Initiative for Climate Action Transparency – ICAT Project in Lesotho

- Recommendations and inputs for NDC revision.
- Mitigation analysis of Energy sector projects identified under revised NDC.

Initiative for Climate Action Transparency – ICAT

Deliverable #1:

1. **Scoping Study (Recommendations and inputs for Lesotho's NDC revision)**
2. **Mitigation analysis of Energy sector projects identified under revised NDC.**

AUTHORS

Molibeli Taele (Energy Research Centre, National University of Lesotho)
Leloko Mokhutšoane (Independent Renewable Energy Consultant)

REVIEWERS

Ivana Audia (UNEP Copenhagen Climate Centre)
Buddika Hemashantha (ClimateSI)
Maqhanolle Tsekoa (Lesotho Meteorological Services)
Theletsa Mpholle (Lesotho Meteorological Services)

February 2024

PREPARED UNDER

The Initiative for Climate Action Transparency (ICAT), supported by Austria, Canada, Germany, Italy, the Children's Investment Fund Foundation and the ClimateWorks Foundation.

The ICAT project is managed by the United Nations Office for Project Services (UNOPS).

Table of Contents

List of Tables

List of Figures

List of Acronyms

AFOLU	Agriculture Forestry and Other Land Uses
BAU	Business As Usual
CO_2	Carbon dioxide
COP	Conference of Parties
EMP	Electrification Master Plan
GACM0	Greenhouse gas Abatement Cost Model
GEF	Global Environment Facility
GHG	Greenhouse Gases
ICAT	Initiative for Climate Action Transparency
LMS	Lesotho Meteorological Services
LREEAP	Lesotho Renewable Energy and Energy Access Project
MAC	Marginal Abatement Cost
MDSE	Ministry of Defence, Security and Environment
MRV	Monitoring Reporting and Verification
MW	Megawatt
NDC	Nationally Determined Contribution
SADC	Southern African Development Community
UNFCCC	United Nations Framework Convention on Climate Change
UNEP-CCC	United Nations Environment Programme – Copenhagen Climate Centre
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organisation
UNOPS	United Nations Office for Project Services

Executive Summary

Lesotho submitted its first set of Nationally Determined Contributions (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat in 2017 to support the achievement of emission reduction goals under the Paris Agreement. As per decision 1/CP21 and Article 4.9 of the Paris Agreement, parties are required to update their NDCs every five years. Therefore, Lesotho was required to present its updated NDC by 2021. The existing mitigation options and measures, including those for the energy sector, were developed through a qualitative assessment without quantitatively evaluating their Greenhouse Gas (GHG) impacts and sustainable development impacts. This assessment aims to evaluate the GHG impacts and sustainable development impacts of the updated NDC so that policy-makers can make informed decisions while finalizing the energy sector NDC. Lesotho's NDC was formulated based on previously submitted INDC following the principle of common but differentiated responsibilities and respective capabilities. However, due to limited guidance and awareness on developing the initial NDC, Lesotho, like other developing countries, had developed the NDC using a qualitative approach without quantitatively analyzing their GHG effects.

This assessment is meant to provide *recommendations and inputs for Lesotho's updated* NDC with a focus on the energy sector. The benefits of having more robust data and emission factors over the previous version of the NDC submitted in 2017, including the availability of Lesotho's First Biennial Update Report (2021) are highlighted. Amongst others, the recommendations and inputs build upon key national planning documents, including the National Climate Change Policy and Implementation Strategy (2017), the Third National Communication to the UNFCCC (2021) and the National Strategic Development Plan II, 2018/19 – 2022/23. The assessment carefully considers national capacity and circumstances as well as the availability of technological advancements. It therefore represents an ambitious improvement in the planning and projections of national commitments over the previous NDCs, which were largely underpinned by generalized assumptions and deficiencies in data needed for accurate projections.

The NDC provides a solid framework for implementing mitigation measures in identified sectors, with the requirement to submit updated and more ambitious NDC every 5 years. Reviewing the agreed mitigation actions and assessing their status will be necessary in accordance with UNFCCC requirements. The mitigation actions include substituting lower-emission energy sources and reducing the use of traditional household fuels, particularly firewood, dung and illuminating paraffin in areas that cannot be effectively electrified**,** expanding rural electrification, adopting clean and

efficient cooking and lighting technologies, promoting and developing renewable energy, improving energy efficiency and conservation, decarbonizing road transportation and transitioning to more environmentally friendly modes of transport**.**

Several mitigation projects have been excluded from this analysis for various reasons. Some were deemed unfeasible for the planning horizon in question (2030), such as s*hifting passengers from private cars to public transport.* Others were excluded due to a lack of reliable data availability, such as *reducing traffic congestion in order to reduce GHG emissions.* Additionally, some projects were not included because there were no calculation options for them in the GACMO tool, such as ***efficient operation of public transportation and e-commuting.***

The first deliverable under this assignment, "*Recommendations and Inputs for NDC Revision"*, generated a list of **14** mitigation options after evaluating the current actions and additional mitigation actions against the SMART (*Specific, Measurable, Actionable, Relevant and Time-bound*) criteria.

The report assessed the GHG impacts of a list of **14** mitigation options using the GACMO tool[1]. The results of this evaluation will inform the prioritization and updating of the Nationally Determined Contributions (NDC) related to the energy sector.

Lesotho's mitigation contribution takes the form of a reduction in GHG emissions relative to a business-as-usual (BAU) emissions baseline over the period to 2030. Lesotho' emission reduction target is to **unconditionally** lower its GHG emissions in the energy sector by **4.2%** (**166 ktCO_2eq)** by 2030 relative to business**-as-usual** (BAU) scenario emissions of 3,936 **ktCO_2eq; and in line with its sustainable development agenda. Unconditional mitigation actions** are based on the implementation of the **already-scheduled** and **in-progress** projects, all of whose funding has been defined, and ongoing Government initiatives. An additional 25.8% (**1,017 ktCO_2eq)** emission reduction is attainable, subject to timely international support in the form of finance, investment, technology development and transfer, and capacity building to cover the full cost of implementing proposed additional mitigation actions, bringing the total emission reduction to **30.1%** (1,183 **ktCO_2eq)** below BAU emission levels by 2030.

Expected Trajectory: In meeting its targets, Lesotho expects its emission trajectory to be as follows:

[1] GACMO (Greenhouse Gas Abatement Cost Model) is a GHG emissions projections tool developed over more than twenty years by the UNEP Copenhagen Climate Centre. GACMO tool can be downloaded and used free of charge.

- **Unconditional:** To reach **3,414 $ktCO_2eq$** in 2025 and **3,770 $ktCO_2eq$** in **2030**, decreasing by **0.8%** and **4.2%** compared to BAU emission in 2025 and **2030**, respectively,
- **Conditional:** To reach **3,357 $ktCO_2eq$** by 2025 and **2,753 $ktCO_2eq$** by 2030, decreasing by **2.5%** and **30.1%** compared to BAU emission in **2025** and **2030**, respectively.

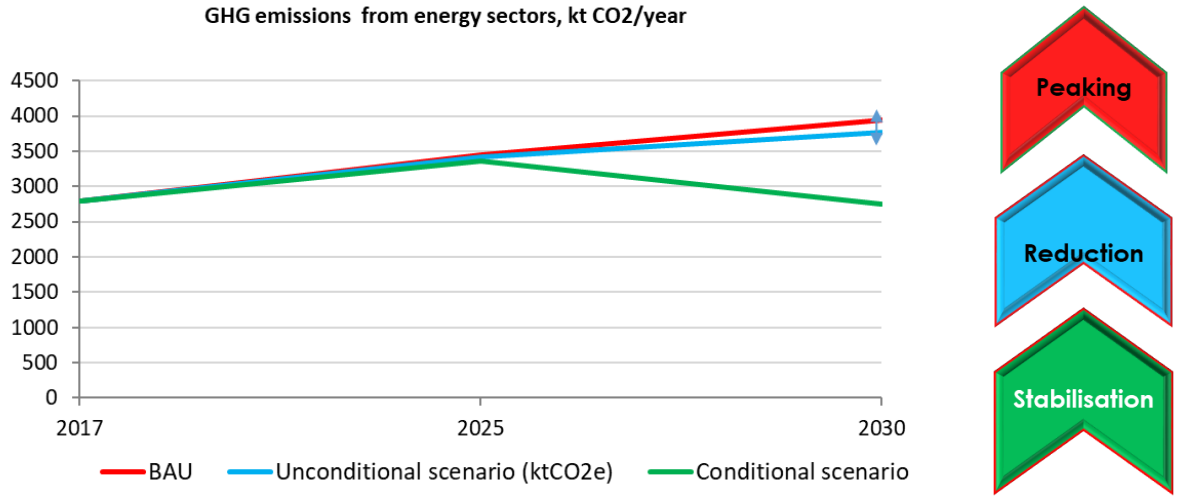


Figure 1: Expected GHG emissions Trajectory between 2017 and 2030 (Authors)

Like other developing countries, Lesotho now has a better understanding of NDC and how they should be formulated. In addition, there have been several visible changes in the energy sector compared to 2017. Some of the energy sector priorities that were in place at the time of submitting NDC in 2017 have now shifted.

1. Introduction

1.1. Background

In line with the Paris Agreement, almost all countries in the world have committed to nationally determined contributions (NDCs) to limit global temperature rise, adapt to changes already occurring, and regularly increase their efforts over time. The central aim of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. To date, 195 Parties have ratified of the agreement out of 198 Parties to the Convention. Lesotho also ratified the Paris Agreement in 2016.

As per the requirement of the Paris Agreement, Lesotho submitted its first NDC to the UNFCCC in 2017. Lesotho's NDC comprises three areas: Mitigation, Adaptation and Means of Implementation. Lesotho's current GHG emissions are relatively low estimated at 5 660.44 $ktCO_2eq$, representing less than 0.01% of total global emissions (Ritchie, Roser and Rosado, 2020). Lesotho is putting its progressive efforts to avoid or mitigate the climate the effects of change that have emerged in its economic growth through the NDC.

