energy Access Scale-Up Project (EASP). [online] Available at: <http://www.energyandminerals.go.ug/site/assets/files/1281/tor_easp_electrification_of_public_institutions.pd> [Accessed 11 September 2021]

[69] MINISTRY OF ENERGY AND MINERAL DEVELOPMENT SECTOR PERFORMANCE REPORT 2020 "Utilising Energy and Mineral Resources for Economic Recovery: Post Pandemic. [online] Available at: <http://www.energyandminerals.go.ug/site/assets/files/1272/sector_performance_report_2020.pdf> [Accessed 6 September 2021]

[70] Ibid

[71] Ibid.

[72] Ministry of Water and Environment, 2015. Uganda's Intended Nationally Determined Contribution (INDC) October 2015. [online] Available at: <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Uganda%20First/INDC%20Uganda%20final%20%2014%20October%20%202015.pdf> [Accessed 26 September 2021]

Others include reducing vulnerability in priority sectors such as agriculture and livestock, forestry, infrastructure (with a particular emphasis on human settlements, social infrastructure, and transportation), water, energy, health, and disaster risk management. In aggregate, the estimated cumulative effect of mitigation policies and measures could result in a roughly 22% reduction in national greenhouse gas emissions in 2030, compared to business-as-usual. In its interim NDC submitted on 12 October 2021, Uganda emphasises adaptation as its priority response to climate change.[73] It also notes that the updated NDC (expected in December 2021) will feature mitigation co-benefits resulting from adaptation actions.

Uganda intends to take several actions in the energy sector, both for mitigation and adaptation. These include increasing the efficiency of biomass use in the traditional energy sector; promoting renewable energy and alternative energy sources; increasing the efficiency of the modern energy sector (primarily electricity); and ensuring the best possible use of hydropower through prudent management of water resources energy systems. By 2030, the country aims to reach a total capacity of at least 3,200 MW of renewable energy generation, up from 729 MW in 2013. By 2030, the energy sector measures will increase renewable energy capacity by at least 1,100 MW over current levels. For the cooking sector, however, Uganda only lists additional mitigation actions to promote and increase the adoption of energy-efficient cooking stoves or induction cookers.

On the policy and regulation side, the Government is committed to supporting the growth of the power sector. Through the Uganda 'Vision 2040' and the National Development Plan 2015/16-2019/2020, the Ugandan Government commits to developing and generating modern energy to power the country's manufacturing and service sectors. The Vision 2040 notes that modern energy is critical in mitigating climate change because it can offset the rampant use of wood and charcoal, which are driving significant deforestation. Additionally, it acknowledges the gravity of climate change. It commits to promoting the use of renewable energy sources such as wind, solar, and biogas in addition to conventional energy sources such as hydropower, geothermal, nuclear, and thermal. The Government has several laws and policies to drive the country's climate change and energy agenda, for example, the 2015 National Climate Change Policy (NCCP). Several legal and policy measures apply to energy access, including the Energy Policy of Uganda, 2002; the Atomic Energy Act of 2008, the Renewable Energy Policy of 2007; the Electricity Act of 1999; and the National Biomass Energy Demand Strategy (BEDS), 2001–2010.

7.3 Uganda's Cooking Sector and LPG use

Fully 95% of Ugandan families utilise charcoal, wood, or other biomass sources for domestic cooking, while use of clean fuels such as LPG, biogas, and ethanol are still very low. Approximately 0.7% of households rely on LPG for cooking. Compared to other SSA nations, which have an average LPG per capita consumption of 3 kg/year, studies show

[73] Ministry of Water and Environmnet (2021). Submission of Uganda's Interim Nationally Determined Contribution (NDC) 12 October 2021. [online] Available at: <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Uganda%20First/Uganda%20interim%20NDC%20submission_.pdfv> [Accessed 23 September 2021]

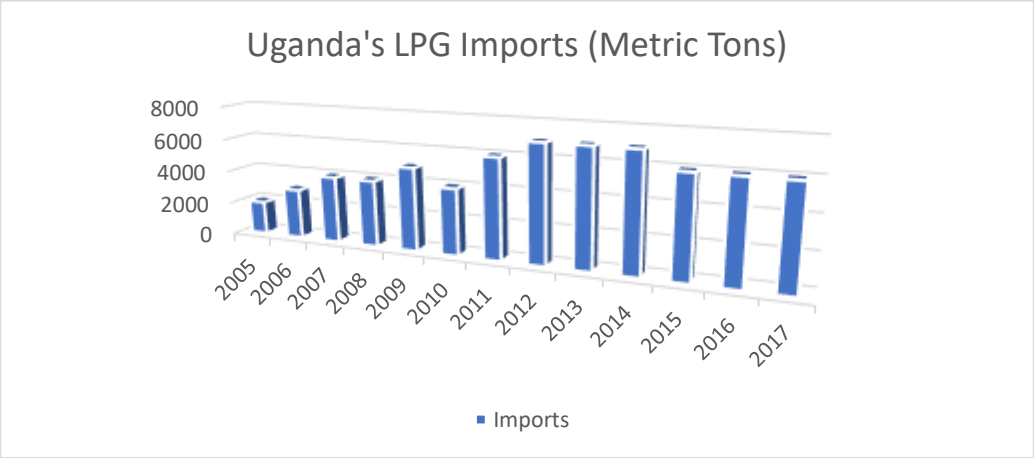
Uganda's average LPG use per capita is 0.2–0.5 kg/year.[74] Even though 22% of the population can afford LPG at home, only 0.8-1% of the population use it due to a negative attitude, safety concerns, poor access, and the high initial cost of purchasing the cylinders.[75] According to a 2019 study by *Energizing Finance*, clean fuels will account for ten times as much cooking access as they do now, accounting for 7.5% of total cooking access by 2030. The remaining 12.2 million homes (88.7% of the total) will likely continue to utilise wood and charcoal for cooking.[76] The task will be to transition all of these households away from traditional wood-based cooking technologies, which are detrimental to health and the environment.

