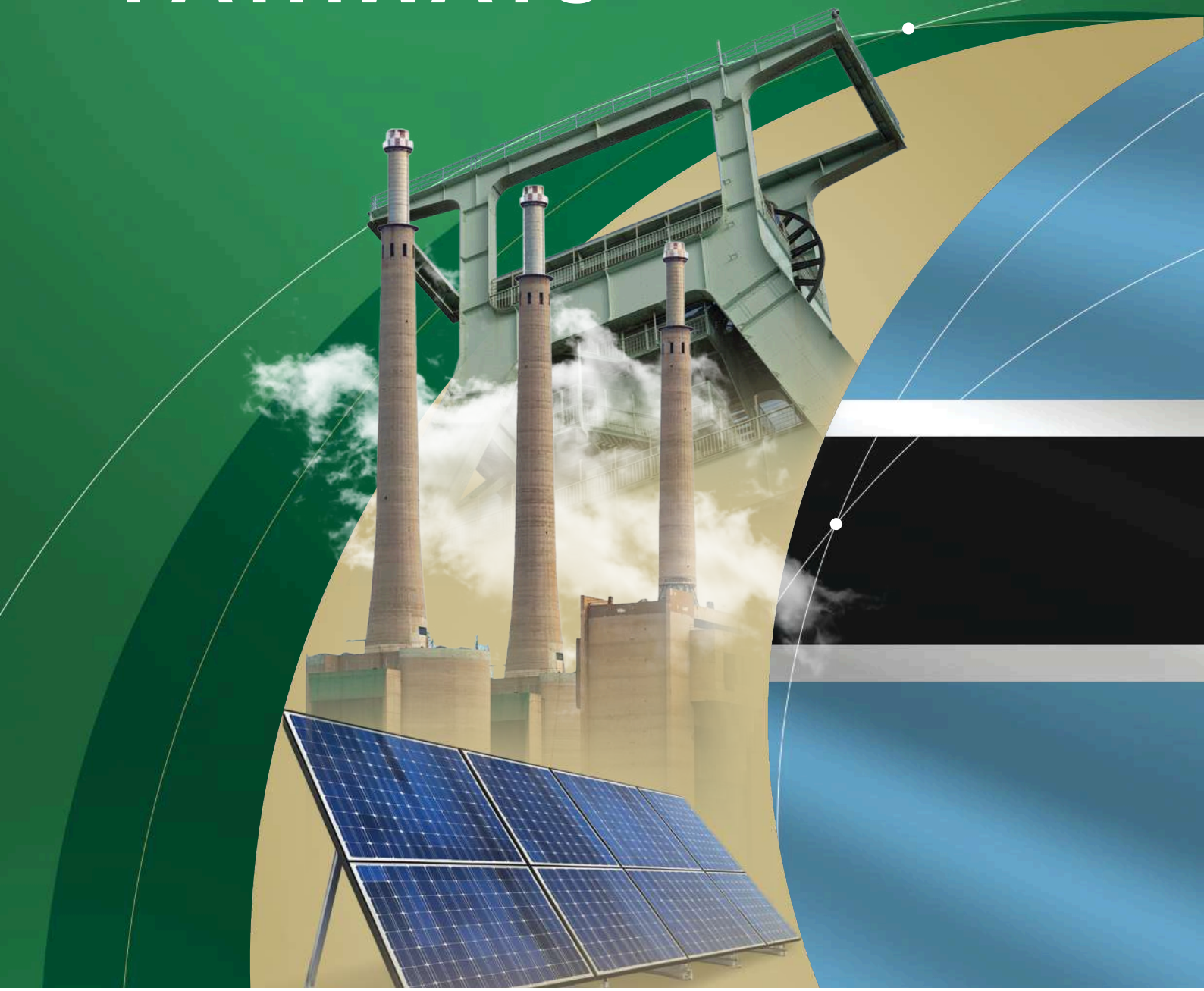
BOTSWANA NATIONAL DEEP DECARBONISATION PATHWAYS



AFREC
African Energy Commission

African Union

FOREWORD

This National Deep Decarbonization Path (NDDP) is the very first in the history of the Republic of Botswana. It came at a very important time, as Botswana is a signatory to the Paris Agreement, thereby committing to the global effort to combat climate change through its Nationally Determined Contributions (NDCs) set target of 15% emission reduction by 2030. The NDDP provides a critical framework through which Botswana can achieve these commitments while aligning with nationally set policy goals and development targets, including the global net zero emission reduction by 2050.

This strategy presents a significant opportunity to transition towards renewable energy systems, simultaneously addressing power shortages and climate change impacts. The NDDP outlines clear pathways for deep emission reductions across all energy fuels within a timed period of short, medium, and long term—focusing on key energy consuming sectors such as households, transport, industry, buildings, and agriculture.

The successful implementation of the NDDP requires robust multi-sectoral collaboration, bringing together government, private sector, academia, civil society, and international development partners. The journey may present challenges—including high costs, technological constraints, and the need for policy coordination—but it also offers substantial benefits. These include the creation of green jobs, enhanced energy security, and improved public health outcomes.

The Government of Botswana reaffirms its commitment to deep decarbonization and building a sustainable and resilient future for all. Therefore, the Ministry of Minerals and Energy (MME), as the custodian of energy policy formulation and implementation, calls upon all stakeholders to actively support and engage in this transformative journey. The MME has confidence that with unity, innovation, and determination, we will rise to the occasion, overcome the challenges, and seize the opportunities that lie ahead.

Hon. Nani Juwara
Minister of Petroleum, Energy and Mines
The Gambia

ACKNOWLEDGEMENT

The Gambia National Deep Decarbonization Pathways (NDDPs), as well as those for Madagascar and Botswana, have been developed as part of the broader continental initiative under the African Energy Transition Programme (AFRETRAP) spearheaded by the African Energy Commission. Developed to domesticate the African Energy Transition Strategy and Action Plan (ETSAP), this document is a testament to Africa's commitment to a coordinated, yet differentiated, just transition that considers local realities.

The NDDP is a collaborative work of the Ministry of Petroleum, Energy and Mines (MoPEM), AFREC and the African Development Bank (AfDB). Overall oversight was provided by Mr. Kemo Ceesay, Director of Energy of MoPEM with the support of a Technical Working Group (TWG). The TWG consisted of the following members: -

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The TWG played a fundamental role in providing the primary and secondary data and defining the country's low carbon ambition for electricity, transport, industry, buildings, agriculture, and oil and gas subsectors.

The Stantec core technical team consisting of Dr.Peter ZHOU, Dr. George KYRIAKARAKOS, Dr. George GIANNAKIDIS and Mr Pascal AUGAREILS led the development of the NDDPs. Eng. Nickson Bukachi, AFREC and Ms. Neza Guillaine, AfDB provided both technical input and project management expertise to the project. This is through overall coordination of the project while working in close collaboration with the TWG, and Stantec represented by Ms. Alba MERILLAS DOCHAO and Ms. Costanza ALESSE.

The development of the document benefited from multisectoral consultations at country level, lessons from the development of the ETSAP at continental level, and insights drawn from the experience in Botswana and Madagascar.

Thanks to AfDB for jointly funding this initiative with AFREC, as well as all stakeholders that contributed to shaping the final document.

While the development of this document demonstrates what we can achieve together, the real work lies in implementing the identified short, medium and long-term priorities. I urge all stakeholders to work together in making the identified programmes a reality. Together, we can contribute to a global sustainable future by leveraging Africa's resources while addressing energy challenges in our continent.

Mr. Rashid Ali Abdallah

Executive Director

African Energy Commission

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Acronyms

4W	Four-wheels
AfSEM	African Single Electricity Market
AFREC	African Energy Commission
AI	Artificial Intelligence
AMI	Advanced Metering Infrastructure
AU	African Union
BAU	Business as Usual
BERA	Botswana Energy Regulatory Authority
BESS	Battery Energy Storage Systems
BOBS	Botswana Bureau of Standards
BPC	Botswana Power Corporation
BWh	Climate classification to denote a hot desert climate
CBAM	Carbon Border Adjustment Mechanism
CBM	Coal-Bed-Methane
CEPS	CBM Emissions-Performance Standard
C&I	Commercial and Industrial
CCS	Carbon Capture and Storage
CO	Carbon Monoxide
CO^2	Carbon Dioxide
DC	Direct Current
DDP	Deep Decarbonization Pathway
DDP LT	Deep Decarbonization Pathway Longer Term
DLMS/COSEM	Device Language Message Specification / Companion Specification for Energy Metering
DNI	Direct Normal Irradiance
E&P	Exploration and Production
EE	Energy Efficiency
EOI	Expression of Interest

ETSAP	African Energy Transition Strategy and Action Plan
EU	European Union
FAO	Food and Agriculture Organisation
FEC	Final Energy Consumption
FT	Fischer – Tropsch
GCF	Green Climate Fund
GDP	Gross Domestic Product
GGFRP	Global Gas Flaring Reduction Partnership
GH_2	Green Hydrogen
GHG	Greenhouse Gas
GIS	Geographic Information System
GPRS	General Packet Radio Service
GWh	Gigawatt Hour
HVAC	Heating, Ventilation, and Air Conditioning
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IPP	Independent Power Producer
IRP	Integrated Resource Plan
ISO	Independent System Operator
KPI	Key Performance Indicator
$ktCO_2eq$	kilotonnes of CO_2 equivalent
Ktoe	Kilotonne of Oil Equivalent
LCA	Life Cycle Analysis
LDAR	Leak Detection and Repair
LEAP	Low Emissions Analysis Platform
LPG	Liquefied Petroleum Gas

MEPS	Minimum Energy Performance Standards
MME	Ministry of Minerals and Energy
MoF	Ministry of Finance
MoMRE	Ministry of Mineral Resources and Energy
MoPE	Ministry of Public Education
MTF	Multi-Tier Framework
MS	Member State
MW	Megawatt
NDB	New Development Bank
NDC	Nationally Determined Contribution
NDDP	National Deep Decarbonization Pathway
NETSC	National Energy Transition Steering Committee
NEVs	New-Energy Vehicles
NG	Natural Gas
NGO	Non-Governmental Organisation
OGI	Optical Gas Imaging
OGMP	Oil and Gas Methane Partnership
OPEX	Operating Expenses
ORC	Organic Rankine Cycle
PM	Particulate Matter
PPA	Power Purchase Agreement
PtX	Power-to-X
PV	Photovoltaic
Q	Quarter
RBF	Result-Based Financing
RE	Renewable Energy
RES	Renewable Energy Sources
RfP	Request for proposal

SACREEE	Southern African Development Community Centre for Renewable Energy and Energy Efficiency
SADC	Southern African Development Community
SAF	Sustainable Aviation Fuels
SAPP	Southern African Power Pool
SCADA	Supervisory Control and Data Acquisition
SDG	Sustainable Development Goal
SE4ALL	Sustainable Energy for All
TA	Technical Assistance
TCO	Total Cost of Ownership
TNC	Third National Communication
ToR	Terms of Reference
TPES	Total Primary Energy Supply
TWh	Terawatt Hour
UNFCCC	United Nations Framework Convention on Climate Change
W	Watt
WD	Working Days
WHO	World Health Organisation

Glossary and Definitions

Adaptation: In human systems, the process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effect.

Advanced biofuels: They are derived from non-food/feed biomass sources, including agricultural and forestry residues, energy crops, and municipal waste, adhering to sustainability criteria. Advanced biofuels are produced through sophisticated processes such as gasification, pyrolysis, and enzymatic hydrolysis, offering a sustainable and less environmentally impactful alternative to conventional biofuels and fossil fuels.

Baseline Scenario: a counter-factual projection for the development of the energy system showing decision-makers the trajectory they implicitly endorse by doing nothing more than what is already in place regarding policy interventions and measures.

Beneficiation: The transformation of a primary material (produced by mining and extraction processes) to a more finished product which has a higher value.

Bio-hydrogen: Hydrogen produced from biomass, which is considered a biofuel.

Blended Financing: Strategic use of development finance and philanthropic funds to mobilise private capital flows at scale, by combining investors with different financial return expectations – from concessional to market rates – to access greater levels of capital than on a standalone basis.

Carbon Border Adjustment Mechanism: The European Union (EU)'s Carbon Border Adjustment Mechanism (CBAM) is a key regulatory initiative designed to level the playing field for EU producers and their international counterparts, considering carbon pricing. It aims to mitigate the risk of carbon leakage by imposing a carbon price on imports of specific goods from outside the EU. This mechanism requires importers to buy carbon certificates corresponding to the carbon price that would have been paid, had the goods been produced under the EU's carbon pricing rules. The CBAM is part of the EU's broader strategy to meet its ambitious climate targets under the European Green Deal, ensuring that its climate efforts do not lead to an unfair competitive advantage for less-regulated foreign producers.

Carbon Intensity: The amount of Carbon Dioxide (CO^2) emitted per unit of another indicator associated directly or indirectly with CO^2 emitting activities. The carbon intensity of electricity is the mass of CO^2 emitted per unit of electricity generated by a plant or by the electricity system. The carbon intensity of the economy is the mass of CO^2 emitted per unit of economic output.

Carbon Neutrality: Having a balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks.

Clean Cooking Access: A household is considered to have access to clean cooking when it primarily uses clean fuels and technologies that significantly reduce exposure to harmful air pollutants and meet health and safety standards. Clean fuels include electricity, liquefied petroleum gas (LPG), natural gas, biogas, alcohol fuels (such as ethanol), and solar energy. In contrast, the use of polluting fuels such as biomass (wood, charcoal, crop waste, dung), coal, and kerosene is not classified as clean. Clean cooking access requires not only clean fuels but also efficient technologies that meet performance standards for emissions, safety, convenience, and affordability, in alignment with the World Health Organisation (WHO) air quality guidelines and the Sustainable Development Goal (SDG) 7.1.2 target.

Climate Action: Activities and policies aimed at addressing climate change, including mitigation, adaptation, and supporting global efforts.

Climate Change: Long-term alteration in Earth’s climate patterns, primarily due to human activities, especially fossil fuel combustion which increases greenhouse gas concentrations in the atmosphere. Manifests as changes in temperature, precipitation patterns, and increased frequency of extreme weather events.

Climate Change Adaptation: Adjustments in human and natural systems in response to actual or expected climatic stimuli or effects, to minimize harm or exploit beneficial opportunities. Involves infrastructure resilience and emergency planning for extreme weather events.

Climate Change Mitigation: Actions to reduce greenhouse gas emissions or enhance their sinks to limit the magnitude of climate change. Includes technological upgrades, energy efficiency improvements, and preservation of natural carbon sinks.