Lesotho's unconditional and conditional targets entailed a reduction of GHG emissions by 10% and 35%, respectively compared to the business-as-usual (BAU) scenario by 2030. Additionally, Lesotho aims to implement various adaptation measures and initiatives to bolster resilience and reduce the vulnerability of the population, environment and economy to the adverse impacts of climate change.

Furthermore, countries have pledged to the global Sustainable Development Goals (SDGs) outlined in the 2030 UN Agenda for Sustainable Development. Among the 17 SDGs, SDG 7 emphasizes the need to ensure access to affordable, reliable, sustainable and modern energy for all. The achievement of SDG 7 is interconnected with numerous other goals, particularly ending poverty (SDG 1), fostering job creation and economic growth (SDG 8) and combating climate change (SDG 13) (Fuso-Nerini *et al.*, 2018).

Lesotho Baseline Trajectory (2017 – 2030): According to GACMO, projections of GHGs for energy for the baseline scenario are presented in Table 1 and Figure 2. The projections indicate that without any climate change mitigation measures, emissions in 2030 will be 41% higher than in 2017, at 3,936 $ktCO_2e$ (*extrapolated based on historical and forecasted GDP values*). The baseline scenario projections depict that the largest share of emissions currently comes from the transport subsector. If all proposed NDC actions are implemented, GHG emissions in the energy sector can be limited to 2,753 $ktCO_2e$ by 2030. if all proposed actions are implemented.

Table 1: Projections of Greenhouse Gases under Baseline Scenario

ktCO2e/year	2017	2025	2030	Percent change 2030/2017
Total	**2,789**	**3,443**	**3,936**	**41%**
Power and other	422	521	596	41%
Industry	1,740	2,085	2,335	34%
Transport	508	703	861	70%
Households	87	97	105	21%
Services	32	36	39	23%

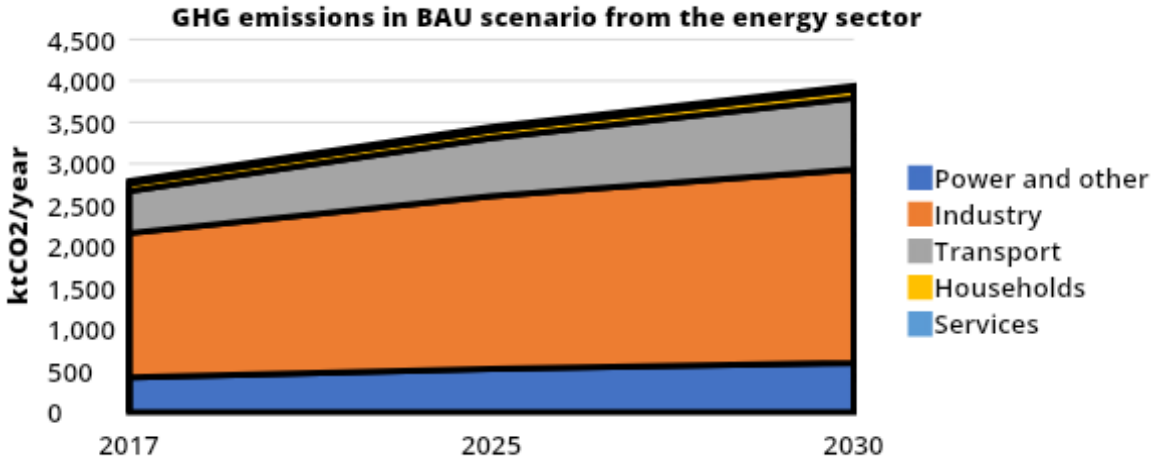


Figure 2: Projection of GHGs for energy Sector under Baseline Scenario (Authors)

Mitigation is guided by the National Climate Change Policy (NCCP) and the National Climate Change Policy Implementation Strategy (CCPIS), which were adopted in 2017 to better frame and implement the options for reducing emissions. The goal of the NCCP and CCPIS is to foster low-carbon economic growth and build a climate resilient society, through the following main objectives:

- Implementing mitigation to promote low carbon sustainable high economic growth;
- Enhancing national capacity to adapt to climate change;
- Increasing public awareness;
- Involving the private sector to address CC challenges;
- Strengthening national institutions and mechanisms for a suitable and functional CC governance framework.

Within the framework of the CCPIS, several sectoral policies and strategies are being developed.

1.2. Initiative for Climate Action Transparency (ICAT)

The revision of Lesotho's NDC is progressing under the patronage of the Initiative for Climate Action Transparency (ICAT). Established in 2015, ICAT came into existence as a result of a collaborative effort involving multiple stakeholders guided by the Donor Steering Committee (DSC). The DSC comprises several donors, namely Austria, Canada, Germany, Italy, the Children's Investment Fund Foundation (CIFF), and the Climate Works Foundation (CWF). Additionally, the UNFCCC Secretariat, which holds a specific mandate for climate change policy within the United Nations, is an integral part of the partnership, along with UNOPS serving as an ex-officio member. The aim of ICAT is to

accelerate climate actions by helping countries and policymakers with tools and support to measure and assess the wider sustainable development impacts of actions for NDC implementation. ICAT provides a comprehensive range of practical, open-source tools, and methodologies designed to deliver efficient assistance to countries worldwide in their transparency initiatives. ICAT is uniquely positioned as one of the transparency initiatives that offers newly developed guidance related to the MRV of policies and actions as well as country capacity building work. Through the work of several implementing partners, ICAT provides ad-hoc technical assistance to partner countries.

1.3. Mitigation measures in the Energy Sector

The energy sector, among other sectors, presents numerous opportunities to reduce GHG emissions on a global scale and here in Lesotho. While Lesotho takes adaptation measures as a priority given its high vulnerability to climate change, the country is committed to contributing to global mitigation efforts. Lesotho has committed to reducing its economy-wide greenhouse gas emissions by 35% below the projected business-as-usual level by 2030, through a combination of the following: unconditional GHG reductions of 10% by 2030 relative to the business-as-usual (BAU) scenario emissions of 5,713 $ktCO_2e$; and in line with its sustainable development agenda, an additional 25% emission reduction subject to timely international support in the form of finance, investment, technology development and transfer, and capacity building to cover the full cost of implementing proposed additional mitigation actions - bringing the total emission reduction to 35% below BAU emission levels by 2030.

1.4. Objectives

The main objectives of the assignment are to:

a) **Provide recommendations and Inputs for Lesotho's updated NDC Revision** by *preparing a list of proposed mitigation options, with a focus on financial feasibility, political preference and effect on GHG reduction*

b) **Conduct Mitigation Analysis of the Energy Sector Identified in the updated NDC** using the GACMO tool to quantify the GHG effects of selected actions.

1.5. Structure of the Reports

This report is divided into four chapters. The first chapter introduces the First Objective, ***Revision of the selected mitigation actions using GACMO tool for the Energy sector***, as part of Lesotho's ICAT Project in Monitoring, Reporting and Verification (MRV) in the Energy Sector. It outlines the deliverables of the first objective, which identified 14 main potential NDC measures and provides an overview of the ICAT project's objective and the existing energy sector NDC. The second chapter presents the status and trends of the energy sector and GHG emissions coming from the sector. Chapter three details the approach and methodology used to provide **recommendations and inputs to Lesotho's updated NDC revision** under the following major steps:

- Identification of policies and actions to achieve the updated NDC;
- Application of the GACMO tool;
- Assessment of the GHG effects;
- Prioritization of revised mitigation options based on mitigation potential, both for conditional and unconditional target.

Chapter 3 also discusses the results of the assessment, which mainly consists of the prioritized mitigation measures based on the results of GHG reduction assessments. It also explains uncertainties associated with the study.
Chapter Four concludes the report by addressing barriers to the study, presenting conclusions and offering recommendations to overcome barriers in the future.

2. Energy Consumption and GHG Emissions in the Sector

2.1. Energy Consumption Patterns

The Energy sector in Lesotho consists of five sub-sectors; Industrial, Transport, Residential, Commercial/Institutional, Agricultural, Forestry and Fisheries. Majority of the Lesotho population is rural-based and has limited access to the electricity grid. As a result, they depend on biomass for basic household energy needs. The energy consumption pattern of Lesotho is dominated by use of biomass fuels which is comprised of wood fuel, crop waste, animal dung and shrubs. Table 2 below depicts energy consumption by sector and fuel type.

Table 2: Energy Consumption by Sector and Fuel Type

Sector	Coal (ktoe)	Oil (ktoe)	Biomass (ktoe)	Electricity (ktoe)
Industry	14,7	50.6	0,2	22.5

Transport	0.0	184.4	0.0	1.3
Households	2.0	79.1	8310676.9	24.8
Commerce and Services	45.6	98.3	5.4	12.8
Agriculture, Forestry and Fishing	0.0	8.4	0.0	0.1
Non-Specified	0.0	0.0	0.0	12.4
Total	**62.3**	**420.8**	**8,310,682.5**	**73.9**