The number of LPG importers and distributors has increased steadily throughout the years (see *Graph 2* on Uganda's LPG imports). Despite low LPG usage, 19 new entrants entered the LPG supplier industry between 2015 and 2019. Currently, Uganda's LPG market has 25 participants (that is, suppliers).[77] A competitive market of LPG suppliers is beginning to form, and there are presently around 10 medium-to-large-sized enterprises now functioning in the market. These include Shell Gas, Total Gas, Ramco Gas, Oryx Gas, Hashi Gas, Lake Gas, Mogas Gas, PET Gas, and Hass Gas. However, there are black market LPG sellers who refill cylinders without regard for safety considerations. In Uganda, there is no regulation of LPG, and certain businesses are not adhering to Health, Safety, Environment, and Community (HSEC) criteria, resulting in a compromise of safety and market inequity.[78]

Additionally, Government interventions in LPG pricing have been sporadic and inconsistent, imposing and eliminating VAT without drawing lessons for future actions. For example, in 2006, LPG was VAT exempt. However, this did not assist customers or the environment, in part because the LPG industry is oligopolistic. The 2013/14 budget reinstated an 18% VAT on LPG, but the Government repealed it again in June 2020.[79] These swings have an impact on the marketing of LPG as a dependable alternative fuel source.

[74] Muwanguzi, J.B.B.A, , Kaggwa R, Werikhe A, Ajidiru R, Kandwanaho J, Guloba A, and Muvawala J., 2021. Evaluating the Energy Requirements for Uganda: Case for Natural Gas. *International Journal of Energy and Environmental Science*, *6*(4), p.68.
[75] Ibid.
[76] Energizing Finance 2019. Taking the Pulse of Energy Access in Uganda. In *Energizing Finance 2019. Report Series: Taking the Pulse*.
[77] Muwanguzi, J.B.B.A, , Kaggwa R, Werikhe A, Ajidiru R, Kandwanaho J, Guloba A, and Muvawala J., 2021. Evaluating the Energy Requirements for Uganda: Case for Natural Gas. *International Journal of Energy and Environmental Science*, *6*(4), p.68.
[78] Ibid
[79] Ibid

Graph 2: Uganda's LPG Imports



Source: Author's Elaboration: Information extracted from TILASTO Uganda: Liquefied petroleum gas, imports (thousand metric tonnes).[80]

As illustrated in *Graph 2*, the amount of LPG imported into the country has steadily increased since 2011, albeit with some variations. The biggest LPG providers now concentrate on the urban market and their existing distribution infrastructure (e.g., fuel stations) rather than expanding into rural and last-mile sectors.[81] Rural and remote markets are generally associated with higher risks and poorer returns due to a lack of economies of scale and substantially lower income levels, as well as delivery costs and constraints. Efforts are being undertaken to reduce the initial prices of LPG in Uganda to develop the market, for example, by making smaller canisters available (e.g. 3-kilogram (kg) against the typical 6kg or 12kg canisters); and by piloting novel pay-as-you-cook service delivery models.[82] Because of their cheaper starting cost, 3kg canisters are the most popular.

7.4 Barriers to LPG uptake

Price plays a major role in determining the choice of fuel. LPG is usually twice the price of alternative fuels in Uganda, notably charcoal, which significantly limits its use as an alternative fuel. Charcoal has also been central in Uganda's urbanisation, like the rest of SSA.[83] The international crude oil price, storage expenses, taxes, bulk transportation costs, filling costs, and margins set by dealers, distributors, and retailers all have a role in influencing LPG prices. Though LPG is the primary source of cooking fuel in the upper-income suburbs, LPG is the primary alternate source of cooking fuel in the middle-income suburbs. Poorer and rural people's access to modern, clean fuel is constrained by relatively high pricing, low demand, and irregular supply; this is especially significant in Uganda, where

[80] TILASTO Uganda: Liquefied petroleum gas, imports. [online] Available at: <https://www.tilasto.com/en/topic/energy-and-environment/liquified-petroleum-gas/trade/liquefied-petroleum-gas-imports/uganda> [Accessed 25 October 2021]

[81] Muwanguzi, J.B.B.A, , Kaggwa R, Werikhe A, Ajidiru R, Kandwanaho J, Guloba A, and Muvawala J., 2021. Evaluating the Energy Requirements for Uganda: Case for Natural Gas. *International Journal of Energy and Environmental Science*, *6*(4), p.68.