Concessional Finance: Below market rate finance provided by major financial institutions, such as development banks and multilateral funds, to developing countries to accelerate development objectives.

Decarbonization: Strategic reduction of carbon dioxide emissions through the transition from fossil fuel-based energy production to renewable and zero-carbon energy sources. Electrification and hydrogen are at the core of the decarbonization actions.

Deep Decarbonization Pathway (DDP): a scenario projecting the development of the energy system aiming in the longer-term reduction of emissions compared to the baseline scenario. DDP implements all the measures discussed in detail in the report and in the longer-term alternative it increases the effort in order to reverse the trend and lead to a reduction of emissions, after peaking around 2040.

Defossilization: It is the transition from long-cycle carbon to short-cycle carbon use for the sectors that it is challenging (e.g., maritime shipping, aviation, agriculture) or even infeasible to fully decarbonize (e.g., pharmaceuticals, plastics).

Digitalization: Digitalization in the energy sector refers to the integration of digital technologies into various facets of energy systems, including generation, transmission, distribution, and consumption. This process involves among others the use of advanced data analytics, Internet of Things (IoT), artificial intelligence (AI), and blockchain technologies to enhance the efficiency, reliability, and sustainability of energy systems.

Distributed Generation: Generation assets that are located close to the particular load that it is intended to serve. General, but non-exclusive, characteristics of these generation assets include: an operating strategy that supports the served load; and interconnection to a distribution or sub-transmission system.

Electricity generation: Another important form of transformation is the generation of electricity. Thermal power plants generate electricity by harnessing the heat of burning fuels or nuclear reactions – during which up to half of their energy content is lost. Renewable power sources generate electricity directly from natural forces such as the sun, wind, or the movement of water.

Electricity access: according to the Multi-Tier Framework (MTF) for Measuring Electricity Access, used for SDG 7 reporting, we are considering Tier 1 access defined as the most basic level of modern electricity service. Households at Tier 1 have access to at least 3 watts of power capacity, sufficient to support limited energy services such as task lighting (e.g., LED lamps) and phone charging. Electricity must be available for a minimum of 4 hours per day, including at least 1 hour during evening hours between 6pm and 10pm. There are no specific requirements for reliability, voltage quality, or the legality of the connection at this tier.

Energy consumption by sector: The sectoral breakdown of a country's energy demand, which is based on its economy, geography, and history, can greatly impact its energy needs and which energy sources it relies on to meet those needs – such as fuelling automobiles, heating or cooling homes or running factories.

Exploration and Production (E&P): the activities undertaken by Oil and Gas Companies to explore for oil and gas and produce the same when commercial reserves are discovered.

Energy Poverty: The absence of sufficient choice in accessing adequate, affordable, reliable, high quality, safe, and environmentally benign energy services to support economic and human development.

Energy Security: The uninterrupted availability of energy sources at affordable prices.

Energy supply per capita: The per-capita energy supply is a function of economic development as well as the structure of the economy – countries whose economies are largely services-based will use less energy per capita than comparable countries whose economies are focused on heavy industries like iron and steel or pulp and paper.

Energy supply: Total Primary Energy Supply (TPES) includes all the energy produced in or imported to a country, minus that which is exported or stored. It represents all the energy required to supply end

users in the country. Some of these energy sources are used directly while most are transformed into fuels or electricity for final consumption.

Energy transformation: Energy sources, particularly fossil fuels, are often transformed into more useful or practical forms before being used. For example, crude oil is refined into many different kinds of fuels and products, while coal, oil and natural gas (NG) can be burned to generate electricity and heat. Other forms of transformation, such as extracting gas or oil from coal, play a relatively minor role in the energy systems of most countries.

Energy Transition: A systematic shift from dependency on fossil fuels (coal, oil, natural gas) to renewable and sustainable energy sources.

Final energy consumption: Final Energy Consumption (FEC) is the energy consumed by end users such as individuals and businesses to heat and cool buildings, to run lights, devices, and appliances, and to power vehicles, machines, and factories. Some of the energy found in primary sources is lost when converting them to useable final products, especially electricity. As a result, the breakdown of final consumption can look very different from that of the primary energy supply. Both are needed to fully understand the energy system.

Fischer – Tropsch (FT): A collection of chemical reactions that converts a mixture of carbon monoxide and hydrogen, known as syngas, into liquid hydrocarbons. CO_2 can be converted to Carbon Monoxide (CO) in FT plants consuming energy.

Green Hydrogen (GH_2): Hydrogen produced by any type of Renewable Energy (RE) resource apart from biomass.

Net Zero: Condition in which metric-weighted anthropogenic Greenhouse Gas (GHG) emissions are balanced by metric-weighted anthropogenic GHG removals over a specified period. If the term is used to refer to non-CO_2 GHG as well, then the quantification of net zero GHG emissions depends on the GHG emission metric chosen to compare emissions and removals of different gases, as well as the time horizon chosen for that metric.

Oil refining: One of the most important types of transformation for the energy system is the refining of crude oil into Petroleum products, such as the fuels that power automobiles, ships, and planes.

Power-to-X (PtX): Power-to-X converts renewable electricity, from wind, solar, hydro, and geothermal power plants, into a wide variety of storable products (X) which include various fuels and chemicals.

Primary Energy productivity: The ratio of Primary Energy Supply over Gross Domestic Product, which is the inverse of primary energy intensity.

Sustainable Aviation Fuel: Sustainable Aviation Fuels (SAF) are defined as renewable or waste-derived aviation fuels that meets sustainability criteria. Currently standardized SAF are essentially biofuels in blends with fossil jet-fuel, while 100% synthetic hydrocarbon SAF are currently in the process of full standardization.

Sustainable biomass: It involves the use of organic materials sourced in a manner that does not compromise the health of ecosystems or deplete resources at rates faster than they can regenerate. Sustainable biomass production considers ecological (including land use), social, and economic factors to minimize impact on biodiversity, soil health, and local communities. It is a critical component in the production of biomass energy and biomaterials, ensuring that biomass exploitation contributes positively to carbon mitigation efforts and sustainable development goals.

Technical Assistance: The process of providing targeted and expert support for development purposes.

Wheeling Agreement: An agreement between generators, consumers, and the owners/operators of the relevant transmission and distribution systems to transmit energy from a generator to an end-user located in another area through the use of existing distribution or transmission networks.

Executive Summary

Overview Purpose and Strategic Alignment

Africa's energy transition is characterized by a profound dichotomy: vast renewable energy potential juxtaposed with a pervasive modern energy deficit. With over 600 million Africans still reliant on traditional biomass, and large segments of the population lacking access to electricity, the urgency to leapfrog towards clean, resilient systems is acute. The African Energy Transition Strategy and Action Plan (ETSAP) anchors this vision across six thematic pillars universal access and energy security, energy efficiency, carbon-smart fossil management, policy harmonization, innovation and human capital development, sustainable economic growth and sustainable prosperity.

In this context, Botswana—alongside The Gambia and Madagascar was selected for piloting the development of the National DDP domesticating from the ETSAP

Despite divergent geographic and socioeconomic contexts, these countries share some commonalities in relation to rapid demographic growth, exposure to climate shocks, and limited fiscal buffers against energy price volatility. The three African Union (AU) Member States (MS) will provide useful lessons to the various African economies that can benefit in a similar manner from a harmonized decarbonization and energy transition drive in the context of the ETSAP.

Objective and Methodological Approach

Botswana's DDP was crafted with three principal aims:

Operationalization of ETSAP pillars: The pathway demonstrates how national actions contribute to regional energy objectives, creating alignment in areas such as off-grid electrification, industrial efficiency, and transport decarbonization.

Risk-aware investment tool: By simulating Baseline and DDP scenarios through the Low Emissions Analysis Platform (LEAP)), the model identifies configurations that balance environmental goals with system reliability and economic growth.

Translation of political commitments into a quantified pathway: The DDP decomposes aspirational targets into sector-specific technology trajectories, regulatory actions, and investment needs.

The pathway spans a time horizon to 2050 with an extension to 2063 congruent with the AU's Agenda 2063 and is structured in three phases: (i) short-term (2025–2030), targeting quick wins and enabling policies; (ii) medium-term (2031–2040), focusing on scaling technologies and institutional reforms; and (iii) long-term (2041–2050) for Botswana but with projections to 2063 for consistency with the other countries, emphasizing net-zero readiness and regional integration.



Methodology & Participatory Design

Four concentric methodological layers underpin the DDP:

- Base year assessment: A 2022 national energy balance was constructed, ensuring accurate reflection of sectoral energy demand, fuel usage, and emissions profiles.
- Scenario analysis: LEAP was employed to simulate Baseline and DDP trajectories, across energy sectors.
- Stakeholder consultations: Conducted in four iterative waves in form of virtual and physical workshops. Stakeholder engagement ensured data accuracy and validation, and co-design of

Current status of the energy system

In 2022, Botswana's energy system remained predominantly fossil-fuel-based, with TPES reaching 2,467 kilotonne of oil equivalent (ktoe). Diesel (715 ktoe) and gasoline (433 ktoe) led among petroleum imports, while domestic coal contributed 692 ktoe, powering electricity generation and industry. Biomass, particularly wood and charcoal, added 467 ktoe, largely consumed by households using inefficient cooking methods. Despite abundant coal reserves, Botswana imported 53% of its energy, primarily petroleum products, highlighting energy security risks. Electricity generation was heavily reliant on coal, with Morupule A and B accounting for 87% of the 3,426 gigawatt hour (GWh) generated in 2023. Only 2.85% of electricity came from renewables. Electricity imports, though declining, remained significant at 1,000 GWh. Grid losses, at 14.5% were still higher than global best practices, reflecting efficiency gaps. Electrification reached 76% in 2025—driven by urban expansion—but rural access fell to 25%, and clean cooking adoption stagnated, especially in rural areas where biomass remains dominant. National strategies aim for 100% electricity and clean cooking access by 2030, backed by mini-grids, grid extension, and institutional reforms. Sectoral consumption data show transport as the largest energy user (976 ktoe), driven by diesel for freight and gasoline for passenger vehicles, all fully imported. Industry (274 ktoe) is energy-intensive, relying on diesel, coal, and electricity. Households used 303 ktoe, mostly biomass, while services consumed 151 ktoe, half of its electricity. Agriculture's small footprint (29 ktoe) was mostly electricity and diesel driven. The full



Scenarios and modelling results

The scenario modelling for Botswana outlines three distinct energy futures: the Baseline, DDP, and DDP Longer Term (DDP LT), each reflecting differing levels of policy ambition and technological transformation. All four scenarios project rising FEC, but the scale and structure differ significantly (Figure 1).

In the short term, by 2030, total final energy consumption under the Baseline scenario reaches 2,324 ktoe, while both decarbonisation pathways (DDP and DDP LT) contain demand at 2,122 ktoe, achieving a 9.1% reduction primarily through early measures in transport electrification, efficiency gains in industry, and improved household appliance standards. Transport remains the largest consuming sector but already shows a 10.5% decline in DDP scenarios relative to the Baseline due to initial electrification and modal shift policies. By 2050, the divergence becomes more pronounced. The Baseline scenario projects final energy demand escalating to 4,144 ktoe, whereas DDP and DDP LT constrain demand to 3,059 ktoe and 3,383 ktoe respectively, translating to reductions of 26.2% and 20.7%. Transport sector demand falls dramatically under DDP LT, with electricity and hydrogen replacing fossil fuels. In households, both decarbonisation scenarios achieve significant biomass substitution with electricity and LPG, with DDP LT almost fully phasing out traditional biomass. Industry sees structural shifts under DDP LT through full electrification and early hydrogen deployment post-2040. Services follow a similar path, becoming fully electrified by 2050 in DDP LT. Overall, while the Baseline scenario reflects an energy system locked into fossil fuel growth, both DDP and DDP LT demonstrate the feasibility of decoupling energy demand from economic growth. The DDP scenario achieves broad efficiency improvements and gradual electrification, while DDP LT introduces a more transformative shift after 2040, with systemic electrification and clean fuel substitution, positioning Botswana towards a deeply decarbonised energy system by mid-century.



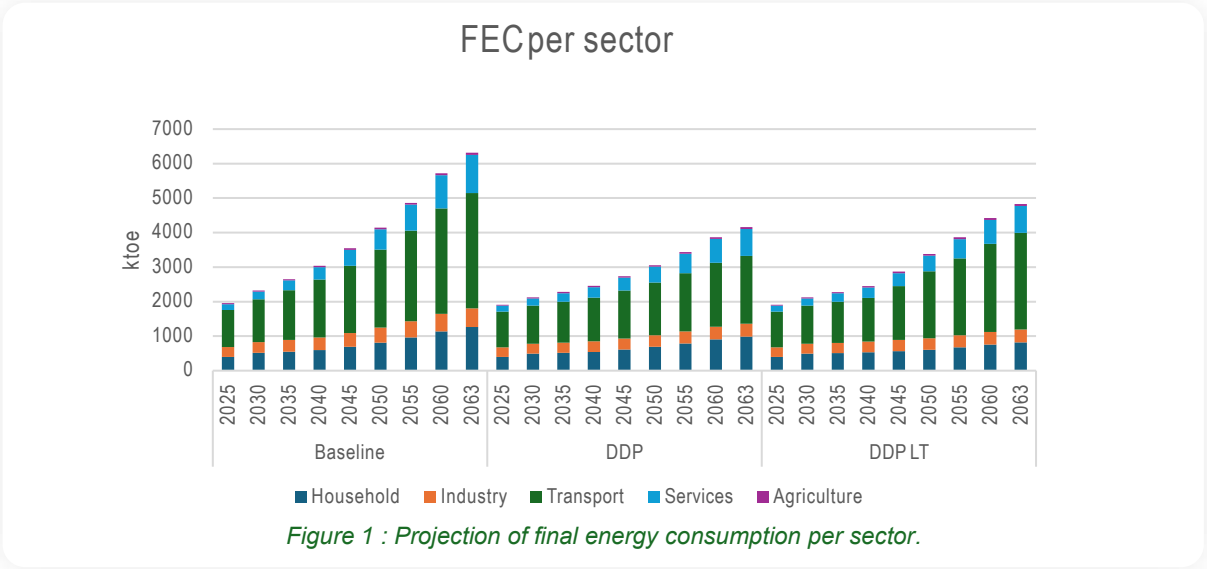


Figure 1 : Projection of final energy consumption per sector.