Source: Lesotho Energy Balance 2019

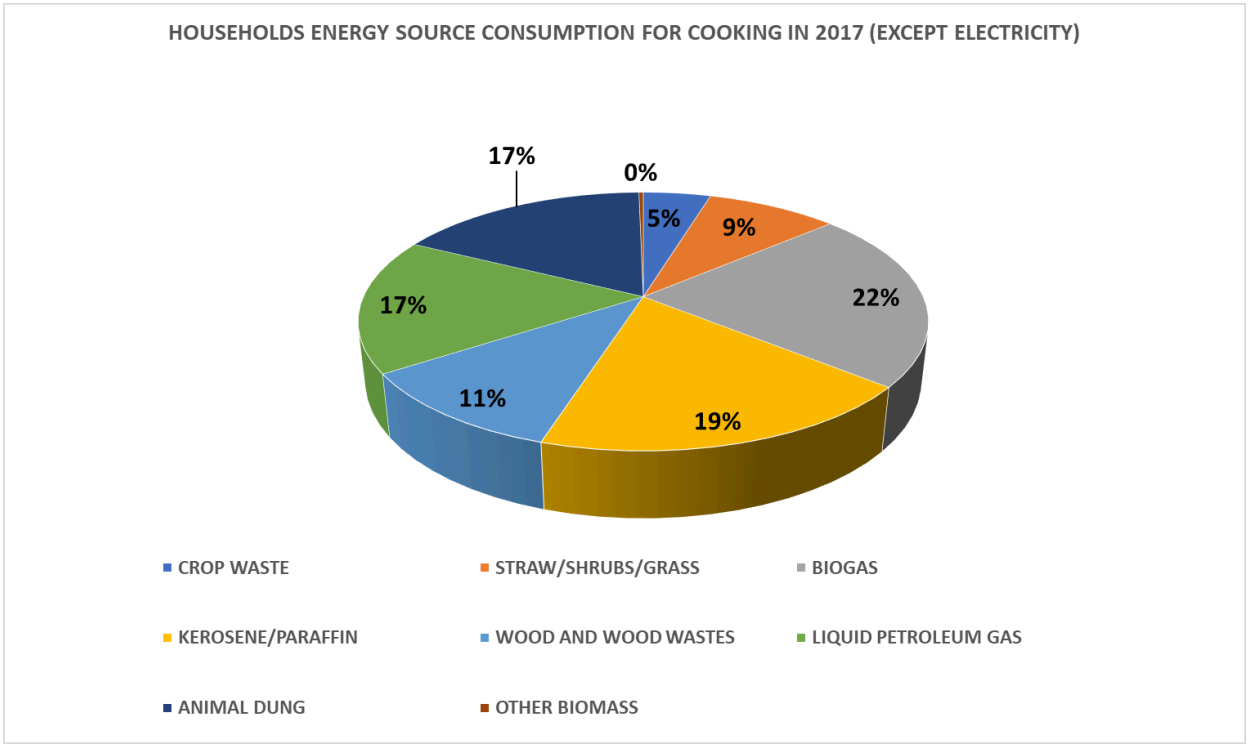
The table above provides a quick overview of the potential areas where mitigation measures can have the greatest impact. This means that any analysis of measures will be conducted in consideration of the intensity of energy use and its contribution to national GHG emissions. The highest energy consumption occurs in households, followed by commerce/services and industry respectively. Of particular interest in this consumption pattern is the significant use of biomass as a fuel source for cooking and space heating in winter. The only mitigation measure that can be applied to this fuel source is increasing access to energy-efficient cookstoves and enhancing energy-efficient building design and construction with a focus on residential buildings.

Use of Energy by Households: Many rural and semi-rural households in Lesotho do not have access to electricity, and they rely on traditional fuels such as biomass for their energy needs.

Biomass (wood and dung) is primarily used for cooking and heating, especially in rural areas which can have negative health effects.

Urban households rely less on biomass and mainly use paraffin and gas for heating and cooking.

Figure 3 below illustrate the energy sources (excluding electricity) that households in Lesotho use for heating and cooking (Lesotho Bureau of Statistics, 2019)



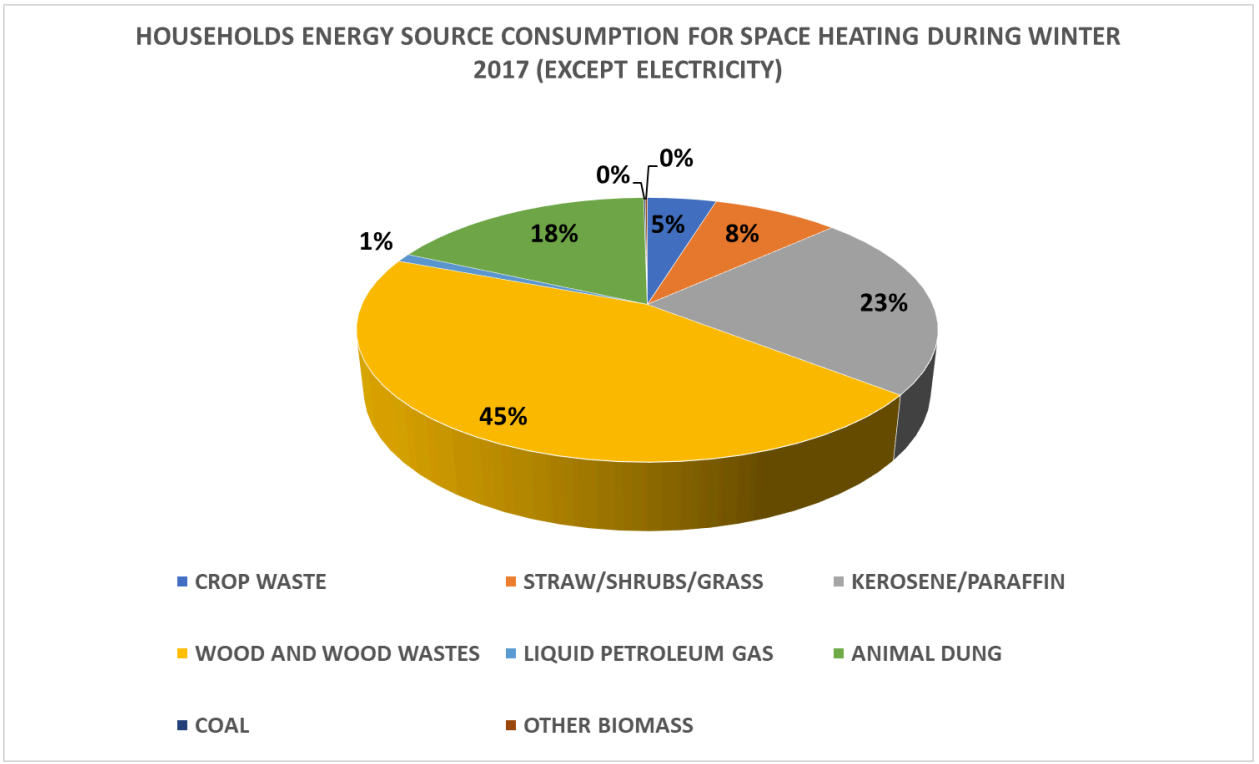


Figure 3: Use of energy by households (Source: Lesotho Bureau of Statistics, 2019)

Cooking is one of the most energy-intensive activities, and the majority of electrified households use electricity as their primary cooking energy source. A small number of electrified households still rely on firewood for cooking, while a few use liquid petroleum gas (LPG or LP gas), solar electricity, paraffin and coal. . Non-electrified households mainly use firewood and paraffin for cooking, with a small percentage using gas, coal, solar electricity and electricity from generators.

Apart from cooking, another energy-intensive thermal application is **domestic space heating**. Electrified households primarily use electricity, with nominal shares using firewood, paraffin and other energy sources. In non-electrified households, firewood is the primary form of energy relied on for space heating.

For **lighting**, urban households rely on a combination of electricity, paraffin and candles. Paraffin (kerosene) is the main source of energy for lighting followed by electricity and candles. In rural areas, candles and paraffin are used for lighting. Households that have been electrified almost exclusively use electricity for lighting purposes. By contrast, most non-electrified households rely on candles and paraffin as the main sources of lighting, with paraffin accounting for the predominant energy source for this purpose.

Use of Energy Efficient Appliances and Devices by Households: Improved cook stoves are up to 50% more efficient compared to traditional stoves and provide health benefits by reducing the amount of emissions in the home.

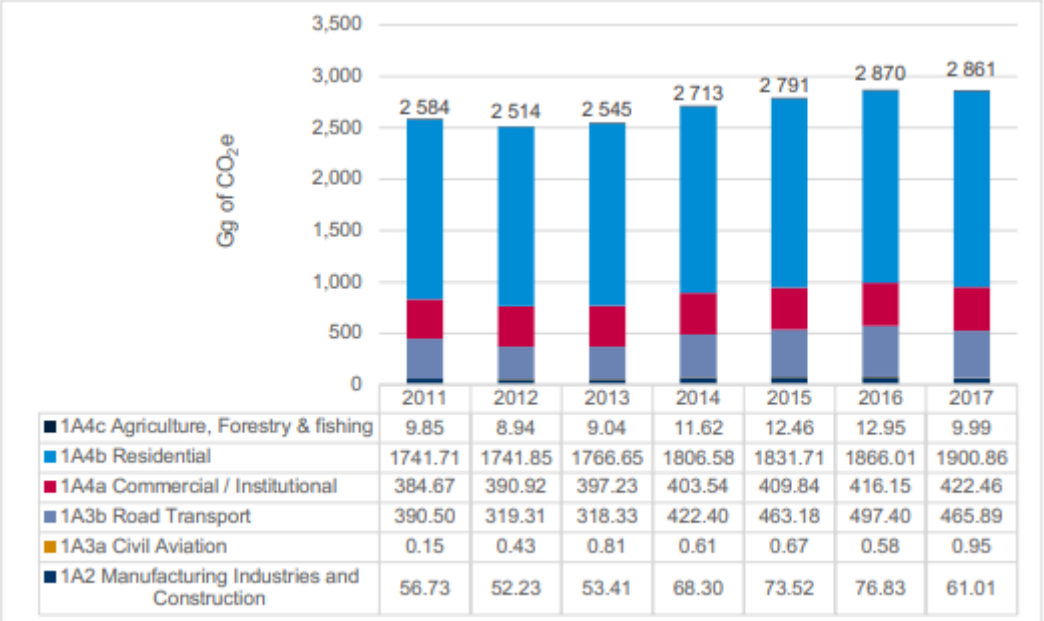
Electricity Generation: Lesotho has taken several initiatives to implement sustainable energy programmes. Key principles in the Energy Policy (2015) guide the country to further develop indigenous renewable energy sources to the optimum level, diversify the generation mix and minimise dependence on imported fossil fuels. It is stated that renewable energy sources should be developed considering resource potential, economics, maturity of technology and quality of supply. These initiatives are expected to bring renewable energy-based power generation to the fore-front. The power sector, for example, has enabled private investment in renewable energy by supportive policy instruments such as Mini-Grid Power Generation, Distribution and Supply Regulations, 2021 (GoL, 2021). Energy efficiency has been incentivised by high energy rates.