[82] Ibid

[83] Branch, A. and Martiniello, G., 2018. Charcoal power: The political violence of non-fossil fuel in Uganda. *Geoforum*, *97*, pp.242-252.

most LPG is imported.[84] The majority of urban residents express interest in and willingness to switch to LPG as their primary source of cooking fuel.

However, various impediments to switching to LPG usage are identified, including the high cost of LPG, safety issues due to fears of LPG cylinder explosions, and difficulty in obtaining it, particularly when compared to charcoal. The primary reasons for Uganda's low LPG uptake cited in the 2019 Draft Energy Policy[85] include the following: insufficient regulations, technical requirements, and certification of LPG cylinders and accessories; inadequate safety standards for LPG filling stations; high upfront costs for LPG cylinders, accessories, and products; and insufficient market development for LPG, which has resulted in limited investments, unreliable supply, over-reliance on imports, and limited service points, particularly in rural areas.

[84] Price, R.A. 2017. Clean Cooking Energy in Uganda – technologies, impacts, and key barriers and enablers to market acceleration. K4D Helpdesk Report. Brighton, UK: Institute of Development Studies. https://assets.publishing.service.gov.uk/media/5bae05abe5274a3e019d86ae/191_Clean_cooking_energy_Uganda.pdf
[85] Ministry of Energy and Mineral Development, 2019. Draft National Energy Policy. https://www.energyandminerals.go.ug/site/assets/files/1081/draft_revised_energy_policy_-_11_10_2019-1_1.pdf

8. LPG: Moroccan Study Case Study

8.1 Overview

Morocco has approximately 36.03 million people and is currently increasing its climate change mitigation and adaptation ambitions. The country ratified the 2016 Paris Agreement, established a new national climate change policy, and hosted the United Nations COP-22 summit in Marrakesh in 2016. Morocco boosted its ambitions for the NDCs under the Paris Agreement. It raised its overall objective for 2030 emissions reductions below predicted business as usual (BAU) levels from 13% in the original Intended Nationally Determined Contribution (INDC) to 17% in its first NDC presented in September 2016.[86] Morocco's energy policy aims to strengthen energy security while also ensuring energy access to the rising population since the 1990s. The 2009 National Energy Strategy reflects national and global energy politics developments and focuses more on renewable energy, energy efficiency, and sustainability.[87]

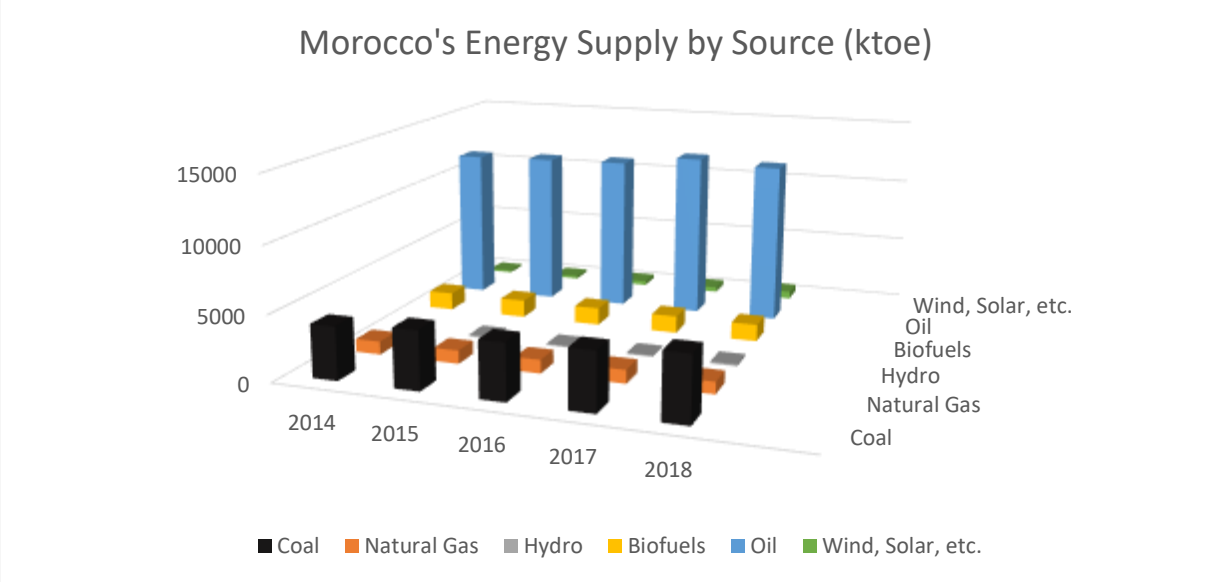
Morocco is making significant strides toward achieving affordable, dependable, sustainable, and contemporary energy per the United Nations SDGs (especially SDG 7). Although the Government has nearly completed rural electrification and is developing its vast renewable energy resources, Morocco continues to rely heavily on imported coal, oil, and gas to provide the majority of its energy demands[88], as shown in *Graph 3* below. For instance, in 2018, oil accounted for 12397 ktoe, coal (4939 ktoe), wind and solar (578 ktoe), biofuels (1311 ktoe), hydro (146 ktoe), and natural gas (924 ktoe).