The evolution of Botswana's electricity generation under the Baseline, DDP, and DDP LT scenarios reveals progressively deeper transitions aligned with policy ambition (Figure 2). In the Baseline, electricity generation grows from 2.55Terawatt Hour (TWh) in 2022 to 17.8 TWh by 2050, driven by planned capacity expansions primarily based on coal, with solar Photovoltaic (PV) and wind contributing modest shares of 5.11 TWh and 0.1 TWh respectively by mid-century. The DDP scenario accelerates diversification after 2030, reaching 24.1 TWh in 2050, with renewables supplying 11 TWh (46%), though coal remains significant. The DDP LT scenario represents a structural shift, with generation reaching 30.6 TWh by 2050 and 37 TWh by 2063, powered by large-scale deployment of Carbon Capture and Storage (CCS) on coal plants and an aggressive build-out of solar and wind, which supply 17.5 TWh (57%) by 2050. This trajectory positions electricity as the central pillar of Botswana's long-term decarbonization, enabling widespread electrification and supporting future green hydrogen production.

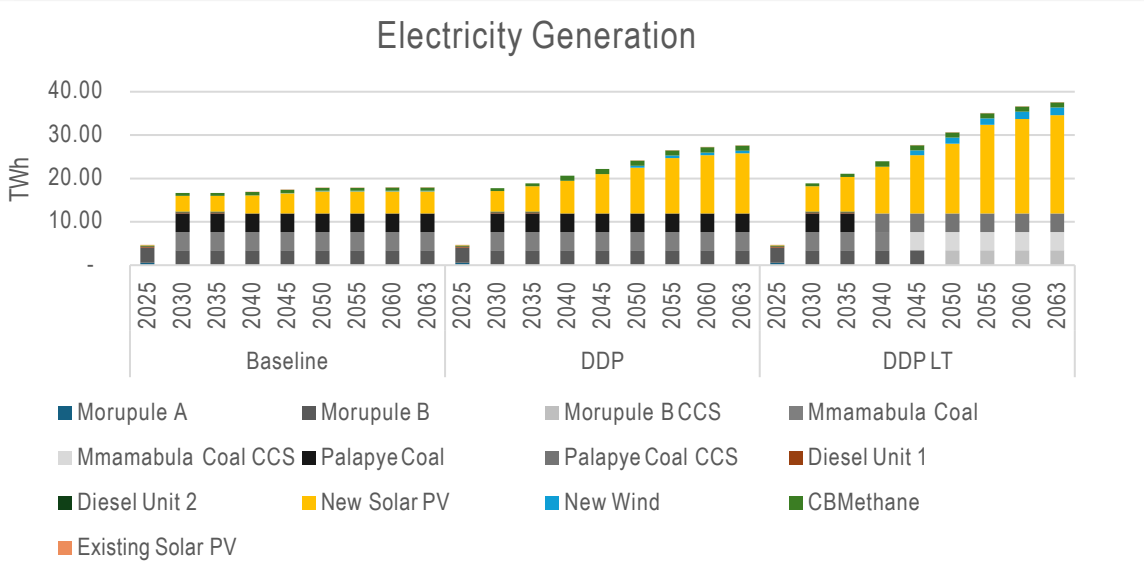


Figure 2: Projection of electricity generation per technology.

Greenhouse gas emissions in Botswana diverge sharply across the Baseline, DDP, and DDP LT scenarios, highlighting the scale of decarbonization required to meet climate goals (Figure 3). Under the Baseline, total emissions rise steadily from 8,497 kilo-tonnes of CO_2 equivalent ($ktCO_2eq$) in 2025 to over 20,000 $ktCO_2eq$ by 2050, driven by unabated coal-based electricity generation, persistent fossil fuel use in transport, and limited clean-based electrification. The DDP scenario achieves partial mitigation, containing 2050 emissions at 16,523 $ktCO_2eq$, with moderated growth in both transformation

and demand-side sources, yet still heavily reliant on fossil fuels without CCS. In contrast, DDP LT delivers a decisive break after 2040: emissions peak at 16,156 $ktCO_2eq$ in 2030, then fall dramatically to 5,776 $ktCO_2eq$ by 2050 and 3,818 $ktCO_2eq$ by 2063. This rapid decline results from systemic electrification, wide-scale deployment of CCS in coal-fired plants, the introduction of hydrogen in industry and transport, and near elimination of gasoline, diesel, and traditional biomass. By 2063, emissions under DDP LT are reduced by 84% compared to Baseline, demonstrating the depth of structural transformation achievable through coordinated mitigation policies and technology shifts.

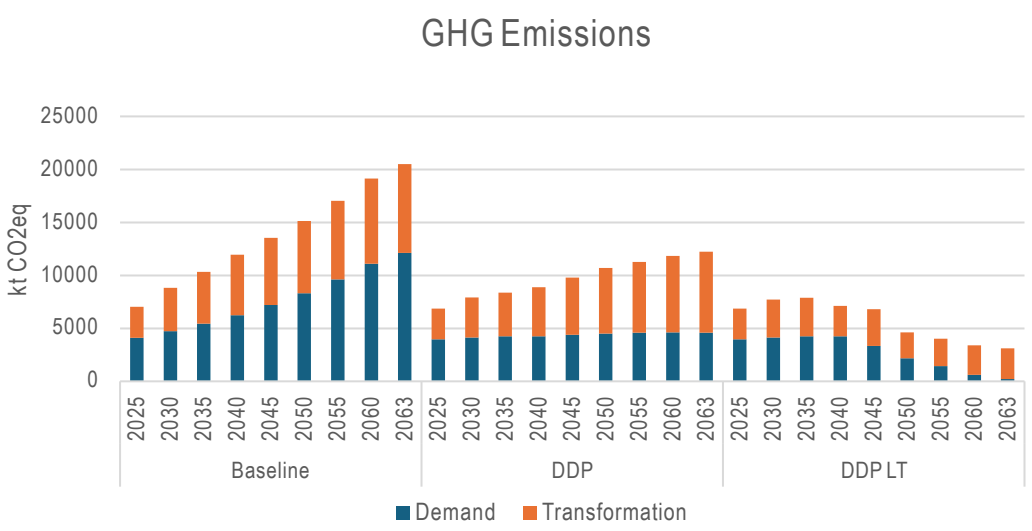


Figure 3 : Projection of energy related GHG emissions.

The economic analysis of Botswana's energy pathways shows distinct cost trajectories across the Baseline, DDP, and DDP LT scenarios, reflecting the trade-off between upfront investments and long-term fuel savings (Figure 4). In the short term (2025–2030), both DDP and DDP LT already generate net savings of around $1 billion compared to the Baseline, primarily through reduced fossil fuel imports that more than offset higher transformation investments. Between 2030 and 2040, the benefits grow, with DDP achieving $6.3 billion in cumulative savings (12% below Baseline) and DDP LT saving $5.2 billion (10% below baseline), as efficiency measures and fuel substitution significantly cut import expenditures. In the long-term horizon (2040–2063), DDP delivers the most substantial cumulative savings of $59 billion (29% below Baseline), driven by $50 billion in avoided fuel imports despite increased transformation investments. DDP LT, while requiring substantially higher transformation and demand-side investments for deeper decarbonization, still achieves $14 billion in net savings (7% below Baseline), demonstrating that even ambitious structural shifts towards electrification and hydrogen remain economically advantageous over time.

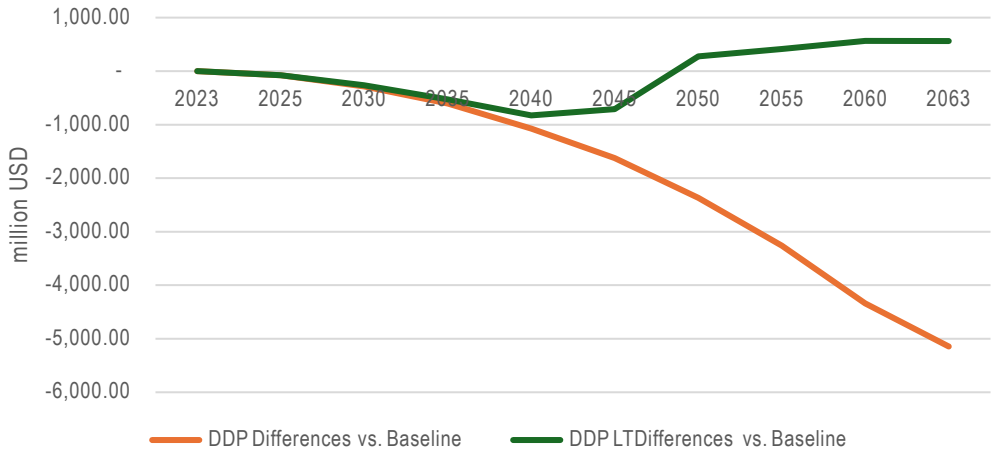


Figure 4: Total cost compared to the Baseline scenario.

In conclusion, DDP offers a significant improvement over the Baseline by stabilising emissions and lowering costs, while DDP LT delivers deep emissions reductions, with clean technology integration, system-wide electrification, and a high share of renewable electricity share by 2050, but at a higher cost compared to DDP.

List of activities

The list of focused practical, near-term interventions for Botswana, aligned with the seven ETSAP subsectors: electricity, industry, transport, buildings, oil and gas, agriculture, and clean cooking are presented in Table 1. These activities are included in the DDP and DDP LT scenarios described above. These represent critical leverage points, where policy ambition is translated into regulatory frameworks, and where clear, targeted signals enable private investment to engage decisively and at scale.

No	Sector	Activity Name	Expected 2030 Impact
1.	Electricity	Promoting the Uptake of Renewable Energy for Grid &	15% decrease in fossil fuel use while an overall increase in energy consumption is observed supporting the universal access to electricity target for 2030.
2.	Electricity	Enforcing Standards for Smart Distribution Networks	Enforcing Standards for Smart Distribution Networks
3.	Electricity	Develop Electrification Plan for Rural Areas	5% increase in primary energy consumption increasing access to electricity rate with zero added emissions.
4.	Clean Cooking	Innovate & Plan for Clean Cooking Solutions	100% Access to Clean Cooking by 2030
5.	Buildings	Energy Labelling for Buildings	10% decrease in primary energy consumption due to improved efficiency in the sector
6.	Buildings	Comprehensive National Guidelines for Energy Performance in Buildings	10% decrease in primary energy consumption due to improved efficiency in the sector
7.	Industry	Energy-Efficiency Regulatory Framework for Industrial Decarbonisation	10% decrease in primary energy consumption of the sector due to improved efficiency
8.	Transport	Scoping, Piloting & Rolling-out New-Energy Vehicles (NEVs)	10% of new sales of four-wheels (4W) vehicles to be electric

Table 1: List of activities

		Multi-modal activities implemented to reduce by 30% the increase in transportation energy demand For buses 25% increase in comparison to Baseline due to switch from private cars and new customers.
8. Agriculture	Development of Bio-energy Supply Chains	10% increase in primary energy consumption in the sector supporting the universal access to electricity target by 2030 with zero added emissions.
9. Agriculture	Development of Bio-energy Supply Chains	10% increase in primary energy consumption in the sector supporting economic growth and the achievement of universal access to electricity by 2030 with zero added emissions.
10. Oil & Gas	Best-Practice Emissions Standards for Coal-Bed-Methane (CBM) Development	10% of new sales of four-wheels (4W) vehicles to be electric

Table 1: List of activities

Reflections and Strategic Significance

The DDP process in Botswana exemplifies the vital role of integrated planning in operationalizing climate ambition. It also demonstrates the value of methodological coherence across national contexts—enabling credible continental progress tracking, policy benchmarking, and coordinated market development. Furthermore, it signals to investors, regulators, and communities that decarbonization is not merely a compliance exercise but a developmental imperative with economic gains and co-benefits spanning public health, employment, and macroeconomic resilience.

By fostering institutional ownership, embedding adaptive triggers, and emphasizing low-regret investments, the pathway aims not only to inform policy but also to catalyse implementation. The real measure of its success will lie in tangible outcomes—reduced emissions, improved access, and sustained economic transformation—underscoring Africa's urgency in steering its own low-carbon



01 Introduction

1.1. Context and Rationale

At the dawn of Africa's energy transition the continent faces a duality: vast renewable electricity and clean fuels potential on one hand and the world's largest modern energy deficit on the other. Close to 69% of Sub-Saharan Africans still rely on traditional biomass for cooking, while electricity networks struggle to reach the last mile. The African Union has responded with a clear political signal, the ETSAP which frames energy not as a peripheral service but as the engine of inclusive industrialisation, social progress and climate resilience. In practical terms ETSAP rests on six interconnected pillars: universal access and energy security, energy efficiency, carbon smart fossil management, policy and regulatory harmonisation, innovation with human capacity development, and a broader quest for sustainable economic growth and prosperity.

Within this continental architecture, Madagascar, Botswana and The Gambia have been selected for a national deep decarbonization pathway (NDDP) development exercise that draws from the ETSAP.

DDPs translate the ETSAP actions into implementatble and investable initiatives and projects. Botswana has submitted its Nationally Determined Contributions under the Paris Agreement, yet those documents stop short of tracing detailed technology mixes, financing envelopes or sectoral trade offs. A DDP fills that gap. It assembles a full national energy balance, projects demand under alternative socio economic futures, and calculates the supply mix respecting environmental and reliability constraints. By doing so it translates political intent into a bankable roadmap and strengthens the credibility of future Nationally Determined Contribution (NDC) revisions.

Botswana's electricity landscape remains dominated by coal from Morupule A & B, which provided most of the domestically produced electricity, necessitating imports whenever units face technical issues. National electricity access has reached 76 %, yet many remote rural communities stay off-grid and rely on firewood for cooking, intensifying dry-land degradation. The country, however, has high solar resource and has pledged through its 2020 Integrated Resource Plan and updated NDC, to achieve 30 % renewables and 15 % emissions reduction by 2030. Accelerating distributed PV-plus-storage, digitalizing the north–south transmission backbone which will also facilitate active participation in the Southern African Power Pool (SAPP), and coupling mini-grids with modern cooking solutions can minimize imports, diversify away from coal, and forge a decentralized, climate-resilient energy architecture.

The adopted development rationale for deep decarbonisation is as follows: Efficient appliances, grid and off grid renewables, decentralised storage and clean cooking solutions reduce household expenditure, free foreign exchange and insulate rural communities from fuel price shocks. Diversified generation portfolios fortify grid resilience against droughts and climate related outages. Local value chains for solar modules, batteries or green hydrogen offer rare opportunities for job creation and mineral beneficiation. Conversely, inaction risks stranded fossil assets, growing balance of payments pressure and escalating health costs from urban air pollution. In short, a well designed transition is cheaper, cleaner and more socially inclusive than business as usual.