Transport: Globally, the transport sector is key in reducing CO_2 emissions. The sector accounts for over 90% of primary oil demand and is responsible for 22% CO_2 emissions from fuel combustion (IEA, 2010). While Africa has comparably low CO_2 emissions from transport (215 kg CO2/per capita in 2008), they are expected to increase with the increase in Africa's total oil demand (from 2.98 million barrels per day in 2008 to 3.7

million in 2030). The transport sector for its part remains a major consumer of fossil fuels. The increase in private vehicle use in urban areas has increased traffic congestion, road accidents and air pollution, and in turn impacts the economy, environment, and society. Under the BAU scenario, the share of public transportation will decline further. However, the updated NDCs are expected to re-invigorate public transportation. Investments in safe, reliable, accessible, and comfortable public transportation can encourage the shift from private to public. An increase in public transport will reduce traffic delays and congestion. Improvement of energy efficiency/fuel economy in the transport sector becomes a national priority to save foreign exchange contributing to the economy, local and global air pollution, apart from its contribution to GHG emissions reduction as stipulated through the NDCs. The majority of vehicles in Lesotho originate from Japan, imported as reconditioned units, usually more than 5 years old. The current motorised vehicle fleet is approximately 230,000 vehicles, up from 151, 081 in 2017, with the average age of vehicles being more than 15 years old. Public passenger transport in Lesotho is a mix between cars, minibuses and buses.

2.2. GHG Emissions from Fuel Combustion Sectors 2011 – 2017

Figure 4 presents the breakdown of national GHG emissions in Lesotho between 2011 and 2017, disaggregated by category.



	2011	2012	2013	2014	2015	2016	2017
1A4c Agriculture, Forestry & fishing	9.85	8.94	9.04	11.62	12.46	12.95	9.99
1A4b Residential	1741.71	1741.85	1766.65	1806.58	1831.71	1866.01	1900.86
1A4a Commercial / Institutional	384.67	390.92	397.23	403.54	409.84	416.15	422.46
1A3b Road Transport	390.50	319.31	318.33	422.40	463.18	497.40	465.89
1A3a Civil Aviation	0.15	0.43	0.81	0.61	0.67	0.58	0.95
1A2 Manufacturing Industries and Construction	56.73	52.23	53.41	68.30	73.52	76.83	61.01

Figure 4: Breakdown of GHG emissions in Lesotho: 2011 – 2017 (LMS, 2019)

Lesotho's GHG emissions from the energy sector were 2,583.6 Gg CO_2e in 2011, and steadily increased 2,861.2 Gg CO_2e by 2017. The residential sub-sector, particularly the burning of biomass (wood, shrubs, dung and crop residues) accounted for the largest share of the sector's emissions at 66.44% in 2017. Reduced consumption of diesel and petrol in 2012 and 2013 led to a decrease in GHG emissions to 2,513.7 Gg CO_2e and 2,545.5 Gg CO_2e respectively. Overall, emissions from the energy sector increased by 10.74% from 2011 to 2017. The average annual growth rate for the residential sector is 1.5%, 1.6% for the commercial/institutional sector, and 51.8% for civil aviation.

Lesotho's transport sector GHG emissions are growing rapidly, at an average annual growth rate of 4.1%. Transport sector emissions were 390.65 Gg CO_2e in 2011, increasing to 466.85 Gg CO_2e in 2017 representing 16.28% of Lesotho's net total Energy Sector CO2e emissions. The majority of emissions come from road transport, accounting for 99% of total CO_2e emissions from the transport sector. GHG emissions from commercial/institutional sectors amounted to 384.67 Gg CO_2e in 2011 and 422.46 Gg CO_2e in 2017, (LMS, 2019).

Based on trends in the last ten (10) years of imported petroleum-based products, the transport subsector has grown as the country's largest user of total petroleum-based products. Consumption of petroleum products increased by 14% from 227,125 kiloliters in 2016/17 to 258 972 kiloliters in 2019/20. Most vehicles in the country are often poorly maintained. It is therefore highly probable that emissions of CO_2 from the transport sector will increase in future due to the increased consumption of petroleum-based products in the sector. Consequently, the Energy sector, based on trends and expert opinions, is likely to grow significantly and concurrent with this would be an increase in the total GHG emissions.

National planning for GHG mitigation should take into account more recent macro-economic data and trends. Real GDP contracted by 3.2% and 1.2% in 2017 and 2018, respectively, before rebounding and expanding by 2.6% in 2019. It then contracted sharply by 6.5% in 2020 largely due to the COVID-19 related restrictions and several country lockdowns. The downturn continued into 2021, with the economy contracting by 11.1% in the first quarter, after which it recovered and expanded by 10.5% and 2.2% in the second and third quarters of 2021, respectively. Real GDP growth is projected to average 2.1% between 2022–2024. The expected recovery in the medium term is set to be led by a rebound in the mining, manufacturing (including textiles) and construction activities on the back of supportive external demand conditions and improved business and consumer confidence. These sectors consume a considerable

amount of energy continually for their operations. In 2017/18 and 2018/19 years, these sectors combined, consumed 309,007.48 MWh and 319, 235.54 MWh respectively both equivalent to around 60% of the national consumption (Government of Lesotho, 2018).

In the medium-term, economic growth is expected to be boosted by construction-related projects including the second phase of the Lesotho Highlands Water Project (LHWP II), the Lesotho Lowlands Water Development Projects (LLWDP I and II), government roads construction projects and the Maseru district hospital construction. In light of these economic trends, it appears likely that future efforts to mitigate GHG emissions in Lesotho will increasingly need to focus on energy consumption (demand-side management such as energy efficiency and saving), renewable energy development, and production activities.

Over the years, Lesotho has been implementing several mitigation technologies in the energy sector, both renewable technologies and energy efficiency measures, although at varying scales of application. In this regard, several national plans, initiatives and policy documents such as the National Strategic Development (NSDP) II (Government of Lesotho, 2018) are being followed to transform and diversify the energy sector. Lesotho's Energy Policy 2015-2025 vision is: "Energy shall be universally accessible and affordable in a sustainable manner, with a minimal negative impact on the environment" (DoE, 2015).

3. Revision Process: Methodology and Approach

3.1. Methodology and Approach

To meet the requirements of the ICAT Project, a mixed-methods approach was utilized for effective delivery of the NDC revision process. This involved extensive document review, data collection, model development and validation, as well as key stakeholder consultations.

Desk Review of Pertinent Documents: As a first step, an initial assessment of existing mitigation measures against **SMART** (*Specific, Measurable, Actionable, Relevant and Time-bound*) criteria was conducted. This was followed by a comprehensive desk review of pertinent documentation including technical publications, sector specific reports and other research papers. Additionally, other relevant literature was consulted, including but not limited to the following documents: 2023 Draft Lesotho's updated NDC (excluding the energy sector), Lesotho Climate Change Policy and **Implementation**

Strategy (2017), Lesotho's 3rd National Communication (2021) including the inventory of greenhouse gases prepared for the TNC, Lesotho's 1st Biennial Update Report (2021), **National Strategic Development Plan (2018/19 – 2022/23), and Lesotho Energy Policy 2015 – 2025. The review and all recommendations from this study were intended to serve as a starting point for technical expert input and consultations.** The National Sustainable Energy Strategy looks to introduce new emissions reducing technologies and encourage healthier practices that are more energy-efficient.

Key Stakeholders' Consultations: The analysis was further enhanced through separate discussions and interview with key stakeholders to understand the development priorities, institutional structures, public finance availability and financing, and capacity needs for the NDC in the energy sector. A list of key stakeholders was developed, and stakeholder engagement plans were rolled out to ensure meaningful engagement and participation of key stakeholders in the NDC revision process. Stakeholders were categorized according to relevant indicators and considerations, including technical experts, government officials, the private sector, non-governmental organizations, and academia to ensure the full participation of cross section of the citizenry. These stakeholders were engaged through various platforms such as email exchanges, telephone communications, virtual and physical meetings. The discussions reassessed the existing energy sector NDC´s targets and put forth recommendations including the analysis and inclusion of new targets, as well as the identification of additional subsectors, for inclusion in Lesotho's revised NDC.

The assessment also **aims** to better understand the identification of opportunities and support provided by external **organizations** to complete the **NDC** and conduct mitigation **analysis,** including **modeling activities.** It also **attempts** to **analyze trends in** NDC implementation in the energy sector, using key **elements related** to the Enhanced Transparency Framework (ETF)[2] of the Paris Agreement, the **regulatory** framework, and institutional arrangements. It also analyzed the NDC implementation trends in the energy sector, using key factors linked to the Enhanced Transparency Framework (ETF) of the Paris Agreement, the legal framework, and institutional arrangements.

3.2. Identify policies and actions to achieve the proposed mitigation options

[2] The ETF guides countries on reporting their GHG emissions, progress toward their NDCs, climate change impacts and adaptation, support provided and mobilized, and support needed and received.

Lesotho Government has developed Lesotho **Electrification Master Plan in 2018**, **Lesotho Power Generation Masterplan in 2010**, **Framework for Private Sector Investment in Electricity Generation, Distribution And Supply (*A Guide For IPP And PPP for On-Grid and Off-Grid Development*) in 2023, and Renewable Energy Potential Maps for Lesotho in 2020 for three major** renewable energy resources - solar, wind and hydro, considering the seasonal variations and geographic segmentation. Presently, the Government of Lesotho is in the process of developing **Least-cost Power Development Plan for Lesotho** that outlines the energy mix that the country is recommended to adopt over a specified planning period to meet its energy needs in a cost-effective, sustainable, and environmentally responsible manner. Therefore, these renewable energy capacities appearing in these documentations were considered as mitigation measures.

To achieve the goals and the NDC targets, different policies and actions have been proposed. The proposed actions and policies which will contribute to achieve the revised and updated NDC are listed in Table 3.

Therefore, Lesotho's updated NDC related to energy sector including transport sub-sector consists of 14 **NDC measures under unconditional and conditional scenarios**. The main NDC measures are listed in the table below.