[86] IRENA 2021

[87] Vidican-Auktor, G., 2017. Energy security, sustainability, and development in Morocco. In *The Political and Economic Challenges of Energy in the Middle East and North Africa* (pp. 236-247). Routledge

[88] IEA. 2021. *Morocco - Countries & Regions - IEA*. [online] Available at: <https://www.iea.org/countries/morocco> [Accessed 25 September 2021]

Graph 3: Morocco's Total Energy Supply by Source 2014-2018



Source: Authors own illustration (Information Extracted from IEA World Energy Balances 2020).[89]

8.2 LPG Use and Clean Cooking in Morocco

In Morocco, oil - mostly LPG or Butane, is the primary fuel in the residential sector. LPG accounts for 63% of total consumption, followed by electricity and biofuels, as shown in *Graph 4*. Between 2007 and 2017, LPG usage climbed by 50%, and electricity consumption increased by 67%, mainly displacing solid biofuels as the primary source of cooking and heating.[90] In the residential sector, consumption of conventional biomass (wood and charcoal) declined by 43% over the period. The primary energy consumers in the residential sector include cooking (which consumes almost two-thirds of total domestic energy consumption), refrigeration, water heating, electric appliances and lighting.[91] Morocco is attaining extraordinary levels of LPG penetration, with over 95% of the population cooking using LPG or other clean fuels.[92]

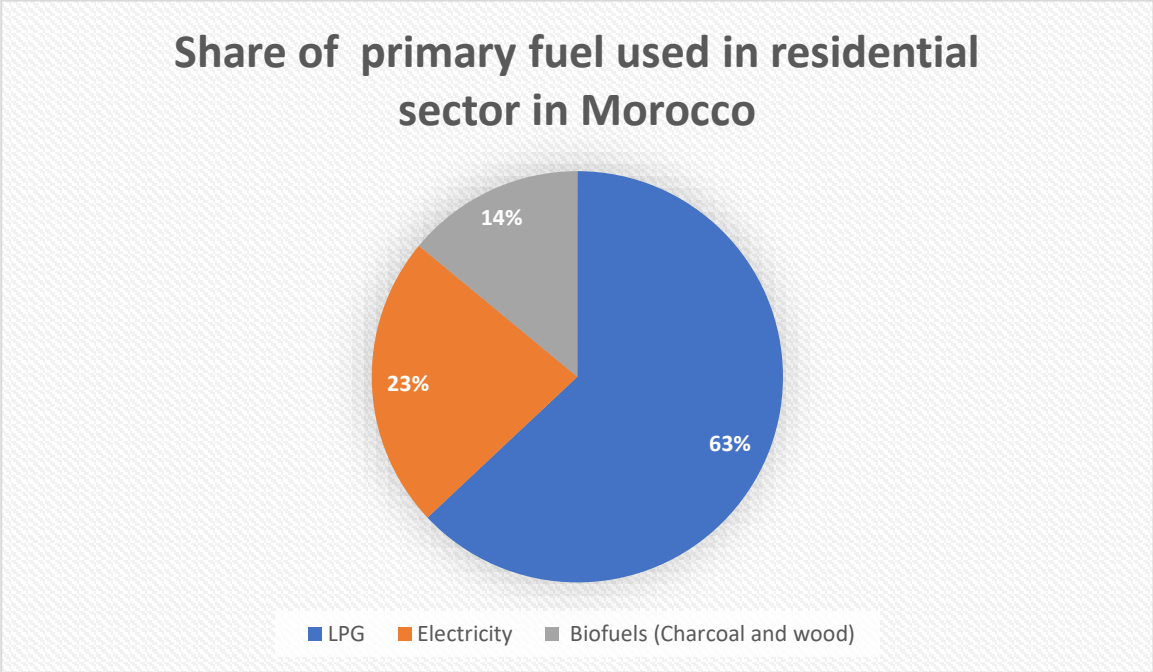
[89] IEA 2020. World Energy Balances. [online] Available at: <https://www.iea.org/subscribe-to-data-services/world-energy-balances-and-statistics> [Accessed 22 September 2021]; Documentation, [online] Available at: <https://iea.blob.core.windows.net/assets/4f314df4-8c60-4e48-9f36-bfea3d2b7fd5/WorldBAL_2020_Documentation.pdf> [Accessed 22 September 2021]

[90] IEA 2019. Energy Policies Beyond IEA: Morocco. International Energy Agency, Paris. [online] Available at: <https://www.connaissancedesenergies.org/sites/default/files/pdf-actualites/Energy_Policies_beyond_IEA_Contries_Morocco.pdf> [Accessed 22 September 2021]

[91] IEA 2019. Energy Policies Beyond IEA

[92] WHO, 2018. *Global Health Observatory data repository: Population with primary reliance on clean fuels and technologies 2016.* Geneva: World Health Organization.