This methodology followed for the three NDDPs underlines this logic of coordinated diversity. It signals to policymakers, financiers and development partners that national pathways are elements of a larger continental puzzle—whether that concerns standard setting for new energy vehicles, synchronised grid codes or the prospective African carbon market. It also accelerates peer learning: officials in Banjul, Gaborone and Antananarivo can benchmark assumptions, identify common bottlenecks and exchange practical solutions long before final reports are printed.

Uncertainty is, of course, inevitable over a four decade horizon upto 2063. Fuel prices fluctuate, technology costs decline, political priorities evolve. For that reason, adaptive management strategies—modular project design, flexible finance instruments, periodic scenario refresh—are integral to the exercise, mirroring ETSAP's own M&E and risk mitigation framework.

1.2. Objectives & Scope

Designing the NDDP for Botswana entailed defining clear milestones anchored by specific targets and a defined timeline resulting in a practical tool for guiding policy, securing finance, planning and technology deployment over the long term.This section therefore sets out in sequential fashion, what the NDDPs seek to accomplish and over which horizon they shall unfold.

1.2.1. What the DDP aims to achieve

At its core, the DDP pursues a threefold mission. **First**, it translates the highlevel commitments embedded in each country's official targets (e.g., NDCs) and the AU's ETSAP into a quantified, internally consistent roadmap. Such a translation is indispensable, because headline percentages "30 % economywide emissions by 2030" or "100 % access by 2035"—offer insufficient guidance on the granular sequence of capital deployments, technology choices and regulatory adjustments required to reach them. The DDP therefore provides the pledges, allocates them across sectors, and rebuilds them into an integrated supply–demand architecture that respects system reliability, fiscal prudence and socioeconomic equity.

Second, the DDP serves as the analytical platform for aligning national trajectories with the six pillars of ETSAP—universal access and energy security, energy efficiency, carbonsmart fossil management, harmonised governance, innovation & human capacity, and sustainable economic growth and prosperity. While these pillars are continental in scope, their materialisation depends on coherent national actions. Hence the DDP asks, for example, how many megawatts of decentralised photovoltaics must be installed in Botswana for the access pillar to be realized, or what suite of transport sector incentives Botswana must adopt to honour the efficiency pillar. In effect, the DDP binds continental ambition to national implementation.

Third, the pathway provides an investment and risk management tool for public and private actors alike. Energy assets possess multi-decade lifetimes; ill-timed or ill-matched investments can lock-in carbon intensity, exacerbate balance-of-payments pressure, and strand fiscal resources. The DDP mitigates such hazards by running scenario simulations— Business as Usual (BAU) and the DDP scenarios. The outputs equip ministries of finance with expenditure envelopes, utilities with capacity expansion plans, development banks with credit-worthiness insights, and communities with information on employment prospects and tariff trajectories.

1. Base year resolution

A contemporary, country specific energy balance is reconstructed for the base year 2022, disaggregated by sector, enduse and fuel. Where data gaps surface—most notably in informal biomass —proxy markers and international databases estimates were adopted largely based on the African Energy Commission (AFREC) database to safeguard coherence and transparency. It has to be highlighted that AFREC only hosts data that have been officially submitted by the AU Member States.

2. Scenario articulation

Three harmonised narratives are elaborated to 2050 and are extended to 2063 for consistency reasons among the DDPs and for being in line with the ETSAP which in turn coveres the Agenda 2063 horizon:

- Baseline, rooted in historical growth elasticities with conservative energy access targets;
- DDP, with the application of the measures co-designed with the national stakeholders aiming at a pathway of reduced emissions compared to Baseline and ambitious clean energy access.
- DDP LT which shows a pathway of further reduction of GHG emissions after 2040 compared to the DDP scenario towards a net-zero carbon economy by 2050 through an

3. Investment scheduling & financing logic

Three harmonised narratives are elaborated to 2050 and are extended to 2063 for consistency reasons among the DDPs and for being in line with the ETSAP which in turn coveres the Agenda 2063 horizon:

4. Adaptive management triggers

Recognising that any long horizon plan must be updated to account for real world events, the DDP establishes quantitative data sets — fuelprice thresholds, technologyc ost breakpoints, demand growth deviations — that will prompt updating of the DDP every 5 years.

1.2.2. Time horizon

The selected time horizon to 2050 for NDDP and the extention to 2063 to be consistent with the ETSAP was aligned with the end-date of the AU's Agenda 2063 and is long enough to afford sufficient scope for technology learning, industrial maturation and social adaptation while focusing on decarbonization development trajectory. The DDP partitions the horizon into three discrete implementation phases, each with its own strategic content and in order to take stock after each term whether the desired targets are being achieved. The terms also allow adjustments as needed in accordance to both national

- **Short Term | 2025–2030**
  This phase emphasises "low-hanging-fruit" measures: grid loss reduction, appliance and equipment market transfromation through energy efficiency, accelerated rollout of solar home systems and minigrids, and policy groundwork (standards-setting, data architecture, incentive frameworks). The phase applied derisking instruments like guarantee funds, payment security mechanisms to crowd-in private capital for renewables and clean cooking ventures.
- **Medium Term | 2031–2040**
  Having stabilised the enabling environment, the focus shifts to scale. Bulk renewables are integrated with strengthened transmission corridors and regional power pool interconnectors. Electric mobility uptake accelerates, hydrogen and derivatives pilots for freight and fertiliser begin, and heavy industry retrofits gain momentum. Policy convergence across the AU countries becomes tangible through aligned efficiency standards, vehicle emission regulations and
- **Long Term | 2041–2050**
  The final phase drives the system towards significant emissions reduction. Residual fossil assets are either decommissioned or replaced by lower emission fuels or equiped with Carbon Cature and Storage options; power-to-X facilities convert surplus renewable electricity to synthetic fuels; circular economy principles dominate material flows. Critical mineral beneficiation—nickel, cobalt and lithium refining for batteries and solar glass—takes place domestically, supported by green hydrogen hubs. At this stage the regional energy market is mature allowing in turn the full operationalization of continental markets; AfSEM, fuels and carbon markets, enabling trade of

This 3-phase approach mirrors the natural progress of infrastructure rampup, institutional maturation and behavioural adaptation but remains flexible. When technology costs decrease faster than anticipated or climate impacts intensify earlier, the adaptive triggers mentioned above will guide investments forward or pivot them to alternative options. By embedding such flexibility, the pathway

1.3. Approach & Methodology

The approach adopted was the same for all the three AU MS pilot countries starting with establishing the same base year of 2022 and establishing agreed targets either from national reports and stakeholders' inputs for the 2030, 2040 and 2050. Base year data for Botswana used where derived from the AFREC data base, where base year data was insufficient, complemented with benchmarking as needed.

The methodological structure was erected starting with the base year assessment that captures national energy system in the reference year 2022 That was followed by scenario simulations executed using the LEAP model. Beyond that stakeholder consultations took place complemented with both inputs and examination of the outcomes and how they fitted into the context of the African Union's ETSAP and its catalogue of "low hanging fruit" interventions. The steps are mutually reinforcing: the base year grounds the scenarios, the scenarios enrich stakeholder dialogue, the dialogue refines alignment with continental strategy, and the continental anchor in turn supplies coherence and analytical discipline to the entire construct.

Stakeholders play an active role throughout. This iterative engagement not only grounds the reported data in local realities but also builds modelling capacity inside energy directorates—a horizontal action expressly prioritised in ETSAP's implementation plan. Experience has shown that such capacity is

1.3.1. Base year assessment of the energy system

The base year is the foundation of the future pathway and hence has to be accurate for optimal modelling and mapping with clarity the flow of energy from primary extraction through transformation to final consumption, and ultimately to the release of greenhouse gases.

The process started with adopting publicly available datasets including AFREC's continental energy statistics, national utility reports and reports from the regulators, customs import records, and population censuses among others. Where numbers were mismatched, preference was given to sources anchored in national statistical systems, provided they met minimum criteria for temporal consistency and spatial granularity. All activity levels and conversion matrices were harmonized to 2022, choosing that year because it offered the most complete post COVID pandemic data.

Where adequate data were currently un-available an effort was made to utilize the available datasets to the extent possible by addressing as many gaps as possible through the extensive consultation process which involved both virtual stakeholders' meetings as well as physical workshops in Botswana.

Finally, the harmonized energy balance was validated for mass energy equivalence and emissions consistency since the carbon that enters the system must exit either as stored product, atmospheric release, or embedded export.

The resulting energy balance reinforces the forward simulations and exposes potential decarbonization opportunities that are worth further intervention irrespective of long term ambition. For example, Botswana displays a paradox of plenty: a solar resource among the world's richest, yet a generation mix still almost completely depended on coal fired plants, inviting questions of political economy rather than technical possibility. These insights feed directly into the "low-hanging-fruit" analysis presented later in the report. An overview of the base year analysis for Botswana together with the identified key insights are presented in the next Chapter, with a focus on the final energy consumption of the seven sectors that have been identified as key for the decarbonisation pathways in the ETSAP. Annex 1 presents the energy balance that has been used for the analysis as well as all the other base year information that is used for the model calibration, including population, number of households, urbanisation, vehicle fleet and the historical macro-economic path of total and sectoral Gross Domestic Product (GDP).

1.3.2. Scenario modelling for Botswana using LEAP

1. Baseline scenario

extrapolates historical elasticities of GDP, population and structural change, assuming no significant policy shift. Baseline acts as the counterfactual—showing decision makers the trajectory they implicitly endorse by doing nothing. The key assumption for the drivers used in the scenario are included in Table 2. Annex 1 presents in detail the projections of the scenario drivers, including the macro-economic projections of the GDP, the demographic projections related to the total population and the share of urban-rural population, the number of persons per household and the projection of demand for

Table 2: Key scenario drivers

	203	204	205	206
GDP growth rate	3.3	3.3	3.3	3.3
Population	2.72	3.25	3.88	4.90
Urban population share	72	81	81	81
Persons per household	3.34	3.23	3.13	3.0%

The targets for electricity and clean cooking access in the Baseline scenario for 2030 and 2050 are presented in

Table 3: Access target for Baseline and DDP Scenarios

	2030	2040	2050
Total Electricity Access	76%	100	100
Electricity Access Urban	96%	100%	100%
Electricity Access Rurual	25	100	100
Total Clean Cooking	66%	80%	100%
Clean Cooking Urban	87%	90%	100%
Clean Cooking Rural	25	55	100

2. **DDP Scenario** pushes the target of GHG emissions towards net-zero (or near zero) by 2050. In this scenario the access targets presented in Table 3 are reached and all the measures co-designed with the national stakeholders aiming at a pathway of reduced emissions are applied in Botswana. The macroeconomic and demographic drivers of the DDP scenario are the same as in the Baseline, but the scenario implements all the interventions discussed in detail in the last Chapter including energy efficiency measures, measures for reducing the demand in vehicle kilometres for transportation and for the modal shift from private to public transport modes, electrification of end uses and large scale deployment of variable renewables in the electricity generation. The detailed input assumptions for the DDP scenario can also be found in Annex 1. The selection of the technologies that are used in the scenario analysis was based on their potential to accelerate decarbonisation, within the framework of the policies and measures that have been developed for Botswana.

3. **DDP LT Scenario** is based on DDP scenario (i.e. it uses the same macroeconomic and demographic drivers) but pushes even further the decarbonization of the energy sector in the longer term after 2040. The same targets for energy access as in DDP are used but the efforts for decarbonization are increased after 2040, with increased capacity of renewable energy sources, full electrification of passenger road transport, partial electrification of freight transport, introduction of new energy carriers like hydrogen, fuel switching in industry and services towards cleaner alternatives and electricity, higher energy efficiency achievements and implementation of new technologies in all sectors. The detailed scenario assumptions for the DDP LT are also presented in Annex 1.

LEAP calculates the development of the energy sector based on the projected effects of the measures that are described in detail in the following chapters. The interface visualizes the outcome of the calculations as Sankey flows (refer to Chapter 3 for details), techno-economic dashboards and cumulative emissions blocks, translating complex calculations into visuals that can be interpreted by non-specialists hence enabling productive stakeholder engagement.

1.3.3. Stakeholder consultations

The NDDP development process embedded participatory loops at every decision point, transforming stakeholders from only being recipients to co-authors hence empowering ownership of the results. The engagement unfolded in four waves; each wave timed to maximize the knowledge divide.

- **Wave 1: Data validation** brought together ministries, regulators, statistics bureau, utilities, fuel
- **Wave 2: Scenario framing** convened relevant ministries, regulators and utilities alongside the private sector and civil society to inform formulation of narrative boundaries, e.g., the strictness of efficiency norms. By discussing implicit assumptions, the exercise protected the model

against the critique of “technocratic overreach.”

- **Wave 3: Results examination** presented model outputs to the stakeholders. This disclosure gave room for stakeholder feedback and further refinement.
- **Wave 4: Policy packaging** transformed optimized pathways into actionable measures with indicative timelines hence translating energy transition models into ministerial workplans.

The cumulative effect of the four-wave process is two-fold. First, it seeks ownership: when the time comes to prepare and defend capital budget allocations or tariff adjustments. Policymakers can trace the causal chain back to conversations they helped script. Second, it constitutes a crash course in modelling literacy for civil servants and civil society, thereby advancing ETSAP’s human capacity pillar.

1.3.4. Integration with AU Energy Transition Strategy & Low-Hanging Fruit Actions

The final methodological ring links national findings to the continental structure. This is achieved through a dual key mechanism: **metric alignment** and **intervention tagging**.

- **Metric alignment** ensures that each sectoral Key Performance Indicator (KPI) mirrors those in ETSAP’s monitoring and evaluation matrix: gigawatts of renewable capacity added, percentage energy productivity improvement, proportion of population with access to clean cooking. By reporting in comparable units, the three pilot DDPs slot naturally into the continental dashboard, permitting apples to apples aggregation and progress tracking. It has to be highlighted that these metrics are the output of the LEAP model and not high-level estimations.
- **Intervention tagging** classifies every action emerging from the calculation into one of three ETSAP time horizons:
  - *Short term: Low-hanging fruit* (≤ 2029, minimal policy friction, strong cost competitiveness).
  - *Medium term: Scale-up accelerators* (2030–2040, requiring major capital mobilization or institutional reform).
  - *Long term: Transformational enablers* (> 2040, contingent on global technology learning and continental market integration).

By mapping measures this way the DDP performs a political service: it signals to the AU which continental platforms—standardization bodies, regional power pools, climate finance facilities—must synchronize to unlock national ambition and conversely alerts national planners when domestic inertia could hinder continental progress.