Table 3: Recommendations, inputs and actions related to the updated NDC in Unconditional and Conditional Scenarios

No.	Revised/Updated Mitigation Options List	Proposed Actions/Policies	Unconditional scenario (value in 2025)	Conditional scenario (value in 2025)	Unconditional scenario (value in 2030)	Conditional scenario (value in 2030)
1	Efficient Woodstoves	Scale up access and adoption of clean and efficient cooking and heating technologies to *reduced dependence on traditional biomass fuels*	1250 stoves	2800 stoves	9030 stoves	30800 stoves
2	Biogas Plants	Scale up access and adoption of Biogas Technology for cooking and lighting	900 stoves	2800 stoves	6 300 stoves	12 600 stoves
3	Solar LED Lamps	Distribution of Potable Solar LED Lamps (Solar lanterns) to replace paraffin and candles for lighting in the rural households	7000 solar LED Lamps	15000 solar LED Lamps	32 025 solar LED lamps	64 050 solar LED lamps
4	LPG Stoves Replacing Wood Stoves	*Scale up access and adoption of LPG for cooking and heating*	800 stoves	1400 stoves	8 820 stoves	31 500 stoves
5	Solar Cooking	Scale up access and adoption of Solar Cooking Technologies to *reduced dependence on traditional biomass fuels*	350 stoves	2800 stoves	8400 solar cookers	9450 solar cookers
6	Solar Home Systems	Scale up SHS for lighting in non-electrified rural households	250 SHS	1400 SHS	10500 SHS	28000 SHS
7	More Efficient Gasoline Cars	Legislative frameworks and smart incentives to promote uptake of fuel-efficient gasoline cars	175 cars	655 cars	21838 cars	43677 cars
8	More Efficient Diesel Cars	Legislative frameworks and smart incentives to promote uptake of fuel-efficient diesel cars	44 cars	131 cars	4368 cars	8735 cars
9	Restriction Of Imported Used Cars	Legislative frameworks to restrict import of used, high-emitting and fuel-inefficient vehicles/cars	0 cars	0 cars	15287 cars	15287 cars

10	New Bicycle Lanes: *Create Secure and Attractive Urban Cycling*	Promotion and development of non-motorized transport (NMT) infrastructure to promote sustainable, carbon neutral modes of transport (e.g. cycling, walking)	3.5 km	10 km	15 km	30 km
11	Electrification (*Number of Additional Households Connected to the Grid*)	Increase electricity access for households to 75% *(compared to BAU of 48% in 2017) to reduce dependence on biomass and paraffin*	12917 households connected	25833 households connected	44330 households connected	134332 households connected
12	Solar Water Heater Residential	Scale up access and adoption Solar Water Heaters (SWH): Residential		0		11200 solar water heaters
13	Landfill Gas (LFG) Plant with Power Production[3]	Methane capture at landfills and waste dumps for energy production		33.1 tons per day		1171 tons per day
14	Two Wheelers	Introduction of Electric Two Wheelers		90 electric two wheelers		910 electric two wheelers

[3] In terms of challenges, Lesotho urban local authorities are experiencing major challenges in managing solid waste due to population growth, urbanization, industrialisation and increased use of non-biodegradable plastics and bottles. Other challenges include the need to train engineers for the waste-to-energy projects.

There are three mitigation options which are not supported by the GACMO tool and they were not considered in the analysis. It is proposed that these options be part of the options available for the country though they require further scrutiny before they are incorporated in the detailed options available for the country, The options referred are the following:-

Table 4. Mitigation Options Not Supported by GACMO

No.	**Mitigation options**	**Proposed Actions/Policies**
15	Shifting Passengers from Mini-Buses to Buses	Invest in public transport infrastructure and awareness to support a modal shift
16	Shifting Passengers from Private Cars to Buses	Improve public road transport for reliability, accessibility, availability, comfort and safety
17	Expansion of Isolated Solar PV Mini-Grids	Expansion of isolated solar PV mini-grids for lighting and water heating in rural communities

3.3. Applicability of the GACMO tool for the proposed updated NDC

The Greenhouse gas Abatement Cost Model (GACMO) was used to quantify the mitigation potential of each mitigation action. In addition, it allows to scale the size of mitigation options and to provide a quick overview of the total effort to reduce GHG emissions. Moreover, the calculation is transparent and easy to follow. Table 4 provides the applicability of the GACMO tool to the identified mitigation actions/policies.

Table 4: Applicability of GACMO tool to the identified mitigation actions

No.	Revised/Updated Mitigation measures	Applicability of GACMO tool	GACMO Technical Area /Methodology for estimating GHG reduction.
1	Efficient Woodstoves	Yes	Emission reduction per stove taken from the CDM project, Efficient Fuel Wood Stoves for Nigeria, 2.72 tons of CO_2eq reduction from 1 stove[4].[5]
2	Biogas plants	Yes	Mostly default parameters of GACMO: 2 m^3 biogas plant feed with cattle dung and other organic waste produce biogas for cooking purpose and heating of hot water. 253 USD cost of 1 bio-digester. Biogas replaces kerosene for cooking[6].
3	Solar LED Lamps	Yes	Hourly consumption of kerosene taken from the CDM PoA project "*Project to replace fossil fuel based lighting with Solar LED Lamps in East Africa*", 0.077 litres/hour[7]
4	LPG Stoves Replacing Wood Stoves	Yes	Mostly default parameters in GACMO. LPG stoves replace firewood stoves[8]. [9]
5	Solar Cooking	Yes	This option is not available in GACMO. It is assumed that solar cookers replace kerosene. *Daily kerosene consumption is approximately 1.5 litres per day (cooking, water heating and lighting).*
6	Solar home systems	Yes	Default parameters of GACMO. Assumed 0.25 litre per day kerosene replaced by solar home system
7	More efficient gasoline cars	Yes	Default parameters in GACMO
8	More efficient diesel cars	Yes	Default parameters in GACMO
9	Restriction of imported used cars	Yes	Default parameters in GACMO

[4] https://cdm.unfccc.int/Reference/PDDs_Forms/PDDs/PDD_form02_v03.doc

[5] The cost of "ACE One" Stove = USD130/stove

[6] Average daily kerosene consumption estimated at approximately 1.5 liters per day (cooking, water heating and lighting).

[7] https://cdm.unfccc.int/ProgrammeOfActivities/poa_db/O9IA02HVDBLZME3FNJYW6CR48U7QKG/4F3KT1LMPE0UDNSR28VBI9G76ZQOCY/DOEDocBefReview/PoA%20design%20document

[8] Firewood consumption (for cooking and water heating): 11 kg/day/household.

[9] Emissions from the wood stove 2.2 per stove, which is in line with this CDM project (CDM: Efficient Fuel Wood Stoves for Nigeria (unfccc.int)) where the emissions from the inefficient wood stove is 2.77 tons CO2e/stove.

10	New bicycle lanes: *Create secure and attractive urban cycling*	Yes	Default parameters in GACMO for new bicycle lanes
11	Electrification (*number of additional households connected to the grid*)	Yes	Not available in GACMO. Assumed they replace 1.5 litre of kerosene per day per household.
12	Solar water heater residential	Yes	Assumed that it replaces firewood, 11 kg per day per household firewood consumption
13	Landfill gas plant with power production	Yes	Default parameters in GACMO
14	Two wheelers	Yes	Default parameters in GACMO
15	Shifting passengers from mini-buses to buses	No	Not yet incorporated in GACMO
16	Shifting Passengers from Private cars to Buses	No	Not yet incorporated in GACMO
17	Expansion of isolated solar PV mini-grids for lighting and water heating in rural communities	No	Not yet incorporated in GACMO

The success in the implementation of the mitigation measures in the energy sector will largely depend on overcoming a number of barriers. The main challenges are the lack of funding for large capital projects, and the absence of supportive policy measures such as tax benefits and low-interest financing to expedite the implementation of renewable energy development and energy efficiency improvement programmes. The electricity grid will also require upgrading to accommodate the numerous renewable energy projects that are planned.

The Lesotho Electricity Company draws predominantly from hydropower and maintains a national grid. The grid emission factor of Lesotho is 0.0 tCO_2/MWh (*the rest of the SAPP's operating grid emission factor is 0.9958 tCO_2/GWh)*[10]*.* Therefore several mitigation options based on renewable energy power generation projects have been excluded from this analysis:

The other mitigation options of the energy sector, such as ***shifting passengers from private cars to public transport***, ***reducing traffic congestion in order to reduce GHG emissions, improving road infrastructure including bridges, efficient operation of public transportation and e-commuting*** do not have calculation options in the GACMO tool, so it is proposed to build more options consistent with the options in the report of Lesotho. In order for Lesotho experts to build their own spreadsheets for new options to take the initiative in calculation, specific guidelines should be included in developing the model.

Co-Benefits of Identified Mitigation Measures: Adaptation is the over-riding priority for Lesotho given her vulnerability profile, an assessment of all the proposed mitigation actions was done to understand any impacts on climate resilience, positive or negative. Several mitigation measures have adaptation and broader sustainable development co-benefits including but not limited to the following:

- Increased uptake of biogas will lead to improved air quality, health and gender outcomes.
- Increased composting and waste-to-energy processing will result in employment creation and reduced pollution to soil and water bodies.
- Improved fuel efficiency will lead to reduced fuel imports, improving Lesotho's balance of trade and macroeconomic stability.
- Increased public transport will lead to increased mobility for low-income populations.

[10] Grid emission factor refers to a CO_2 emission factor (tCO_2/MWh) which will be associated with each unit of electricity provided by an electricity system.

A number of benefits are anticipated from energy efficiency policies, with few risks identified. Many of the measures are likely to lead to the creation of green jobs but ameliorative action might need to be taken to soften the blow of job losses (for example from moving from smaller commuter buses to bigger buses to curb emissions from public transport).

The Government of Lesotho recognises that gender equality is central to climate action and a prerequisite for poverty reduction, food and nutrition security and sustainable development. As part of the update of the NDC, an assessment was made of the potential gender impacts of the policies and measures needed to deliver the mitigation contribution, drawing on previous analysis[11]. As a result of this analysis the many gender-related benefits of the measures in each sector were highlighted to help Lesotho plan future policies in a way that mitigates potential negative impacts on gender equality.

Ensuring the representation and participation of all Basotho in the development and implementation of the NDC is critical to ensuring its effectiveness. In particular, the issues of youth and gender must be considered integral to the process. The specific sensitivities and vulnerabilities of young people and women to the impacts of climate change and their essential role in achieving the emissions reductions targets demonstrate their importance as key stakeholders in the achievement of Lesotho's revised NDC.