Graph 4: The Share of Primary Fuel Used in Morocco's Residential Sector



Source: Author's own illustration: (Information extracted from IEA 2019).[93]

Morocco has far higher access to electricity and clean cooking rates than the global average (both above 95 %), making Morocco a success story in clean cooking methods. According to the IEA, even though most Moroccan families have access to electricity and environmentally friendly cooking methods, official figures indicate that 1.5 % of the population continues to cook over an open fire using traditional firewood.[94] Many of these individuals live in rural, low-income households, and this proportion is still tiny compared to most other African countries.[95]

There is an increased focus on sustainable cooking fuels in Morocco. The Moroccan government's current interest in clean and sustainable cooking in Morocco is motivated by two objectives: (1) The government wants to eradicate the unsustainable use of traditional biomass (charcoal and firewood) for cooking; and (2) the government aims to reduce the country's reliance on imported and subsidised Butane which comes at a high cost to the public budget[96]. Morocco's success in achieving high levels of clean cooking is partly due to the LPG - butane subsidy. Morocco's challenge, therefore, will be to ease the shift away from subsidised cooking fuels while ensuring needy customers retain access to affordable cooking rather than reverting to traditional biomass use.

8.3 LPG Subsidies in Morocco

The main driver of LPG consumption in Morocco is the continued government subsidisation measures for the fuel source. For a long time, Morocco provided consumer subsidies, including for fossil fuels. In some cases, subsidies to LPG companies to target rural areas were directly responsible for Morocco's high level of LPG penetration in rural areas.

[93] IEA 2019. Energy Policies Beyond IEA: Morocco. International Energy Agency, Paris
[94] Ibid
[95] Ibid
[96] IEA 2020. Towards Clean and Sustainable Cooking: The Outlook for Electric Cooking in Morocco Workshop summary report Revision 1 – March 2020. [online] Available at: <https://iea.blob.core.windows.net/assets/915b1781-d9e3-4b0d-ba66-adff57d939ad/MoroccoFinalReport_withAnnexes_reviewed-final_V2-resized.pdf> [Accessed 26 September 2021]

However, in 2012, energy subsidies increased to 6.6% of GDP, rendering them unsustainable financially, and in response to rising subsidies, Morocco went on a path of subsidy reform known as "decompensation" in 2014.[97] Decompensation included eliminating petroleum subsidies, the phase-out of diesel subsidies, a phased increase in electricity rates, and a partial reform of butane gas subsidies.[98]

The Moroccan Government launched a systematic subsidy reform process to eliminate subsidies by 2017 and 2021. All subsidies save those on LPG, typically butane gas used in households for cooking, heating, and hot water preparation, were to be phased out.[99] The reform excluded prices for LPG and agriculture and sugar and flour, mainly consumed by poor households to minimise the impact on vulnerable populations.[100] In 2018, for instance, a 12-kg bottle was priced at MAD 40 (about EUR 3.60), compared to the market price of MAD 96.64. Energy subsidies totalled MAD 9.9 billion (almost EUR 1 billion) in 2017, up from MAD 7.1 billion in 2016 due to higher international oil prices and increased use, putting a substantial strain on the state budget.[101]

The Moroccan Government's fiscal policies on subsidising Butane have two primary justifications. The first one is driven by social motives to provide low-cost ways of providing basic needs to poor rural communities.[102] The second is environmental awareness and protection, since the widespread use of Butane by rural communities reduces household consumption of fuelwood and charcoal, improving air quality and alleviating pressure on deforestation.[103]

8.4 Integrated Fuel Subsidy Reforms

In designing fossil fuel reforms, Morocco took a balanced approach to distribution, welfare, poverty, and fiscal policy, all deemed 'logical' in the modern period.[104] The country integrated significant adjustments to its fossil fuel subsidies with social welfare, health, and education expenditures. The changes increased fiscal headroom and enabled crucial investments such as renewable energy while avoiding adverse effects on the underprivileged.[105] Subsidies for fossil fuels, particularly for LPG, can be critical in reaching the SDGs. Even though energy access benefits women, women frequently do not directly profit from fossil

[97] Bridle, R., Sharma, S., Mostafa, M. and Geddes, A., 2019. Fossil Fuel to Clean Energy Subsidy Swaps. *International Institute for Sustainable Development: Winnipeg, MB, Canada*.
[98] Bridle, R 2019. Ibid
[99] Loewe, M. and Vidican Auktor, G., 2021. Subsidy reforms in the Middle East and North Africa: Strategic options and their consequences for the social contract. *Available at SSRN 3810832*.
[100] Ibid
[101] IEA 2019. Energy Policies Beyond IEA: Morocco. International Energy Agency, Paris
[102] Peszko, G., Black, S., Platonova-Oquab, A., Heine, D. and Timilsina, G., 2019. Environmental Fiscal Reform in Morocco: Options and Pathways
[103] Vidican-Auktor, G., 2017. Energy security, sustainability, and development in Morocco. In *The Political and Economic Challenges of Energy in the Middle East and North Africa* (pp. 236-247). Routledge
[104] Verme P., El-Massnaoui K. 2017. An Evaluation of the 2014 Subsidy Reforms in Morocco and a Simulation of Further Reforms. In: Verme P., Araar A. (eds) The Quest for Subsidy Reforms in the Middle East and North Africa Region. Natural Resource Management and Policy, vol 42. Springer, Cham. https://doi.org/10.1007/978-3-319-52926-4_3
[105] Verme, P. and El-Massnaoui, K., 2017 Ibid

fuel subsidies.[106] Therefore, subsidy changes combined with targeted social welfare programmes can alleviate poverty while simultaneously empowering women.[107]