Taken in concert, the four rings—baseline assay, LEAP scenario engine, stakeholder co-creation, and continental alignment—forge a methodology that is rigorous without being rigid, visionary without lapsing into utopia. It accommodates the disciplined quantification that engineers and financiers crave, the narrative richness that politicians and citizens understand, and the interoperability that continental governance demands.

This approach and methodology accommodate involvement of all stakeholders and achieves understanding of the upcoming results. The success of this approach and resulting methodology goes beyond sophisticated modelling results but catalyse concrete outcomes: e.g. transmission loss reductions visible on utility ledgers, solar farms in rural areas, three stone fires replaced by efficient biomass cookstoves. Only then will the pathway cease to be a strategy on paper but a driver of an African future powered by its own inexhaustible resources of sun, wind, minerals and human ingenuity.



02 Energy System Baseline

2.1. Overview of the Current Energy System

The Sankey diagram of the energy system of Botswana for 2022, according to the detailed and balance provided by AFREC can be seen in Figure 5.

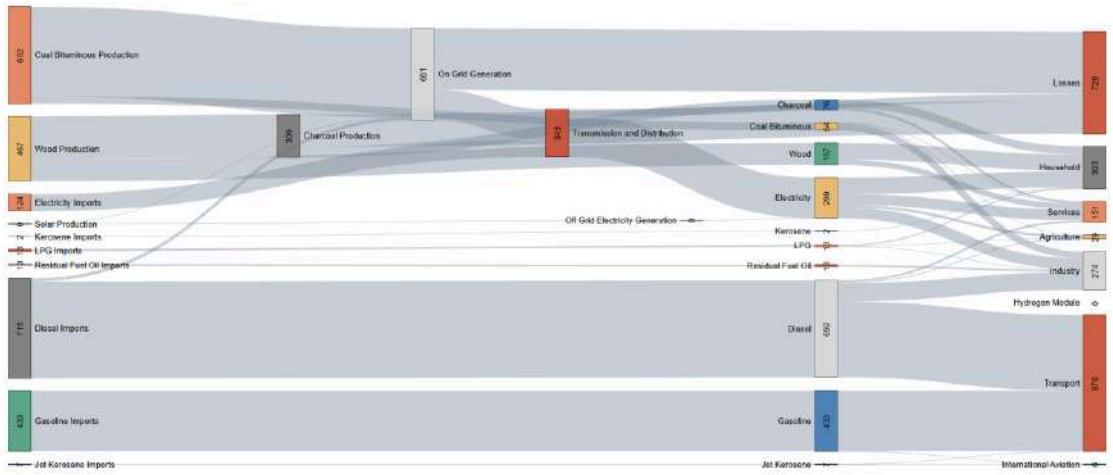


Figure 5 : Sankey diagram Botswana 2022.

The primary energy supply is dominated by local coal production and the import of oil products, mainly used in transportation. Biomass is mainly used in households, either as wood or charcoal.

2.1.1. Primary energy sources (fossil, renewable) & electricity mix

In 2022, Botswana's TPES amounted to 2,467 ktoe. This energy supply was predominantly fossil fuel-based, with diesel (715 ktoe or 29%) and gasoline (433 ktoe or 18%) accounting for the largest shares among petroleum products. Local coal contributed significantly with 692 ktoe (28%), while biomass fuels—wood and charcoal—collectively added 467 ktoe and are notable for their extensive use in household consumption (Figure 6). Imported electricity (124 ktoe) and LPG (13 ktoe) played more modest roles.

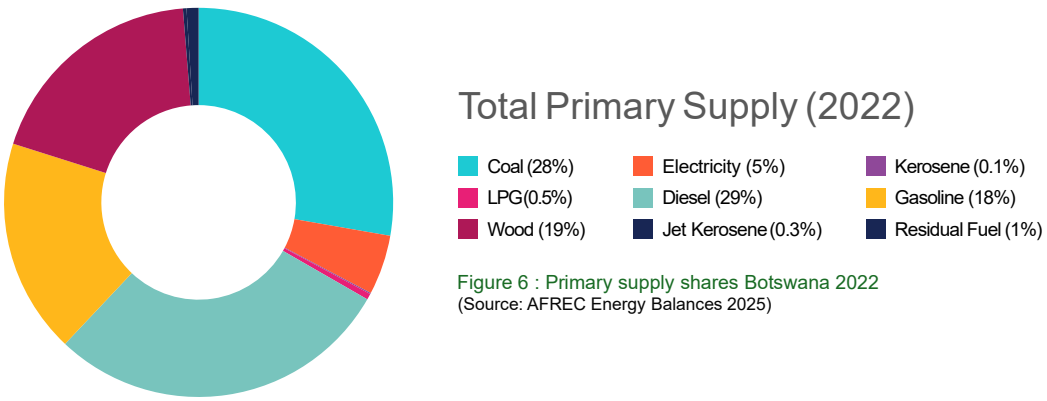


Figure 6 : Primary supply shares Botswana 2022
(Source: AFREC Energy Balances 2025)

Fossil fuels formed the backbone of Botswana's energy system in 2022, collectively representing over 73% of TPES. Diesel and gasoline alone contributed 1,148 ktoe, underscoring their dominant role, especially in transport and industry sectors. Coal, entirely domestically produced, added another 692 ktoe. These three fuels were essential across sectors: diesel was extensively used in transport and industry while gasoline was exclusively used in transport. Coal powered both electricity generation and industrial applications. Despite the country's large coal reserves, fossil fuel imports, especially petroleum products, remain critical for meeting final energy demand.

Biomass, particularly in the form of wood and charcoal, continues to play a substantial role in Botswana's energy balance, contributing 467 ktoe to TPES, accounting for nearly 19% of the total supply. These fuels were almost entirely consumed in the household sector, especially in rural areas. Biomass transformation processes, including traditional earth mounds and brick beehives, indicate reliance on low-efficiency and high-emission technologies. The use of charcoal (76 ktoe final demand) and wood (157 ktoe) reveals persistent traditional fuel dependency, highlighting the energy access and modernization challenges still facing rural households.

Botswana remains heavily dependent on energy imports, which accounted for 53% of its total primary energy supply in 2022. This dependency is particularly acute for petroleum products, gasoline, diesel, jet kerosene, and LPG, which are entirely imported due to the absence of domestic oil refining capabilities. Conversely, coal and biomass are sourced locally, with coal powering key generation plants like Morupule A and B. The reliance on external sources leaves the country vulnerable to regional supply disruptions and price volatility. The Integrated Resource Plan (IRP) underscores a strategic shift toward greater energy self-sufficiency, advocating for increased domestic generation—including renewable energy and coal-bed methane—aiming to transition from an importer to a net exporter of electricity by the mid-2020s

As of 2022, Botswana's installed grid-connected generation capacity is primarily based on coal, with Morupule B contributing 600 Megawatt (MW) and Morupule A adding a further 132 MW, totalling 732 MW of coal-fired capacity. In addition to these, diesel-fired generation units, provide an additional capacity of 160MW and are used as peaking plants only. No additional large-scale renewable capacity existed, underscoring the reliance on fossil-based infrastructure. Botswana's electricity generation mix in 2023 was dominated by domestic coal-fired plants, with Morupule B producing 3,328 GWh and Morupule A contributing 552 GWh—together accounting for 79% of the total generation sent out (3,426 GWh). Emergency diesel-based generation added a minor 33 GWh, representing just under 1% of the generation mix (Figure 7).

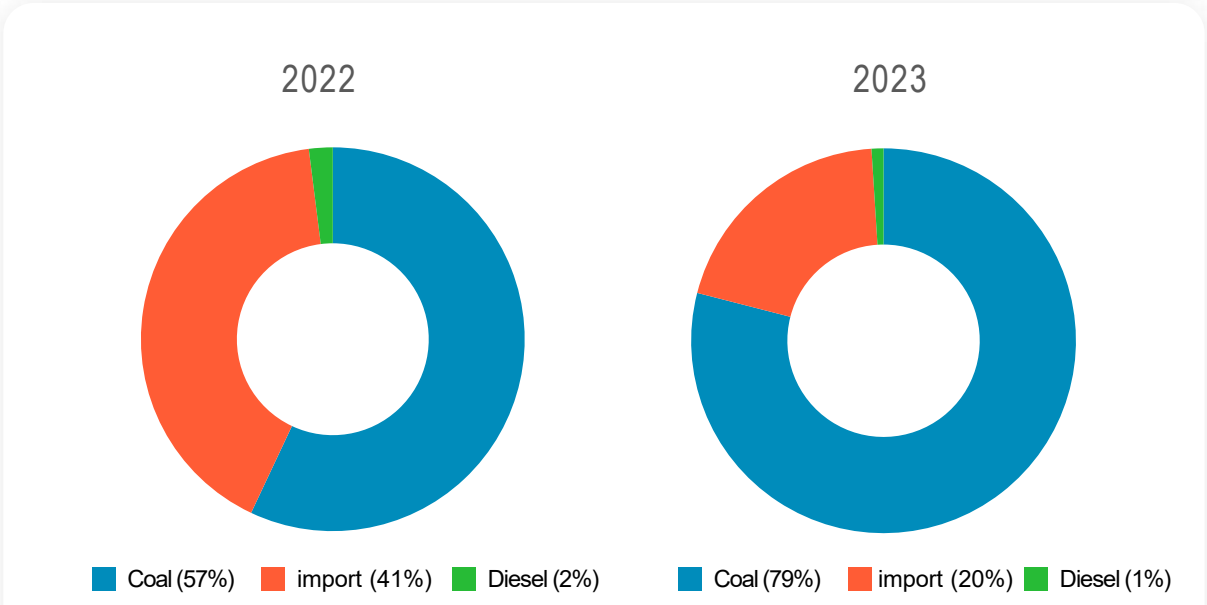


Figure 7 : Electricity generation and import shares Botswana 2022 and 2023
(Source: Botswana Power Corporation (BPC) Annual Report 2023)

These figures confirm the central role of domestic coal in the national energy system, with minimal contributions from diesel and no significant renewable energy generation. Coal's dominance aligns with the national strategy of leveraging vast local coal reserves for energy security. In 2023, Botswana imported 1,000 GWh of electricity, which made up approximately 23% of the total electricity available on the grid (4,425 GWh). This marks a reduction from previous years, such as 2022 and 2021, when imports reached 1,798 GWh and 1,662 GWh respectively, but the import share remains significant, highlighting continued dependence on regional power interconnections with the Southern African Power Pool, to meet the demand. Botswana's national energy security targets, as outlined in the Ministry of Mining and Energy Corporate Scorecard (2025–2026), focus on reducing dependence on electricity imports by significantly increasing domestic generation capacity. The country aims to meet 100% of electricity demand through local generation by 2029/2030, up from 66% in 2025. Intermediate targets show a gradual improvement, with local generation expected to meet 80% of demand by 2027/2028. Achieving this goal is supported by strategies such as the implementation of an operation and maintenance programme for Morupule B Power Station (Unit 2) and Morupule A, as well as capacity expansion through new projects like the Mmamabula Energy Project.

System losses in Botswana's electricity grid in 2023, amounted to 642 GWh, representing 14.51% of total generation and imports, a slight improvement from 15.35% in 2022 and a notable decrease from 16.91% in 2020. These losses are high compared to international best practice benchmarks, typically below 10%, indicating ongoing technical and perhaps commercial inefficiencies in transmission and distribution networks. Continued investment in grid modernization and loss reduction remains a critical need for enhancing supply-side efficiency.

2.1.1. Energy access and grid connectivity

Over the last decade, Botswana has made notable progress in improving national electricity access, although rural-urban disparities persist and access to clean cooking solutions has stagnated at 66% as presented in Table 3. According to official statistics, the national electrification rate increased significantly from 55.6% in 2011 to 75.9% in 2022 and 76% in 2025. This growth was largely driven by urban access expansion, where access rose from 77.6% to 95.5% over the same period. In contrast, rural electrification has regressed, falling from 37.49% in 2011 to just 25.0% in 2022. This downward trend reflects systemic challenges in extending the national grid to sparsely populated and remote settlements, requiring investments in infrastructure by Botswana Power Corporation (BPC) for the achievement of the policy commitments laid out in the National Development Plans and the IRP.

Botswana has outlined clear national targets for electricity access and clean energy as part of its strategic planning to 2030. According to the Ministry of Minerals and Energy, the government aims to achieve 100% electricity access by 2029/2030, up from 76% in 2025. Interim milestones include reaching 85% by 2026/2027 and 91% by 2028/2029. These targets are supported by measures such as the establishment of a Rural Electrification Agency, rationalisation of BPC, deployment of mini-grid and off-grid solar solutions, and accelerated grid connections through network extension programmes. In terms of clean energy, the country also aims for 50% of electricity demand to be met by renewable sources by 2030, a dramatic rise from the 2023 baseline of 2.85%. This will be achieved through the implementation of the IRP, commissioning of renewable technology systems, and the rollout of mini-grid and off-grid renewable projects. These targets reflect Botswana's dual commitment to universal energy access and enhanced national energy security through domestic and renewable energy generation.

In terms of clean cooking access, Botswana shows modest national progress, from 59.4% in 2011 to 66.0% in 2022, but persistent rural-urban disparity remains. Urban access to clean cooking fuels (mainly LPG and electricity) reached 86.9% in 2022, while rural access hovered at a low 25.3%, nearly unchanged from a decade earlier. This reflects continued reliance on traditional biomass (wood and charcoal) in rural areas, which accounts for nearly 20% of the national primary energy supply as of 2022. For clean cooking, the National Energy Policy (2021) emphasizes a transition to modern fuels such as LPG and electricity, aiming for 100% access to clean cooking by 2030, though no intermediate quantitative milestones are clearly defined. These targets are consistent with regional ambitions and reflect Botswana's commitment to reducing energy poverty, particularly in rural areas, while promoting sustainability and health outcomes.

2.2. Energy–related GHG Emissions by Sector

Based on Botswana's Third National Communication (TNC) to the United Nations Framework Convention on Climate Change (UNFCCC), the greenhouse gas emissions from the energy sector in 2014 reached 8,659 $ktCO_2eq$. Energy industries (mainly electricity generation) accounted for the highest share at 4,334.36 $ktCO_2eq$ (50% of total), driven by extensive use of coal. Transport followed with 2,294.89 $ktCO_2eq$ (26.5%), reflecting the significant reliance on diesel and gasoline for both freight and passenger movement. The "other sectors" category—including residential and commercial combustion—emitted 1,575.85$ktCO_2eq$ (18%), significantly influenced by methane and nitrous oxide from inefficient biomass use. Finally, fugitive emissions from solid fuels, primarily methane from coal mining and handling, added 264.79 $ktCO_2eq$ (3%), underlining the non-combustion impacts of coal use. The analysis in the following chapters, focusses only on the energy related emissions.