3.4. Assumptions and methodological approaches for emissions projections

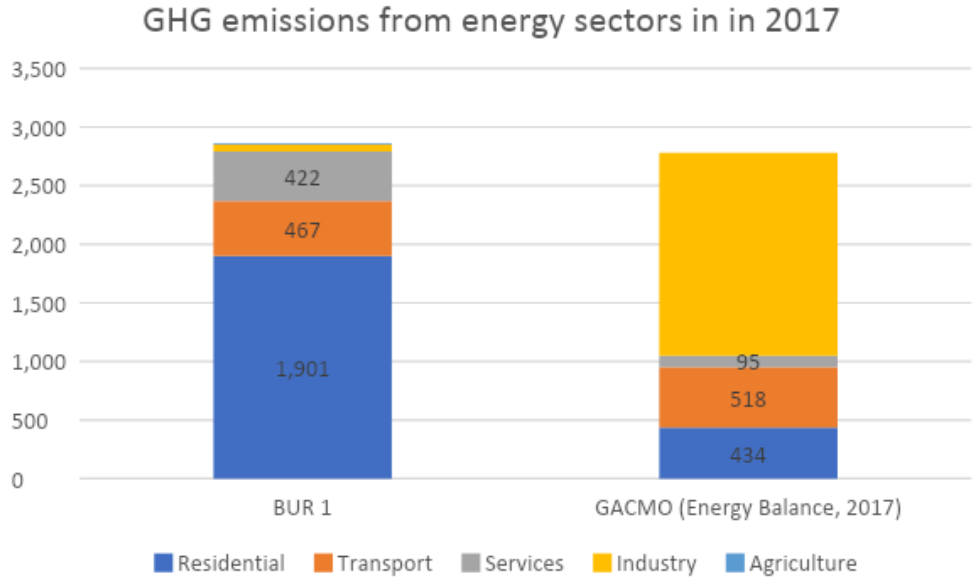
Main input data and assumptions used in the GACMO tool

Start Year: In GACMO, the Energy Balance for the Start Year was based on UN Statistics Division Energy Balance for Lesotho in 2017[12]. This data source was selected because the total emissions for 2017 align more closely with the total emissions in the GHG inventory for 2017 reported in BUR1. However, there are notable differences in sectoral emissions, with *the industry sector showing high energy consumption, while BUR1 assigns high values of fuels to the residential sector.* The total difference in GHG emissions across all sectors is 13%

[11] UNDP Lesotho (2022): Policy Brief on Gender and the Revision of the National Determined Contributions
[12] https://unstats.un.org/unsd/energystats/pubs/balance/documents/2018balance.pdf

Biomass fuels were not accounted for in the Energy Balance to avoid double counting with the AFOLU sector.

The comparison below shows the GHG emissions from energy sectors in the inventory (BUR1) compared to the GHG emissions in GACMO for the Start Year, (2017 UN Statistics Division Energy Balance for Lesotho).



Source (Author)

Growth rates: Assumed annual growth rate for BAU scenario based on the historical growth rate from BUR1 (2011-2017):

- Industry 2.3%
- Transport 4.1%
- Households 1.5%
- Services 1.6%
- Agriculture 1.5%

2017 has been considered as the base year: The Business As Usual (BAU) Scenario has also been established considering the same year. As such, the values of the parameters for the baseline scenario were based on the year 2017. However, the latest available data were taken into account in the absence of the data for the project implementing year.

Lesotho's 4th National Greenhouse Gas Inventory Report 2019 (LMS, 2019) and **Lesotho's 1st Biennial Update Report 2020 (LMS, 2021)** constitute the basis for the projection of GHG emissions in the baseline scenario. Activity data were extracted from

these reports, where possible, as a basis for the projection. Where activity level data was not available, the baseline emissions were projected using an annual population growth of 0.72% up to 2035 and a projected GDP growth of 2.6% annually.

Project scenario: The period for achieving the updated NDC´s targets is 2017-2030.The growth rate for different sectors was based on the list given above. Where historical data are not available, the latest available values were taken into account.

Key actions targeted for mitigation in the Energy sector include: Improved government direction and policy certainty for markets through the development of policy and strategy documents, **substitution** of lower-emission energy sources **and reduction of traditional household fuels, especially firewood, dung and illuminating paraffin for the areas that cannot be effectively electrified,** Expansion of Rural Electrification, Clean and Efficient Cooking and Lighting Technologies, Energy efficiency and conservation, Establishing Energy Efficient and Environmentally Sustainable Transport Systems.

The extent of implementation and achievement of the conditional target as proposed in this updated NDC are mainly conditioned upon the provision of adequate means of implementation (financial resources, capacity building and technology transfer, etc.) by the international community. This condition does not, however, constitute an international obligation to Lesotho. The government is also committed to unconditionally support the implementation and achievement of Lesotho's overall targets through other financial mechanisms including the traditional budgetary allocation to the environment sector.

Emission reductions: Emissions reductions in the year 2030 will be calculated using the following formula.

Emission reductions = **Emissions in BAU scenario** – **Emissions in Project scenario**

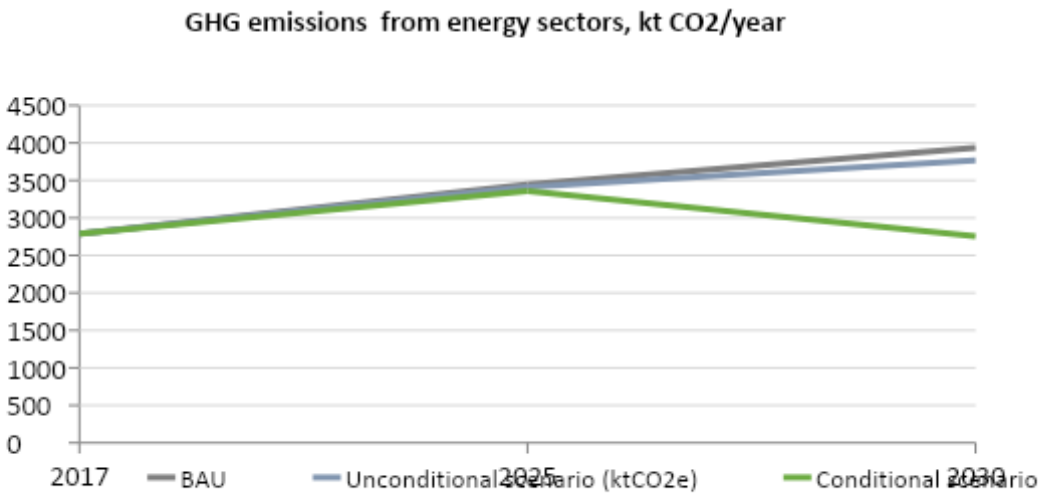


Figure 5: Trajectory of Lesotho's conditional and unconditional contribution (**Energy Sector**) for the period 2017-2030 (using GACMO tool), based on GHG inventory data from the year 2017

- Unconditional scenario reduces GHG emissions by **4.2%** by 2030 compared to BAU scenario in 2030.
- Conditional scenario reduces emissions by **30.1%** by 2030 compared to BAU scenario in 2030.

Lesotho defines unconditional policy responses as actions outlined in national plans and programmes that are prioritized for domestic investments (both public and private) and can be implemented using domestic capacity. These actions are expected to result in a 4.2% reduction in GHG emissions compared to the BAU scenario for the period 2017-2030. Examples include the ongoing electrification through grid extension, with a government of electrifying 15,500 households per year, and innovative private sector initiatives in the sales and distribution of efficient cookstoves.

Conditional policy responses require external support including financing, technology transfer, and capacity building. Many conditional actions are constrained by their lack of market readiness (economic viability) and the immaturity of the technology. Conditional measures form the majority of the actions described in the sector. These actions are important for long-term course-change in the sector. Lesotho is keen to propel its growth by enabling better rural services, improving liveability and efficiency in urban areas and encouraging the growth of services and manufacturing. In this background, conditional scenario has been framed around an analysis that presents the country's commitment to maintaining its trajectory of low-emission growth with international financial and technical assistance. These conditional NDC actions account for an

additional 25.8% of GHG emissions reduction respective to the BAU scenario for the period 2017-2030.

Expected Trajectory: In meeting its targets, Lesotho expects its emission trajectory to be as follows:

- Unconditional: To reach 3,414 ktCO2eq in 2025 and 3,770 ktCO2eq in 2030, decreasing by 0.8% and 4.2% compared to BAU emission in 2025 and 2030, respectively,
- Conditional: To reach 3,357 ktCO2eq by 2025 and 2,753 ktCO2eq by 2030, decreasing by 2.5% and 30.1% compared to BAU emission in 2025 and 2030, respectively.