Morocco continues to subsidise LPG use for cooking and residential purposes. Still, the Government intends to phase out the subsidies after 2021 in preference for tailored social assistance to disadvantaged consumer groups.[108] While promoting LPG demands a significant economic, infrastructure, and logistical effort, it is also a somewhat effective solution to the critical problem of dangerous cooking practices. Moreover, women are the best advocates for clean cooking solutions since they are the first to benefit from reduced indoor pollution and reduced cooking time. Therefore, tying LPG programmes to gender-sensitive and women-led development projects may be vital.[109]

8.5 Other Measures

As noted earlier, one of the main concerns of LPG use is the safety aspect. In developing its LPG sector, Morocco was careful to address safety issues. Morocco has a thorough safety and inspection regime in place, backed up by national legislation, which has enabled the country's market to develop and increase LPG consumption in almost all parts of the country. All gas operators in Morocco are mandated to maintain high gas cylinders and LPG equipment standards. SOMAS in Mohammedia, for instance, is a significant player in Morocco's gas cylinder supply chain, and it controls more than 72% of the country's storage capacity; even during the COVID 19 pandemic, the company continued to operate ordinarily in terms of receipt, storage, and distribution.[110]

Furthermore, Morocco found it necessary to have a common facility for gas, cylinders, and appliances concerning market organisation and equipment considerations. These are known as "maisons d'énergie", and were a critical retail mechanism for expanding LPG markets in the country. Additionally, Morocco introduced reusable plastic propane cylinders on the market to replace the traditional iron cylinder. The cylinders include a more robust safety valve and help prevent gas metering manipulation by accurately measuring the amount of gas contained within.[111]

[106] UNEP, OECD and IISD (2019). Measuring Fossil Fuel Subsidies in the Context of the Sustainable Development Goals. UN Environment, Nairobi, Kenya

[107] UNEP, OECD and IISD (2019). Measuring Fossil Fuel Subsidies in the Context of the Sustainable Development Goals. UN Environment, Nairobi, Kenya

[108] IEA 2019. Energy Policies Beyond IEA: Morocco. International Energy Agency, Paris

[109] Hafner, M., Tagliapietra, S. and de Strasser, L., 2018. Energy Investments for Africa's Energy Transition. In *Energy in Africa* (pp. 77-96). Springer, Cham.

[110] Hatim, Y., 2021. *Ministry of Energy: Morocco Has 40-Day Stock of Gas Cylinders*. [online] https://www.moroccoworldnews.com/. Available at: <https://www.moroccoworldnews.com/2020/03/296942/ministry-of-energy-morocco-has-40-day-stock-of-gas-cylinders> [Accessed 23 September 2021].

[111] Morocco World News 2017. *Plastic Gas Cylinder to Hit Moroccan Markets*. [online] Available at: <https://www.moroccoworldnews.com/2017/05/218115/plastic-gas-cylinder-hit-moroccan-markets-plastic-propane-tank> [Accessed 26 September 2021].

9. Recommendations and Conclusion

The purpose of this study was to identify ways in which Uganda can overcome the barriers that impede LPG use to enable the country to make a transition to cleaner, more sustainable energy sources, with a particular emphasis on LPG use in the domestic cooking sector. More so, for the benefits, LPG posits in the attainment of sustainable growth and development. As Uganda seeks to meet its commitments under the Paris Agreement, the cooking sector must be highly considered. The Government can speed up the achievement of the SDGs by tackling clean energy cooking concerns, especially through LPG. This can be measured in terms of enhanced public health and gender equality: essentially, clean air due to fewer pollutants and cooking, since the majority of culinary tasks are performed by women and girls. This will contribute positively in various ways like: the mitigation of climate change and the acceleration of poverty eradication (since women will have more time to engage in income-generating activities), among other benefits. Additional benefits include the maintenance of biodiversity and forest cover; forests serve as sinks for greenhouse gases in the atmosphere and aid in the rain cycle. This also has multiplier effects like contributing to higher food output (zero hunger). Some of the pathways include the following:

9.1 Government Intervention

The Government needs to scale up efforts to increase the uptake of LPG as a transitional fuel. Even though a fossil fuel, LPG falls within the ambits of 'environmentally preferable products'[112] and transitional fuels for achieving a low-carbon economy and future. The key challenges to be addressed are affordability, availability, accessibility, and safety. The Global LPG Partnership laid down five principles to enable fast and sustainable LPG market development, as shown in *Box 1* below.

[112] The term 'environmentally preferable' refers to products or services that have a lower or negligible impact on human health and the environment when compared to comparable products or services. See UNCTAD, 1995. Environmental Preferable Products (EPPs) as a Trade Opportunity for Developing Countries, Report by UNCTAD Secretariat, UNCTAD/COM/70, Geneva.