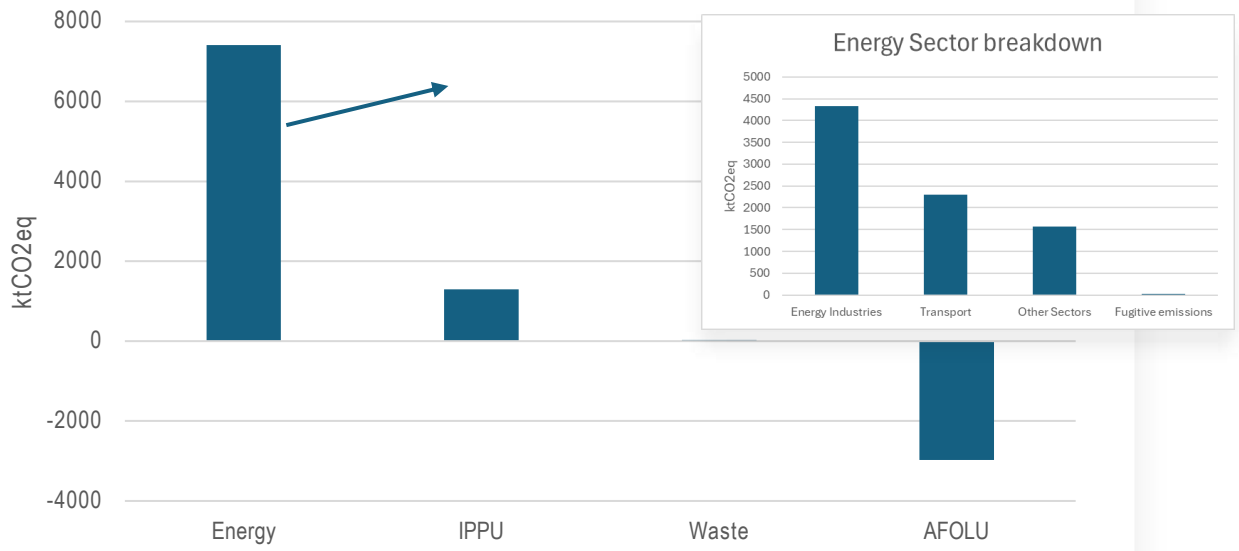


Figure 8 : GHG emissions per sector in 2014.
(Source: Third National Communication 2019)

2.2.1. Electricity

In 2022, Botswana's total electricity sales reached 3,404 GWh, reflecting continued expansion in energy access and economic activity across sectors. The largest share of electricity was consumed by the domestic sector, which used 1,256 GWh, representing 36.9% of total electricity sales (Figure 9). This high Share reflects Botswana's progress in household electrification, particularly in urban areas where electricity access reached 95.5% in 2022. The commercial sector followed closely, accounting for 1,107 GWh or 32.5% of total electricity sales. This consumption reflects Botswana's expanding service-based economy, with increasing demand from retail establishments, offices, and urban commercial services. As commercial energy use typically coincides with peak demand hours, it plays a significant role in shaping daily load profiles and justifies ongoing investments in grid reliability and capacity upgrades.

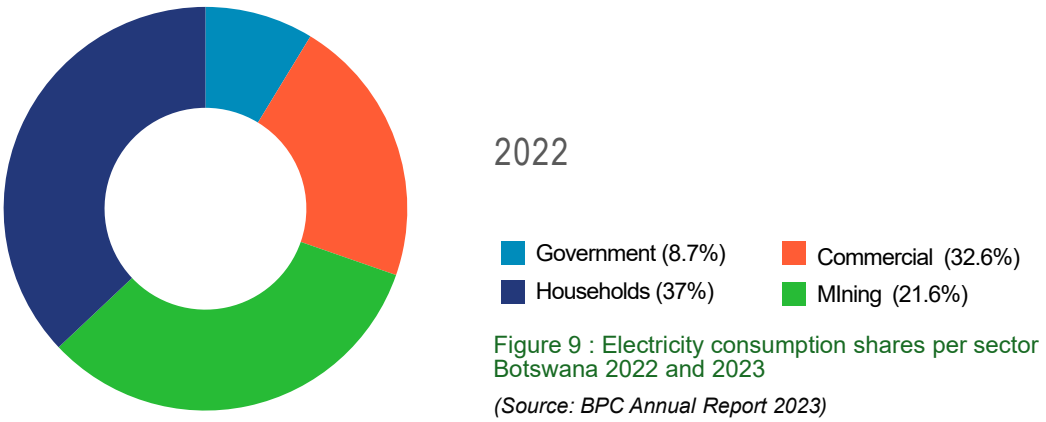


Figure 9 : Electricity consumption shares per sector Botswana 2022 and 2023

(Source: BPC Annual Report 2023)

Mining, a cornerstone of Botswana's economy, consumed 734 GWh in 2022, about 21.6% of total sales. This sector is energy-intensive, with electricity used for mineral extraction, processing, and water pumping, particularly in diamond and coal operations. The relatively stable demand from mining provides a reliable base load for the power system, but it also underscores the importance of uninterrupted and cost-reflective electricity supply to ensure economic competitiveness.

The government sector accounted for 294 GWh, or 8.6% of total electricity demand. This includes consumption by public offices, schools, health facilities, and other administrative infrastructure. The reliable supply to these users is crucial for maintaining public services, and improvements in this segment are often linked with broader development goals such as education and healthcare delivery.

Electricity exports to the SAPP totalled 152 GWh, but the country remained a net importer. In 2022, the country imported 1,798 GWh, nearly 45% of the total electricity sent out and purchased (4,022 GWh). Despite increased output from domestic coal-fired plants such as Morupule A and B, Botswana remains significantly reliant on imports to meet peak and reserve demand. This dependency highlights the need for enhanced domestic generation capacity and diversification of supply sources. Overall, the structure of electricity consumption in Botswana reveals a system under transformation, one with expanding access, high dependence on imports, and rising urban-commercial and household demand. While the supply-side remains anchored in domestic coal-fired power and regional imports, ongoing policy reforms, infrastructure upgrades, and clean energy integration under the Integrated Resource Plan are key to ensuring a reliable, inclusive, and sustainable energy future.

2.2.2. Industry

In 2022, the industrial sector in Botswana accounted for a total final energy consumption of 274 thousand tonnes of oil equivalent (ktoe), equivalent to approximately 15.8% of the total final energy consumption. Industry is the third-largest energy consuming sector after transport and households, and it plays a pivotal role in the national economy, particularly through mining, manufacturing, and mineral beneficiation. According to the Integrated Resource Plan and national development data, the sector is also among the country's most energy-intensive, driven by activities such as diamond processing, copper and coal mining, soda ash extraction, and cement production.

Electricity consumption in the industrial sector was 80 ktoe (approximately 930GWh), corresponding to nearly 29% of total industrial energy use. This is expected, as electricity powers a range of operations from drilling and crushing in mining to motor systems in manufacturing. Diesel made up 129 ktoe, or 47% of industrial energy use, underscoring its dominant role in machinery, on-site generators, and heavy-duty operations in mining and quarrying sites. Residual fuel oil contributed 13 ktoe, primarily in heat production or specific high-temperature applications in industrial plants. LPG, which accounted for 4 ktoe, is typically used for light processing tasks in smaller manufacturing enterprises. Additionally, coal consumption in the industrial sector stood at 49 ktoe, indicating continued reliance on direct combustion of bituminous coal, particularly in large-scale facilities such as cement or brick production. Notably, the industrial sector did not record any use of traditional biomass fuels such as wood or

charcoal, distinguishing it from household and agricultural consumption patterns. This reflects the sector's preference for high-density, commercially distributed fuels with reliable supply chains.

From an economic perspective, industry remains a central pillar of Botswana's growth strategy, contributing significantly to GDP. Although the mining sector's share in GDP is gradually declining—from 22.2% in 2016 to a projected 12.2% in 2040 under the IRP's Business-as-Usual scenario—the sector still underpins export revenues, infrastructure development, and job creation. The manufacturing share, in contrast, is projected to increase to 12.8% by 2040, further reinforcing the relevance of ensuring reliable and cost-reflective energy supply to support industrial competitiveness.

Given its scale, energy intensity, and future growth expectations, the industrial sector is both a challenge and an opportunity for energy policy in Botswana. Reducing the sector's dependence on imported fossil fuels, particularly diesel, and increasing electrification from renewable sources would help meet national targets on emissions and energy security.

2.2.3. Transport

In 2022, the transport sector was the largest final energy consumer in Botswana, accounting for 976 ktoe, equivalent to approximately 56.1% of the country's total final energy demand. This high share underscores the critical role of transport in Botswana's energy landscape and reflects the country's geography, trade structure, and reliance on road-based freight and passenger movement. Botswana is a landlocked country with dispersed population centres and vast distances between urban hubs and border crossings, which amplifies the role of fossil fuels in mobility and logistics.

The bulk of transport energy demand was met through diesel, which contributed 542 ktoe, or 55.5% of transport energy use. Diesel is predominantly used in the freight sector, which accounted for 405 ktoe of the total demand, over 41% of the transport sector's energy consumption. Botswana's freight operations are heavily road-based and serve both domestic movement and cross-border haulage, particularly for mineral exports and imports from ports in South Africa and Namibia. The passenger transport segment consumed 137 ktoe of diesel, reflecting the prevalence of diesel-fuelled buses and long-distance and off-road vehicles.

Gasoline was the second-largest transport fuel, with a total of 432 ktoe, representing 44.3% of the sector's energy use. The passenger sub-sector was the main gasoline consumer, using 330 ktoe, or about 76% of all gasoline consumed in transport. This highlights the dominance of private vehicles and light-duty transport in Botswana's urban and peri-urban areas.

Jet kerosene, consumed by domestic aviation, contributed 1.3 ktoe, a relatively small amount (0.2% of transport energy) Jet kerosene consumption for international aviation accounted for 6 ktoe, so together with the domestic aviation is notable given the importance of regional and international connectivity to the country's economy and tourism sector. No electricity or alternative fuels were recorded in transport energy use for 2022, highlighting the absence of electric vehicles and the current lack of fuel diversification in this sector.



This fossil-fuel dependence also translates into emissions: the transport sector is a significant contributor to Botswana's greenhouse gas emissions, particularly from road freight, which combines high fuel use with long distances. Furthermore, all transport fuels are imported, making the sector a key vulnerability in terms of energy security and trade balance. Rising fuel prices or supply chain disruptions can therefore have immediate economic consequences. Transport is central to Botswana's development strategy, particularly as the country seeks to position itself as a logistics and trade corridor within the Southern African Development Community (SADC). However, the sector's energy profile raises pressing concerns for sustainability and decarbonization. While national policies such as the Integrated Resource Plan and National Energy Policy emphasize the need for cleaner mobility options, there is little evidence in 2022 of a shift toward electric mobility or modal shifts to rail or mass transit.

2.2.4. Buildings

In 2022, the household sector in Botswana consumed a total of 303 ktoe, representing 17.4% of the country's total final energy demand. The energy mix in households was notably diverse, with both modern and traditional fuels in use, reflecting differences between urban and rural energy access and consumption patterns. Electricity accounted for 116 ktoe (1348GWh), making up 38.3% of household energy use. This was driven predominantly by urban areas, where electrification reached 95.5% in 2022, enabling widespread use of electric appliances for lighting, cooking, and cooling. In contrast, rural electrification remained at 25%, which influenced a much heavier reliance on biomass fuels.







Wood and charcoal remained major household energy sources, contributing 117 ktoe and 58 ktoe respectively, together making up over 57.7% of household energy consumption. This dominance of biomass, especially in rural areas, underscores persistent challenges in clean energy access and affordability. Traditional cooking methods using wood and charcoal are associated with low efficiency, indoor air pollution, and unsustainable harvesting practices. The continued reliance on these fuels is also reflected in charcoal production estimates, where transformation losses amounted to a total of 233 ktoe.

LPG made a modest contribution of 9 ktoe, indicating limited but growing penetration of clean cooking fuels. The low LPG use relative to biomass highlights both affordability issues and infrastructure limitations, such as cylinder distribution and supply chain constraints, particularly outside major towns.

Meanwhile, the services sector consumed a total of 151 ktoe in 2022, which is 8.7% of national final energy demand. Of this, 77 ktoe was electricity, making up 51% of energy use in the sector, reflecting its central role in powering lighting, air conditioning, refrigeration, Information and Communication Technology (ICT), and other end-uses in commercial buildings, offices, and public facilities. The services sector also used 40 ktoe of wood and 18 ktoe of charcoal, accounting for nearly 38.4% of its energy use, an unexpectedly high share that suggests significant reliance on biomass in smaller establishments or rural-based service institutions, such as schools and community centres.

Diesel consumption in the services sector amounted to 15 ktoe, used likely for backup power generation, vehicle fleets, and heating. Coal use was negligible at just 1 ktoe, suggesting that direct coal combustion is largely absent in commercial and institutional buildings.

Together, energy use in buildings, covering both households and services, totalled 454 ktoe, or 26.1% of Botswana's final energy demand. While urban buildings are increasingly electrified, the widespread use of biomass in both sectors, particularly for cooking and heating, underscores the urgency of clean energy transitions. The government's long-term energy strategy and Sustainable Energy for All (SE4ALL) Action Agenda recognize this and aim for universal access to clean cooking by 2030. Achieving this target will require accelerating access to LPG, electricity, and potentially other clean fuels, while improving building efficiency and reducing reliance on biomass. Improved building energy codes and appliance standards could further reduce electricity demand growth and environmental impacts. Electrification of end-uses such as cooking and space conditioning, combined with renewable electricity supply, would help align the building sector with Botswana's decarbonization and energy security goals.

2.2.5. Oil & Gas

In 2022 all petroleum products, including gasoline (433 ktoe), diesel (715 ktoe), jet kerosene (7 ktoe), and LPG (13 ktoe), were entirely imported to meet domestic demand. These fuels are critical to the economy, especially for the transport, industry, and household sectors. However, the complete dependency on imports for liquid fuels exposes Botswana to significant energy security risks, particularly price volatility and regional supply disruptions. To reduce this dependency and improve energy self-sufficiency, Botswana has turned its attention to the potential development of CBM, a relatively untapped domestic resource. The country is estimated to hold substantial reserves of CBM, associated with its vast coal deposits, which exceed 200 billion tonnes in total. Recognizing the strategic value of this resource, CBM development has been explicitly prioritized in national energy policy documents and in the IRP.