Table 5: GHG emissions reduction targets as derived from GACMO

	2017	**2025**	**2030**
Population (thousands)	2171	2299	2383
GDP (Current MUS$)	2310	2837	3225
BAU energy CO2 emissions (ktCO2)	2367	2923	3341
BAU other gases GHG emissions (ktCO2e)	422	521	595
BAU GHG emissions (ktCO2e)	**2789**	**3443**	**3936**
Unconditional Mitigation (ktCO2e)	0	29	166
Unconditional scenario (ktCO2e)	**2789**	**3414**	**3770**
Unconditional scenario reduction (%)	0.0%	0.8%	4.2%
Conditional Mitigation (ktCO2)	0	86	1183
Conditional scenario (ktCO2)	**2789**	**3357**	**2753**
Conditional scenario reduction (%)	0.0%	2.5%	30.1%
Total tCO2-e/capita in BAU	1,3	1,5	1,7
Total tCO2-e/1000US$ in BAU	1,2	1,2	1,2

3.5. Applications of the GACMO tool

Mitigation potential: Evaluation for GHG reduction by selected mitigation options

Results of cost calculation and GHG emission reduction potential using GACMO tool are as follows:

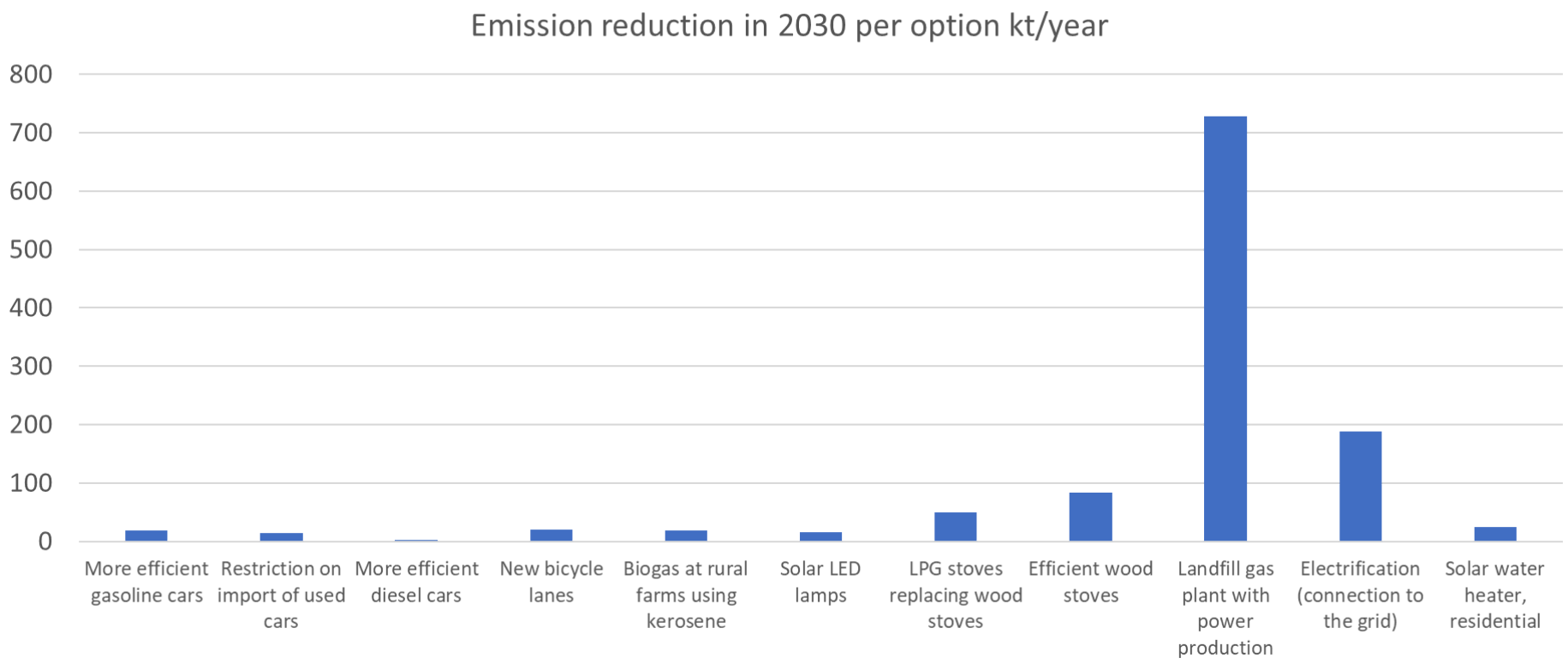
Table 6: Emission reduction potential of proposed mitigation actions

Reduction option	**Measure**	**Emission reduction in 2030 per option kt/year**

Efficient wood stoves	1	83,16
Biogas at rural farms using kerosene	2	18,18
Solar LED lamps	3	16,21
LPG stoves replacing wood stoves	4	49,62
Solar house PVs	6	6,57
More efficient gasoline cars	7	17,86
More efficient diesel cars	8	1,57
Restriction on import of used cars	9	14,24
New bicycle lanes	10	20,60
Electrification (connection to the grid)	11	187,93
Solar water heater, residential	12	24,73
Landfill gas plant with power production	13	728,45
Solar cooking	5	13,48
Electric two-wheelers	14	0,21

Emission reductions were computed using the GACMO tool. The model's calculation results in Table 5 indicate that the greatest potential for emission reduction was from the measure 13, which is ***Landfill Gas (LFG) Utilisation*** followed by measure 11, ***Electrification (Connection to the Grid)*** and measure 1, ***Efficient Wood Stoves***. These results are visually represent in Figure 5, showing the emission reduction potential for each option in kt/year.

Figure 5: Emission reduction in 2030 per mitigation option (kt/year) (Author using GACMO tool)



3.6. Assessment of Sustainable Development Impacts

Table 7 below provides a summary of the Implementation Plan for each mitigation measure, organized by sector. It includes information on the government ministries responsible, implementing entities, planned timeline, adaptation and resilience co-benefits, and alignment with the UN Sustainable Development Goals. It is important to note that all mitigation measures have a notable impact on Energy (SDG 7) and Climate Action (SDG 13), with some measures also contributing to other SDGs.

Table 7: Mitigation Measures for the Energy Sector, Alignment with SDGs and Timelines

Residential Subsector										
Mitigation Measure	**Indicator (s)**	**Baseline (2023)**	**2030 Target**	**Responsible Department**	**Other Key Implementing Entities**	**Adaptation and Resilience Co-Benefits**	**Alignment With SDGs**		**Timeline**	
									2023 - 2025	**2025 - 2030**
Efficient Woodstoves: Dissemination of modern efficient cook stoves to 80% of the rural population and 50% of the urban population by 2030, achieving a more sustainable balance between supply and demand of biomass, and reducing firewood and fossil energy consumption for cooking	Percentage of households and rural institutions using Efficient Woodstoves.	No available information was found on percentage of households and institutions	30,800 stoves by 2030	Department of Energy, Department of Forestry	District Forestry Offices, District Councils, NGOs, Area and Village Development Committees	Reduced demand for traditional biomass, which helps to reduce pressure on forestry resources with associated reduced impacts from extreme rainfall events.			✔	✔

Biogas Plants: *Increased use of on-farm anaerobic digestion of manure for bioenergy (bio-digesters).*	Percentage of households and rural institutions using Biogas Plants	No available information was found on percentage of households and institutions	12,600 plants by 2030	Department of Energy, Department of Environment, Local Government	District Councils Private Sector, CSOs, NGOs	Reduced dependence on traditional biomass fuels, which is vulnerable to climate variability. Reduced pressure on forests and forest biodiversity. Increased off-farm business for rural community having access to energy also increases adaptive capacity.			✔	✔
Solar LED Lamps	Percentage of households and rural institutions using Solar LED Lamps	No available information was found on percentage of households and institutions	64,050 LED lamps by 2030	Department of Energy	District Councils Private Sector, CSOs, NGOs	**Increased opportunities for education, indirectly increasing population resilience to extreme weather events. Reduced household expenditure on energy enhances resilience.**			✔	✔
LPG Stoves Replacing Wood Stoves: *Deployment of efficient LPG cook stoves to urban and rural households,*	Percentage of households and rural institutions using LPG Stoves to replacing Wood Stoves:	No available information was found on percentage of households	31,500 stoves	Department of Energy, Ministry of Local Government	District Councils Private Sector, CSOs, NGOs	Reduced dependence on traditional biomass fuels, which is vulnerable to climate variability. Reduced pressure on forests			✔	✔

thereby reducing demand for fuel wood.		and institutions				and forest biodiversity. Increased off-farm business for rural community having access to energy also increases adaptive capacity.				
Solar Cooking	Percentage of households and rural institutions using Solar Cookers	No available information was found on percentage of households and institutions	9,450 solar cookers	Department of Energy, Ministry of Local Government	District Councils Private Sector, CSOs, NGOs	Reduced dependence on traditional biomass fuels, which is vulnerable to climate variability. Reduced pressure on forests and forest biodiversity. Increased off-farm business for rural community having access to energy also increases adaptive capacity.			✔	✔
Solar Home Systems: *Scale up SHS for lighting, phone charging, etc. in selected non-electrified rural households by Lesotho Government, Development Partners and Private Sector,*	Percentage of households and rural institutions using Solar Home Systems		31,500 SHS	Department of Energy, Local Government	District Councils Private Sector, CSOs, NGOs	Reduced dependence on paraffin, increased opportunities for education, indirectly increasing population resilience to extreme weather events. Reduced household			✔	✔

and Non-Governmental Displacement of kerosene for domestic energy use						expenditure on energy enhances resilience.				
Increased Electrification Access (Increasing *number of households connected to the grid for lighting, cooking and space heating. Displacement of traditional biomass fuels, diesel and kerosene for domestic energy use*	Number of Additional Households Connected to the Grid		134,332 additional households connected to the grid	Department of Energy, , Local Government, Department of Energy	IPPs, Private Sector, Department of Lands, LEC	Reduced dependence on fossil fuels including imported liquid fuels, the supply and distribution of which are vulnerable to climate impacts both globally and regionally.			✔	✔
Solar Water Heater (Residential): *Installation of solar thermal water heaters within residential buildings supported by use of loans and grants to subsidise purchase costs*	*Number of additional households with SWH*		11,200 SWH installed by 2030 countrywide	Department of Energy, Local Government	Private Sector, District Councils, NGOs	**Improved climate resilience of buildings and reduced reliance on material and energy consumption, including energy imports.**				

Transport Subsector										
Mitigation Measure:	**Indicator(s)**	**Baseline (2022)**	**2030 Target**	**Responsible Department**	**Other Key Implementing Entities**	**Adaptation and Resilience Co-Benefits**	**Alignment With SDGs**		**Timeline**	
									2023 - 2025	**2025 - 2030**
More Efficient Gasoline Cars: *Reduction of GHG and local emissions from gasoline use*	Number of Efficient Gasoline Cars	No specific guidelines established	43,677 cars	Ministry of Transport, Ministry of Energy	Private sector	Decreased dependence on imported fossil fuel energy products. Improved health and reduction of harmful local air pollutants, enhancing resilience of population to disease and adverse climate impact.			✔	✔
More Efficient Diesel Cars: *Reduction of GHG and local emissions from diesel use*	Number of Efficient Diesel Cars	No specific guidelines established	8,735 cars by 2030	Ministry of Transport, Ministry of Energy	Private sector	Decreased dependence on imported fossil fuel energy products. Improved health and reduction of harmful local air pollutants, enhancing resilience of population to disease and adverse climate impact			✔	✔

Restriction of Imported Used Cars: *Measures introduced to increase vehicle emissions performance, including tax incentives and scrappage of older vehicles, and inspection*		No specific guidelines established	15,287 cars by 2030	Ministry of Transport, Ministry of Energy	Private sector	Decreased dependence on imported fossil fuel energy products. Improved health and reduction of harmful local air pollutants, enhancing resilience of population to disease and adverse climate impact				✔
New bicycle lanes: *Create secure and attractive urban cycling*	Number of Kilometres of urban cycling routes	No specific guidelines established	*30 km of complete dedicated NMT corridors, constructed in Maseru in 2030*	Ministry of Transport, Ministry of Local Government	Private Sector, NGOs,				✔	✔
Introduction of two Wheelers	Number of Efficient Two Wheelers	910 electric two wheelers are in operation by 2030		Ministry of Transport	Private Sector					
Modal Shift: Private to Passenger *Transport:*	Percentage of passengers shift to public transport		Increasing the share of passenger transport from around 10% at present to	Ministry of Transport and Public Works	Passenger Associations, Bus Operators Associations, City Councils,	Increased resilience of transport infrastructure. Improved health and reduction of harmful local air			✔	✔

			around 30% in 2030, reducing GHG emissions from gasoline and diesel use.			pollutants, enhancing resilience of population to disease and adverse climate impacts.				