Box 1: Five principles for fast and sustainable LPG market development

Principles:

- Implement and rigorously enforce effective, self-consistent LPG market rules, with a central emphasis on property rights protection in marketer-owned LPG cylinders and on public safety.
- Ensure stability and continuity of the LPG fuel supply in all regions to be served.
- Implement stable, market-sustaining and market-stimulating policies.
- Ensure high LPG retail density.
- Develop a consensus-based national master plan for coordinated LPG investments and interventions.

Source: Global LPG Partnership, 2015

9.2 Policy Reform:

Policy reform is critical to the success of the LPG business. This includes tailoring energy policy to LPG; large-scale transformations can happen quickly with appropriate policies and reforms.[113] It is vital to create a robust enabling environment for LPG through a combination of national planning, legislative reform, and targeted investments throughout the supply chain. Morocco has increased the average demand per capita to 70kg per capita by steering investments throughout the LPG value chain. The Government and all stakeholders should be involved in decision-making to ensure that planning considers all pertinent issues, such as upstream investment and supply chain management, health, safety, environmental concerns, and access and cost. Policymakers must decide whether and how to modify pricing regimes, taxes, and subsidies to enable impoverished people to accept and utilise LPG sustainably. However, substantial awareness programmes are necessary to ensure safe usage and to promote consumption.

9.3 Affordability and Accessibility measures

(a) Subsidies

Addressing the affordability and accessibility of LPG is critical to deepening LPG adoption and consumption in Uganda and achieving effective energy transition to LPG throughout the nation. Morocco, for instance, has long subsidised its LPG sector, which led to a higher uptake of fuel at the household level. Sometimes, however, subsidising gas has often shown to be inefficient in terms of the resultant fiscal burden[114], and sometimes it has failed to reach the intended target groups. The subsidies did not help the rural poor in India due to delivery challenges, low LPG demand, high overhead costs, and poor perception/attitude.[115]

[113] Puzzolo, E. and Pope, D., 2017. Clean fuels for cooking in developing countries. *Encyclopedia of Sustainable Technologies; Elsevier: Amsterdam, The Netherlands*, pp.289-297.
[114] Skovgaard, J. and van Asselt, H., 2019. The politics of fossil fuel subsidies and their reform: Implications for climate change mitigation. *Wiley Interdisciplinary Reviews: Climate Change*, *10*(4), p.e581.
[115] D'Sa, A. and Murthy, K.N., 2004. LPG as a cooking fuel option for India. *Energy for Sustainable Development*, *8*(3), pp.91-106

However, unlike Morocco, which has no LPG domestic production capacity, Uganda is poised to produce its LPG once the refineries are constructed for its upcoming petroleum activities. As such, Uganda would be able to serve its domestic market. This means the country may not have to adopt a general approach to subsidise the LPG sector, which Morocco did. The focus would rather be on ensuring that the general population, especially low-income households, can afford the LPG even at relatively lower costs.

(b) Targeted Subsidies

The Government can provide differential LPG subsidies to households where LPG adoption will cost a reasonable share of household income, especially for households that cannot afford LPG. Morocco shows us the route, as the Government there intends to remove general LPG subsidies as is the case with other petroleum products. Morocco is considering the limitation of subsidies to poorer households due to the heavy burden of subsidies on the national finances. Its focus will be on subsidising and aiding underprivileged families to access LPG instead of the general population. While general energy consumer subsidies are ineffective in reducing energy poverty, their elimination could be detrimental to poor persons unable to pay the total cost of modern energy services.[116]

(c) A Holistic and Integrated Subsidy Approach

The country should also bolster the incomes of its population if the LPG sector is to grow. Morocco managed to do this by integrating significant adjustments to its fossil fuel subsidies with social welfare, health, and education expenditures, thus creating broad-based sectoral improvements. Although these measures might not immediately increase household income, they can foster LPG adoption and consumption in households by cutting expenses on other basic needs. The would then be left with more money to spend on LPG use. In the long run, the incomes of the households could be increased.

9.4 Fiscal Regime Transformation

The country could also consider adopting a flexible fiscal regime that exempts LPG from customs duties and value-added tax (VAT) at the domestic level to boost consumption in the residential sector. These exemptions can extend to gas equipment and cooking appliances. For instance, it can allow specific LPG equipment (cylinder, hose, regulator) and simple cooking stoves to be imported tax-free while promoting LPG cooking. These can be limited to a given size which is most in demand among low-income households. As earlier noted, the tax regime for LPG has been unstable in Uganda. For example, the 2013/14 budget reinstated an 18 %VAT on LPG. However, the Government repealed it again in June 2020.[117]

9.5 Creating a Favourable Investment Climate

A conducive investment climate for the LPG supply chain is crucial. This is because the adoption of LPG requires investment in infrastructures such as import, bulk storage,

[116] Scott, A. and Pickard, S., 2018. *Energy safety nets*. Working Paper 1018. Catholic Agency for Overseas Development (CAFOD)
[117] Ibid

transportation, and filling facilities and LPG cylinders. Further, there is a need for expanded distribution and retailing networks to ensure reliable and affordable supply and safe delivery of the LPG to end-users. If upstream supply issues are not addressed, LPG promotion programs will not provide long-term benefits. Uganda must invest in bulk storage facilities, which may entail establishing LPG storage facilities in regional towns.