Under the IRP, Botswana's government plans to integrate CBM into the national electricity generation mix. A 10 MW CBM pilot project has already been identified, with procurement processes underway and commercial operation expected within the next planning cycle. This project serves as a testbed for broader CBM-based energy generation.

CBM offers several advantages, since it is a cleaner-burning fossil fuel compared to coal, with lower CO_2 and particulate emissions, it can be developed relatively quickly using modular, distributed generation systems, and it offers potential for rural electrification through decentralized energy production. Moreover, it aligns with Botswana's strategic objective to become a net electricity exporter within the SAPP. However, realizing the potential of CBM faces technical and financial hurdles. These include the need for extensive exploration and well development, infrastructure for gas processing and power generation, and regulatory frameworks to manage environmental risks such as groundwater contamination and methane leakage.

2.2.7. Agriculture

In 2022, the agriculture sector in Botswana accounted for a relatively small share of the country's total final energy demand, consuming 29 ktoe, just 1.7% of the national total. This low energy footprint is consistent with the structure of Botswana's agricultural economy, which is predominantly subsistence-oriented, rain-fed, and characterized by low mechanization levels. Nonetheless, energy use in agriculture remains vital for essential activities such as irrigation, livestock production, crop processing, and water pumping in rural areas.

The sector's energy consumption was dominated by electricity, which accounted for 18 ktoe, or 62.1% of total agricultural energy use. This electricity is primarily used in commercial farms, cattle posts, and irrigation schemes where access to the grid or standalone systems are available. The use of electricity in agriculture is generally associated with water pumping for irrigation and livestock, refrigeration, and lighting and powering of equipment in larger agricultural operations.

Diesel was the second-largest energy source in agriculture, contributing 7 ktoe, or 24.1% of sectoral demand. Diesel fuels machinery such as tractors, harvesters, and water pumps, especially in more mechanized commercial farming enterprises or in locations not connected to the national electricity grid.

LPG contributed 1 ktoe (3.4%), likely used in heating, small-scale processing, or cooking on commercial farms. The presence of coal consumption, at 4 ktoe, is more unusual in the agricultural context and may be linked to heating or drying processes in specific sub-sectors such as small-scale food processing that still rely on solid fuels.

Notably, the sector recorded no consumption of traditional biomass fuels such as wood or charcoal, at least in formal energy accounting. This may reflect the limited use of biomass in agricultural operations, although informal usage may persist in remote farming contexts, often underreported in official balances.

Despite its small energy footprint, agriculture plays an essential socio-economic role in Botswana, employing a significant portion of the rural population and serving as a critical source of food security. The low energy intensity and dependence on fossil fuels like diesel highlight opportunities to improve productivity and resilience through cleaner and more efficient energy technologies. Electrification of rural agriculture, especially through decentralized solar-powered irrigation systems, solar water pumps, and cold storage, can boost yields, reduce reliance on diesel, and support climate adaptation. As Botswana moves toward its 2030 energy access and sustainability targets, integrating agriculture into the national energy transition will be crucial. Energy planning for agriculture should prioritize affordability, reliability, and sustainability.

2.2.8. Clean Cooking

In Botswana, access to clean cooking remains a significant developmental and environmental challenge, particularly for rural households. As of 2022, national access to clean cooking stood at 66.0%, with a substantial urban-rural divide: 86.9% of urban households had access to clean cooking solutions, compared to only 25.3% in rural areas. While this represents a modest improvement from 59.4% nationally in 2011, the pace of progress has been slow, and traditional biomass, mainly wood and charcoal, continues to dominate cooking energy sources, especially outside urban centres.

The reliance on biomass is reflected in the national energy balance, which shows 117 ktoe of wood and 58 ktoe of charcoal consumed by households in 2022, making up more than 57% of total household energy use. These fuels are mostly used in inefficient cookstoves or open fires, which contribute to indoor air pollution, health risks (especially for women and children), and unsustainable wood harvesting. In contrast, modern fuels such as LPG accounted for only 9 ktoe in the household sector, indicating that access and affordability remain barriers to wider adoption.

Botswana has recognized these challenges and incorporated clean cooking targets into national energy planning frameworks. The National Energy Policy (2021) and the SE4ALL Action Agenda commit the country to achieving universal access to clean cooking by 2030, in line with Sustainable Development Goal 7. These ambitions are echoed in the Ministry of Minerals and Energy (MME) corporate scorecard, which emphasizes modern energy access, including clean cooking, as a strategic priority.

A number of pilot projects and small-scale interventions have taken place, often with donor or Non-Governmental Organisation (NGO) support, aimed at promoting the use of improved biomass

cookstoves, LPG dissemination, and awareness campaigns on indoor air pollution. While Botswana has made notable strides in electrification, the clean cooking transition is lagging and requires, focused policy and investment attention. Achieving universal access to clean cooking by 2030 will depend on turning strategic commitments into coordinated action—supported by infrastructure, regulation, financing, and innovation.

2.3. Key Challenges

Botswana's energy sector faces a complex set of interrelated challenges that hinder its ability to meet growing demand, ensure energy security, and align with sustainability goals. Despite notable progress in electrification and policy development, systemic issues persist across supply, infrastructure, access, and investment.

Botswana's energy supply is heavily reliant on fossil fuels, particularly coal and imported petroleum products. Coal-fired power stations, such as Morupule A and B, provide the majority of domestic electricity generation. However, these plants have faced operational challenges, including maintenance issues and inefficiencies, leading to frequent power outages and load shedding. To meet peak demand, Botswana often resorts to importing electricity from neighbouring countries, notably South Africa. This dependence on imports exposes the country to external supply disruptions and price volatility, undermining energy security.

The national grid infrastructure suffers from aging equipment, need for coverage extension, and relatively high transmission and distribution losses. These issues reduce the reliability of power supply in remote and rural areas. Efforts to expand and modernize the grid are ongoing but face financial and logistical hurdles.

While urban electrification rates have improved significantly, rural areas lag behind. As of 2022, only 25% of rural households had access to electricity, compared to 95.5% in urban areas. Similarly, access to clean cooking solutions remains low, with many households relying on traditional biomass fuels like wood and charcoal.

Botswana possesses significant renewable energy resources, especially solar energy, given its high solar irradiance levels. However, the adoption of renewable energy technologies remains limited. Barriers include high initial investment costs, lack of financing options, and insufficient policy incentives. Although Botswana has developed several energy policies and strategies, including the National Energy Policy and the Renewable Energy Strategy, implementation has been relatively slow. Regulatory frameworks need to be strengthened to attract private sector investment and facilitate the development of independent power producers. The heavy reliance on coal for electricity generation contributes to greenhouse gas emissions and environmental degradation. Transitioning to cleaner energy sources is essential to meet Botswana's commitments under international climate agreements. However, balancing economic development with environmental sustainability presents a complex challenge that requires integrated planning and stakeholder engagement

Addressing these challenges necessitates a multifaceted approach involving policy reforms, infrastructure investment, capacity building, and stakeholder collaboration. Prioritizing renewable energy development, enhancing grid reliability, expanding access to modern energy services, and creating an enabling environment for private investment are critical steps toward a sustainable and secure energy future for Botswana.



03

Scenarios & Modelling Results

3.1. Baseline Scenario

This section presents the results of the energy system modelling for Botswana for the Baseline scenario. This scenario explores the pathway of energy demand, supply, and emissions evolution under current policies and achieving the targets of full access to electricity and clean cooking by 2030. The analysis covers sectoral dynamics, fuel use, and emissions trends from 2025 to 2050 with a projection to 2063.

Final Energy Consumption

Between 2025 and 2050, Botswana's final energy consumption under the Baseline scenario is projected to grow almost threefold, with substantial sectoral shifts reflecting both demographic and economic transitions**Error! Reference source not found.**. This scenario assumes the continuation of current policies and the full achievement of national targets for electricity and clean cooking access. The overall trajectory highlights the increasingly dominant role of the transport sector, continued growth in household energy use due to rising electrification and modern fuel adoption, and steady, though relatively slower, growth in industrial and service sectors.

In the short term, from 2025 to 2030, total FEC is projected to increase from 1,960 ktoe to 2,324 ktoe, an increase of approximately 18%. Transport remains the largest energy-consuming sector, expanding from 1,068 ktoe to 1,241 ktoe (22.5% increase) over this period. By 2030, the transport sector accounts for 54% of total energy demand, supported by growing passenger and freight mobility as the economy continues to expand. Household energy consumption grows from 398 ktoe to 515 ktoe (29% increase), increasing its FEC share slightly to 22% of total demand by 2030 from 20% in 2022. This rise is associated with ongoing improvements in electrification and access to modern cooking technologies, especially in rural areas. Industrial demand sees a modest increase from 288 ktoe to 312 ktoe (8% increase), representing around 13% of the total FEC by 2030. The services sector also grows consistently, from 175 ktoe to 223 ktoe (27% increase) and a FEC share of 10%, and agriculture remains a minor (1.4% of FEC) but steadily growing component, increasing from 30 ktoe to 33 ktoe (a 10% increase)

In the medium term, from 2030 to 2040, FEC accelerates further, growing from 2,311 ktoe to 3,041 ktoe, a gain of almost 32%. Transport remains the dominant sector, with demand reaching 1,675 ktoe in 2040, or 55% of total final consumption. The sustained rise in transport energy use highlights the sector's structural significance, still underpinned by a high dependence on road-based travel and slow modal diversification. Household energy consumption increases to 597 ktoe by 2040, although its relative FEC share falls to 19% due to faster growth in other sectors. Industry reaches 368 ktoe, maintaining a stable FEC share near 12.1%, while services expand more noticeably to 363 ktoe (11.9% of FEC), reflecting urbanization and the increasing role of the tertiary economy. Agriculture grows to 39 ktoe, maintaining a very small FEC share of 1.3%.

In the long term, between 2040 and 2050, total FEC increases from 3,041 ktoe to 4,144 ktoe, a substantial rise of 1,106 ktoe or 36.4%, the largest absolute growth across the three examined timeframes. By 2050, the transport sector reaches 2,262 ktoe, accounting for approximately 54.5% of FEC. This continued dominance raises critical concerns about Botswana's dependence on imported fuels, vulnerability to oil price fluctuations, road congestion, and the environmental impacts of transport emissions. Household energy consumption grows significantly to 814 ktoe by 2050, representing 19.6% of FEC. This increase reflects ongoing improvements in residential energy access and standards of living, though the share remains lower than in earlier decades due to transport sector expansion. Industry rises to 432 ktoe, but its FEC share declines slightly to 10.4%, suggesting moderate energy intensity improvements or a structural shift toward less energy-intensive activities. The services sector grows to 590 ktoe and contributes about 14.2% of FEC, consistent with economic diversification and urban growth. Agriculture increases modestly to 46 ktoe, continuing to account for 1.1% of FEC.

Overall, the projection from 2025 to 2050 paints a picture of steadily rising energy demand, increasingly driven by the transport sector. Despite strong growth in household energy use, its relative importance declines as transport continues to absorb the largest share of energy inputs. The industrial and services sectors experience consistent but comparatively modest increases, while agriculture remains marginal throughout. This evolving profile of energy demand underlines the importance of implementing more ambitious transport energy strategies, promoting alternative fuels, improving energy efficiency across all sectors, and integrating renewable energy sources to enhance energy security and sustainability.

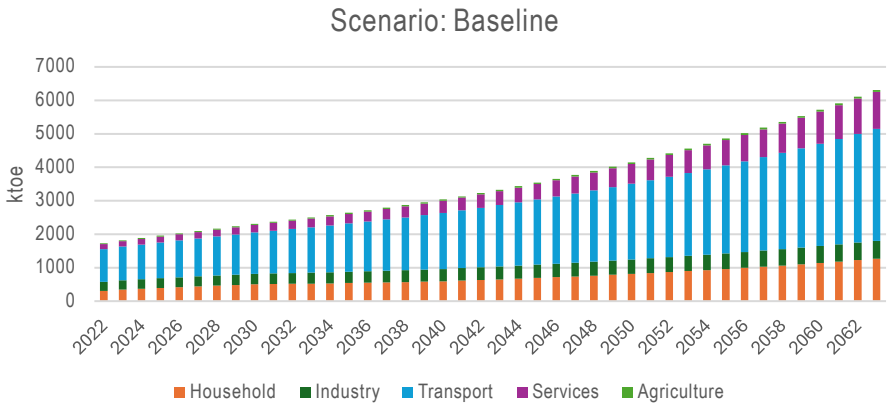


Figure 10 : Projections of **Final Energy Consumption** per sector for the Baseline scenario.

Between 2025 and 2050, Botswana's projected FEC by fuel under the Baseline scenario reveals a deepening reliance on petroleum products, a steady rise in electricity demand, and evolving patterns in biomass use. This scenario assumes full achievement of electrification and clean cooking targets by 2030 and continuation of existing energy policies. In the short-term period from 2025 to 2030, diesel continues to dominate Botswana's final energy consumption, rising from 758 ktoe in 2025 to 882 ktoe in 2030 (a 16.4% increase). This represents 38.6% of total final demand in 2025 (Figure 11) and 38.1% in 2030, maintaining its role as the largest single fuel source. Gasoline also increases significantly from 468 ktoe to 534 ktoe, contributing 23.8% of FEC in 2025 and 23.0% in 2030. Electricity grows from 325 ktoe to 423 ktoe, making up 16% and 18% of FEC, respectively, reflecting continued electrification and rising appliance penetration. Biomass trends begin to shift during this period. Wood consumption increases from 253 ktoe in 2025 to 317 ktoe (25% increase) in 2030, though the rate of growth tapers off, signalling the start of a plateau. Charcoal use grows more slowly from 68 ktoe to 73 ktoe, suggesting continued reliance among peri-urban households. LPG rises from 13 ktoe to 18 ktoe, driven by national clean cooking campaigns.