Waste-to-Energy Subsector								Timeline	
Mitigation Measure	Indicator(s)	2030 Target	Responsible Department	Other Key Implementing Entities	Adaptation and Resilience Co-Benefits	Alignment With SDGs		2023-2025	2025-2030
Introducing Landfill Gas Recovery in existing and new solid waste disposal sites *Generation of electrical power from landfill gas extraction, collection and utilization applied to sanitary landfills, resulting in reduced CH_4 from landfill sites and avoided CO_2 from displacement of fossil-based energy use.*		1,171 tons/day landfill gas plant for power production	Department of Environment, Department of Energy	City and District Councils, Department of Energy, LEWA	Improved quality of water, soil and local atmosphere, increasing human and environmental resilience. Increased access to electricity and reduced dependency on traditional biomass energy. Creation of revenue generation			✓

					opportunities for urban population in the waste management process chain.				

Prioritization of mitigation actions

The most economically feasible and environmentally efficient mitigation actions can be determined by analyzing their individual GHG effects. Therefore, the new proposed measures will be ranked according to their emission reductions. The proposed measures and their corresponding GHG effects are detailed in Table 8.

Table 8: Prioritized mitigation measures.

Mitigation Measure	Measure #	Emission Reduction (tCO_2e)	SDG Impacts	Prioritization (*Rank*)
More efficient gasoline cars	7	17,86	**High**	**1**
Restriction on import of used cars	9	14,24	**High**	**2**
More efficient diesel cars	8	1,57	**High**	**3**
New bicycle lanes	10	20,60	**High**	**4**
Biogas at rural farms using kerosene	2	18,18	**High**	**5**
Solar LED lamps	3	16,21	**High**	**6**
LPG stoves replacing wood stoves	4	49,62	**High**	**7**
Efficient wood stoves	1	83,16	**High**	**8**

4. Conclusions and Recommendations

The emission reduction options available have the potential to greatly decrease high GHG emissions in the energy sector. To strike a balance between investment costs and the potential for reducing greenhouse gas emissions, it is important to consider implementing a combination of effective solutions.

The energy sector's proposed NDC target is 30.1%, with 4.2% being unconditional and 25.9% conditional. Therefore, if the proposed mitigation actions and policies are implemented as intended, Lesotho will be able to achieve its NDC targets within the targeted timeframe. In the updated NDC, Lesotho maintains its strong ambition to increase the adoption of *Clean and Efficient Cooking Technologies* to gradually reduce reliance on traditional biomass fuels.

Mitigation targets: It is anticipated that the implementation of the updated/proposed NDC will lead to a reduction in GHG emissions compared to the BAU scenario by 30.1% in the energy sector (**4.2% unconditionally and 25.9% conditionally**) equivalent to an

estimated mitigation level of 108 ktCO2e unconditionally and 3,639 $ktCO_2e$ conditionally (total of 3,747 $ktCO_2e$) of carbon dioxide equivalent during the period of 2017-2035

Recommendations:

a) The GACMO tool relies heavily on input data, and the accuracy of this data significantly impacts the calculation results. Therefore, conducting thorough research is highly recommended to ensure the data's legal basis aligns with Lesotho's context and the IPCC guidelines. With a comprehensive and adequate database, the model can validate previous national GHG mitigation efforts' results and facilitate the formulation of future mitigation strategies, providing an overview of mitigation efforts.

It is suggested to establish a dedicated NDC unit within the energy sector to oversee the management of NDC-related documents. Enhancing a project registry that lists initiatives contributing to greenhouse gas emission reductions on a shared platform will enhance stakeholder awareness and streamline the NDC revision process. Implementing digital data collection and reporting methods that link all stakeholders with the energy sector's NDC unit will enhance the effectiveness and efficiency of future NDC revisions

Some mitigation options in the energy sector, such as ***shifting passengers from private cars to public transport***, ***reducing traffic congestion to lower GHG emissions, improving road infrastructure including bridges, and promoting efficient operation of public transportation and e-commuting,*** are not included as mitigation options in the GACMO tool by default. Therefore, it is proposed to add these additional options consistent with the ones in the GACMO Tool adapted to Lesotho. Specific guidelines should be provided to Lesotho experts to help them create their own spreadsheets for these new options and facilitate their inclusion in the calculation process.

Uncertainties: Even though data were validated by the respective entities, predicted data (for the year 2030) and data extracted from different sources in the absence of country specific, project specific data might cause some uncertainties in the results.

Barriers: Major barriers to reviewing the NDC were the unavailability of the data sources used for formulating Lesotho's INDC, not having a proper reporting mechanism in place, lack of data, and delay of the data communication due to a manual process, etc.

References

DoE (2015) 'Lesotho Energy Policy 2015-2025'. Ministry of Energy, Meteorology and Water Affairs. Maseru, Lesotho.

Fuso-Nerini, F. *et al.* (2018) 'Mapping synergies and trade-offs between energy and the Sustainable Development Goals', *Nature Energy*, 3, pp. 10–15.

GoL (2021) 'Mini-Grid Power Generation, Distribution and Supply Regulations'. Government of Lesotho. Maseru, Lesotho.

Government of Lesotho (2018) 'National Strategic Development Plan II 2018/19-2022/23'. Available at: https://www.gov.ls/wp-content/uploads/2021/06/National-Strategic-Development-Plan-II-2018-19-2022-23.pdf (Accessed: 28 May 2023).

Lesotho Bureau of Statistics (2019) '2017 Household Energy Consumption Survey Analytical Report'. Bureau of Statistics. Maseru. Lesotho. Available at: https://www.bos.gov.ls/Publications.htm.

LMS (2019) 'Lesotho's 4th Greenhouse Gas Inventory Report'. Lesotho Meteorological Services. Maseru, Lesotho.

LMS (2021) 'Lesotho's 1st Biennial Update Report to the UNFCCC'. Ministry of Energy and Meteorology, Maseru, Lesotho. Available at: https://unfccc.int/sites/default/files/resource/NAI_BUR1.pdf (Accessed: 2 August 2023).

Ritchie, H., Roser, M. and Rosado, P. (2020) 'CO_2 and Greenhouse Gas Emissions', *Our World in Data* [Preprint]. Available at: https://ourworldindata.org/co2/country/lesotho (Accessed: 30 July 2023).

Annex: Proposed criteria to update Lesotho's NDC

SMART: **S**pecific, **M**easurable, **A**ctionable, **R**elevant, **T**ime bound

Specific: In order to include any mitigation options in the NDC under energy sector, there should be specific mitigation action, which have already been identified by the country.

Measurable (Measurability and Effect on GHG reduction): According to paragraph seven of Article 13 of the Paris **Agreement**, *"Each party shall regularly provide the following information; (b) information necessary to track progress made in implementing and achieving its nationally determined contributions under article four".* Measurement, reporting and verification of the progress on NDC implementation are needed to meet aforesaid international reporting requirements. Therefore, one of the main features of any NDC should be the measurability. As such, the existing NDC were assessed by exploring the availability of internationally accepted methodologies to quantify GHG effects and potential GHG reduction based on expert knowledge before applying the GACMO tool to quantify the exact emission reductions.

Actionable (*financial and political feasibility of the mitigation action*)

Financial feasibility: when selecting the most suitable mitigation actions to be included in the NDCs, it is necessary to consider whether the particular mitigation action can be implemented with the existing or potential domestic or international finance sources based on its financial assessment.

Political preference: when implementing a particular project in the country, the effect on GHG emission reduction is not the only decisive factor. Factors that will have a high influence on the policy makers will have more influence in the political decisions. As such, evaluation of the political preference in implementing those identified mitigation actions will be critical.

Relevant (*alignment of the mitigation actions with national policies and strategies*): This criterion provided an opportunity to ensure that the NDCs are well integrated with national development priorities. There are several existing national strategies and policies in relation to Energy Sector such as, **2nd National Strategic Development Plan, 2018/19 – 2022/23, National Climate Change Policy (NCCP) 2017-2027, National Climate Change Policy Implementation Strategy (CCPIS) 2017, National Communications and GHG Inventories, National Energy Policy 2015 – 2025, Scaling-Up Renewable Energy Programme (SREP) Investment Plan for Lesotho 2017 and Electrification Master Plan 2018** which specify the national priorities in

energy sector. When the NDC are based on existing policies and strategies, NDC are judged to be very ambitious and preparedness for implementation is quite advanced.

Time bound: In Decision 1/CP21, it was agreed that the information to be provided by parties communicating their NDCs, may include, as appropriate, *inter alia*: time frames and/or periods for implementation. The time-frame given in Lesotho NDC is from 2020 to 2030, and the revised Energy Sector NDC will also cover the same time period.