9.6 Expanding Refill Stations

The country would need to establish filling stations outside of Kampala to ensure that rural areas have access to refills to address accessibility. According to 'Vision 2040', one of the Government's development plans for the period 2013-2040 is to promote the use of LPG by partnering with neighbouring governments to construct a gas pipeline connecting to and from the region's gas reserves – "to supplement the country's energy needs while conserving the environment."[118]

9.7 Looking Ahead: Introducing BioLPG in the Energy Mix

Lastly, as the world is moving from fossil fuels to cleaner energy sources, Uganda also needs to look beyond fossil fuels. Climate mitigation measures are increasingly central at the international level, like the COP26 event to be held in Glasgow between October and November 2021. Further, early action will also help Uganda meet its 22% national greenhouse gas emission reduction target by 2030 as submitted under its NDC. Therefore, the country should invest more in cleaner energy sources in the long run – for environmental protection, improved health and life, and sustainable development.

Uganda should explore alternative cleaner fuel sources, particularly 'bioLPG'. This is a chemically indistinct but renewable variant of conventional LPG. The World LPG Association also recommends that consumers should transition from conventional LPG to bioLPG,[119] BioLPG is essentially Propane manufactured using renewable feedstocks such as plant and vegetable waste; it is also known as renewable Propane or biopropane.[120] Whereas LPG comprises Propane or Butane, that are by-products of crude oil refining and natural gas processing, BioLPG is composed of biomass. Although it is chemically identical to LPG, the source is quite different. BioLPG is an excellent energy source for people looking to minimise their carbon footprint, as it emits up to 80% less CO_2. It is identical to ordinary LPG in terms of use and performance and can be used in cooking, heating, agricultural, and industrial applications.

Most importantly, bioLPG can be distributed in the same way and using the same facilities as LPG. This means that the country would not need many structural changes to

[118] Uganda Vision 2040. [online] Available at: <https://www.greengrowthknowledge.org/sites/default/files/downloads/policy-database/UGANDA%29%20Vision%202040.pdf> [Accessed 21 September 2021]

[119] WLPGA, 2021. Clean, decentralised and efficient energy just like LPG, but renewable. World LPG Association. [online] Available at: <https://www.wlpga.org/wp-content/uploads/2021/03/BioLPG-Charter-of-Benefits.pdf> [Accessed 23 September 2021]

[120] Chen, K.C., Leach, M., Black, M.J., Tesfamichael, M., Kemausuor, F., Littlewood, P., Marker, T., Mwabonje, O., Mulugetta, Y., Murphy, R.J. and Diaz-Chavez, R., 2021. BioLPG for Clean Cooking in Sub-Saharan Africa: Present and Future Feasibility of Technologies, Feedstocks, Enabling Conditions and Financing. *Energies*, *14*(13), p.3916.

accommodate bioLPG, which is cleaner than LPG. Further, bioLPG can be combined with fossil LPG, allowing for a gradual yet secure transition to 100% bioLPG.[121] Further, LPG supply chains can help achieve cost-effective decarbonisation. Immediately, they can be used as an alternative to high-carbon fuels and, in the long-term, as an agent for deep decarbonisation through bioLPG.[122] Further, it is a viable way of waste management in the country. For instance, in Kampala City alone, over 1,300 tons of waste are produced daily, with only 50% collected and taken to landfills.[123] On the other hand, Uganda would need to establish a national enabling environment and regulatory measures relating to feedstock supply, chemical processing plants, and market readiness to safely use bioLPG as clean cooking fuel on a large scale.[124]

[121] Jasi, A., 2020. *LPG industry aims for 100% transition to bioLNG by 2040*. [Online] The Chemical Engineer. Available at: <https://www.thechemicalengineer.com/news/lpg-industry-aims-for-100-transition-to-biolng-by-2040/> [Accessed 26 September 2021]

[122] WLPGA, 2021. Clean, decentralised and efficient energy just like LPG, but renewable. World LPG Association. [online] Available at: <https://www.wlpga.org/wp-content/uploads/2021/03/BioLPG-Charter-of-Benefits.pdf> [Accessed 21 September 2021]

[123] Kinobe, J.R., Bosona, T., Gebresenbet, G., Niwagaba, C.B. and Vinnerås, B., 2015. Optimization of waste collection and disposal in Kampala city. *Habitat International*, *49*, pp.126-137.

[124] GLPGP, 2020. *Assessing Potential for BioLPG Production and Use within the Cooking Energy Sector in Africa*. New York: The Global LPG Partnership. [online] Available at: <https://mecs.org.uk/wp-content/uploads/2020/09/GLPGP-Potential-for-BioLPG-Production-and-Use-as-Clean-Cooking-Energy-in-Africa-2020.pdf> [Accessed 26 September 2021]

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