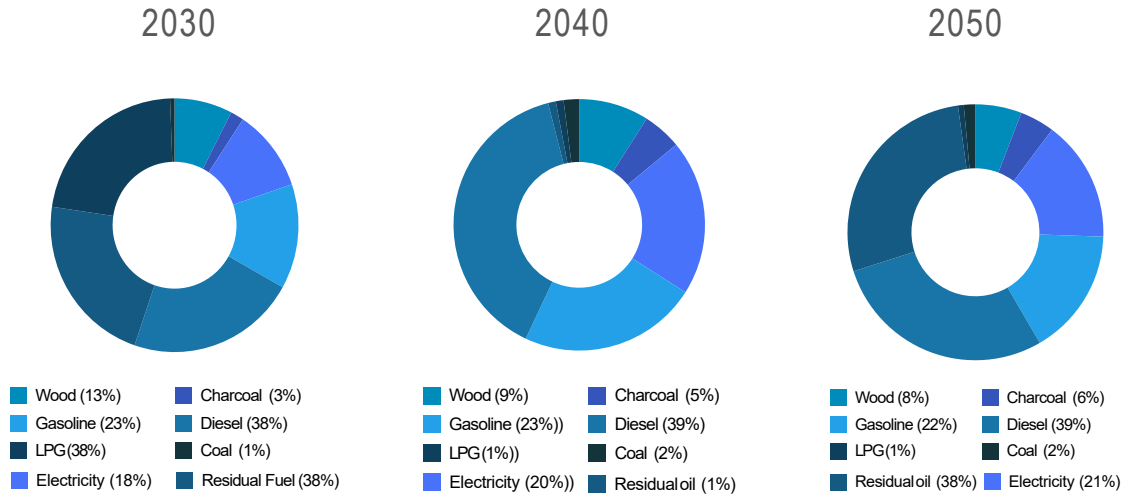


Figure 11 : Fuel shares in Final Energy Consumption for the Baseline scenario.

In the medium-term period from 2030 to 2040, diesel demand rises sharply to 1,196 ktoe, making up 39% of FEC. Gasoline continues its moderate increase, reaching 695 ktoe and maintaining a stable FEC share of 23%. Electricity consumption expands to 607 ktoe, equivalent to 20% of FEC, reflecting greater electrification and growing economic activity. During this period, biomass undergoes a structural shift: wood consumption declines from 317 ktoe to 287 ktoe (4.7% decline), while charcoal grows more rapidly from 76 ktoe to 135 ktoe (80% increase), likely due to increased urban and peri-urban usage of

processed biomass. LPG grows from 18 ktoe to 26 ktoe a 45% increase), aligned with clean cooking ambitions. Coal use also rises gradually from 62 ktoe to 74 ktoe (19.4% increase), maintaining a modest role primarily in the industrial and services sectors. In the long-term horizon from 2040 to 2050, diesel continues its sharp upward trajectory, reaching 1,629 ktoe by 2050, and accounting for 39% of FEC. Although still dominant, its relative share increases only slightly, indicating the gradual rise of competing fuels. Gasoline consumption grows to 902ktoe, representing 22% of FEC, still substantial, though its share declines compared to earlier periods. Electricity use reaches 890 ktoe, equivalent to 21% of FEC in 2050, underscoring its consistent, of moderate growth. Biomass continues to show resilience. Charcoal use increases significantly to 236 ktoe, while wood hovers around 335 ktoe, indicating only a slight decline from 2040, and collectively biomass still comprises approximately 14% of the FEC in 2050. LPG consumption grows to 39 ktoe, showing wider uptake in cooking and possibly heating applications. Coal rises modestly to 88 ktoe, continuing its niche presence in energy-intensive sectors. Other fossil fuels such as residual fuel oil and jet kerosene remain minor, with combined shares under 2%, and hydrogen does not appear in the projected energy mix through 2050.

In the Baseline scenario projections, over the 25-year period from 2025 to 2050, Botswana's energy system becomes more petroleum-intensive, with diesel and gasoline jointly accounting for more than 60% of final energy demand by mid-century. Electricity use more than doubles in absolute terms but grows more slowly than liquid fuels. Biomass remains an important part of the energy mix, particularly wood and charcoal, highlighting the inertia in household energy practices despite policy targets. These projections suggest that, without additional interventions, Botswana's energy system will remain heavily reliant on imported fossil fuels, with significant implications for energy security, environmental sustainability, and the country's decarbonization commitments. The rising demand for liquid fuels and modest growth of cleaner alternatives also signals the need for policy action to scale up renewable electricity, promote electric mobility, and accelerate the clean cooking transition.

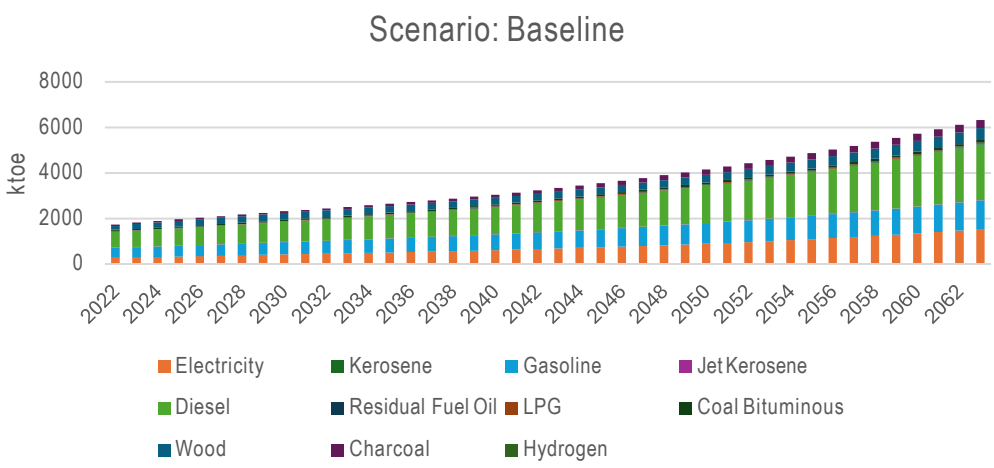


Figure 12 : Projections of Final Energy Consumption per fuel for the Baseline scenario.

Household sector by energy fuel/source

The household sector in Botswana is projected to undergo significant changes in its FEC patterns between 2025 and 2050, reflecting the country's progress toward universal access to electricity and clean cooking fuels. Total household energy demand grows substantially across the three timeframes, short-, medium-, and long-term, although the structure of energy use within households reveals a transition away from kerosene and a gradual reduction in biomass reliance, balanced by rising use of electricity and LPG. In the short-term period from 2025 to 2030, household electricity consumption in Botswana increases steadily from 135 ktoe in 2025 to 202 ktoe in 2030, accounting for 34.1% and 40.2% of total household energy use, respectively. This continued rise reflects progress in electrification—particularly in urban and peri-urban areas—and the growing adoption of electric lighting, appliances, and possibly electric cooking. LPG also shows upward momentum, growing from 8 ktoe to 13 ktoe over the same period, reaching 2.6% of household energy demand by 2030, indicating modest progress in clean cooking efforts. Biomass remains the dominant energy source for households. Wood use increases from 202 ktoe in 2025 to 237 ktoe in 2030, making up 47.2% of total household energy

demand by the end of the period. Charcoal use remains relatively stable, rising slightly from 49 ktoe to 50 ktoe, maintaining around 10% of household demand.

In the medium-term period from 2030 to 2040, electricity use grows significantly, reaching 293 ktoe in 2040 and accounting for 49.4% of total household energy demand. This increase reflects its broader use beyond lighting—extending into refrigeration, cooling, and possibly electric cooking. LPG expands more gradually, reaching 20 ktoe, or 3.4% of household energy demand.

Biomass patterns diverge since wood use begins to decline slightly in absolute terms, falling from 237 ktoe in 2030 to 186 ktoe by 2040, now accounting for 31.4% of household energy demand and, charcoal demand rises to 94 ktoe but used in more efficient appliances representing 15.8% of total household energy demand

By the long-term period from 2040 to 2050, household electricity demand reaches 437 ktoe, accounting for 53.7% of total household energy demand—surpassing half for the first time and cementing electricity as the dominant residential energy source. LPG use continues its upward trend, reaching 32 ktoe, or about 3.9% of household energy demand.

Meanwhile, wood use stabilizes at 179 ktoe, representing 22.0% of the total household energy demand, while charcoal reaches 167 ktoe, making up 20.5% of household energy demand. However, both fuels are used in more efficient devices. In summary, the household energy profile in Botswana is projected to shift meaningfully between 2025 and 2050 in the Baseline trajectory. While electricity becomes the dominant source by mid-century and LPG use expands steadily, biomass remains deeply embedded in the energy system. The declining trend of wood use indicate progress toward clean energy goals, but the continued use of charcoal suggests a need for more targeted interventions to accelerate transitions to fully modern energy.

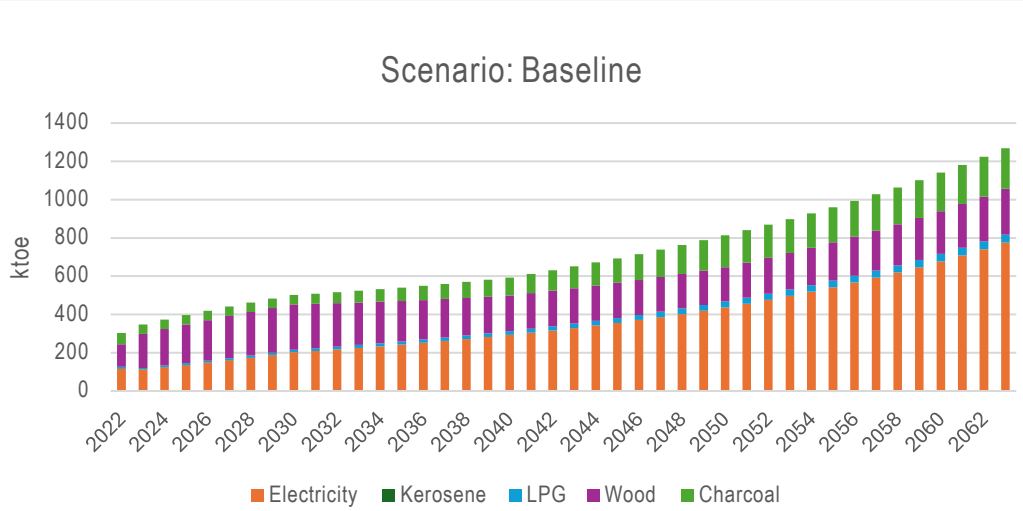


Figure 13 : Projections of Final Energy Consumption per fuel in Households for the Baseline.

Transport sector by energy fuel/source

In the transport sector, there is no projected adoption of electricity or hydrogen, in this scenario, highlighting the sector's continued dependence on conventional liquid fuels. In 2025, total transport energy demand is estimated at 1,068 thousand tonnes of oil equivalent (ktoe), of which 598 ktoe is diesel and 468 ktoe is gasoline. By 2030, this demand grows to 1,241 ktoe, with diesel contributing 705 ktoe and gasoline 534 ktoe. Diesel alone makes up more than 56% of the total transport energy demand, reflecting its central role in Botswana's freight transport. In the medium term, by 2040, total transport energy use reaches 1,675 ktoe, of which 1,012 ktoe is diesel and 712 ktoe is gasoline. Jet kerosene increases gradually but remains marginal, contributing just over 2.5 ktoe in 2040. By 2050, final energy demand in transport surges to 2,262 ktoe, with diesel contributing 1,449 ktoe and gasoline 950 ktoe. These figures underline the structural dominance of liquid fuels and the absence of a transition toward electric or low-carbon alternatives in this scenario. The continued rise in diesel demand, in particular, signals the growing energy intensity of Botswana’s logistics and road transport systems and points to critical challenges in decarbonizing the sector. Without policy shifts to support modal switching and land use planning, electrification, or fuel diversification, the transport sector is set to remain the largest and fastest-growing source of fossil fuel demand in the national energy system.

Industry sector by energy Fuel/source

In Botswana's industrial sector, final energy demand is projected to rise steadily between 2025 and 2050, driven by growth in electricity and diesel demand, with smaller but sustained contributions from coal, residual fuel oil, and LPG. The Baseline scenario reflects continued use of existing fuels under current policy frameworks, without substantial structural shifts toward low-carbon alternatives such as hydrogen or electrification beyond what is already underway. In the short-term period from 2025 to 2030, total final energy demand in the industrial sector grows from 288 ktoe to 312 ktoe, representing an 8.3% increase. Diesel remains the dominant energy source, increasing from 135 ktoe to 147 ktoe, and accounting for 46.9% of the sector's total energy consumption/demand in 2025 and 47.1% in 2030. This dominance reflects its widespread use in machinery, generators, and transport within industrial processes. Electricity ranks second, increasing from 84 ktoe to 91 ktoe over the same period, contributing approximately 29.2% of energy use and demand in 2025 and 29.2% again in 2030, showing stable reliance on grid power. Use of coal also rises slightly from 52 ktoe to 56 ktoe, maintaining a sector energy share of around 18%. Other fuels such as residual fuel oil and LPG remain minor contributors, collectively accounting for less than 7% of industrial energy use.

In the medium-term period from 2030 to 2040, total industrial energy demand grows to 368 ktoe, a 17.9% increase over the decade. Diesel expands significantly to 172 ktoe, sustaining a near-majority sector energy share at 46.7%. Electricity consumption grows more steadily, reaching 107 ktoe in 2040, and represents 29.1% of the total sector energy share. Coal use also increases to 66 ktoe, maintaining its steady role at about 18% of industry energy share. The contribution of residual fuel oil and LPG rises slowly, reaching 18 ktoe and 5 ktoe respectively, yet remains marginal.

In the long-term period from 2040 to 2050, industrial final energy demand increases from 368 ktoe to 432 ktoe, an industry energy demand growth of 64 ktoe or 17.4%. Diesel remains the dominant fuel, rising from 172 ktoe to 203 ktoe and accounting for approximately 47% of total industrial energy demand in 2050. Electricity follows as the second most important energy source, increasing from 107 ktoe to 125 ktoe, which corresponds to about 28.9% of the total sector energy demand. Coal demand also grows, from 66 ktoe to 77 ktoe, contributing roughly 17.8% of total industry energy demand by 2050, indicating its continued role in industrial heat applications and the cement sector. Residual fuel oil usage increases slowly, reaching 21 ktoe, while LPG remains marginal at 6 ktoe. Overall, the industrial sector in Botswana is projected to remain heavily reliant on fossil fuels in the Baseline scenario, especially diesel and coal, through 2050. Despite steady electrification, the absence of structural shifts toward low-carbon fuels or efficiency gains poses significant challenges to the country's decarbonization goals.

Services Sector by energy fuel/source

In the services sector, final energy demand in Botswana is projected to grow significantly from 2025 to 2050 under the Baseline scenario, driven primarily by increasing electricity demand and sustained use of biomass, with smaller but growing contributions from diesel and coal. Electricity accounts for just over 50% of energy use in 2025 (89 ktoe), rising to 113 ktoe by 2030, reflecting the sector's growing dependence on power for lighting, appliances, cooling, and IT infrastructure in offices, commercial buildings, and institutions. Biomass—comprising both wood and charcoal—remains a substantial component of the energy mix. Wood use rises from 46 ktoe in 2025 to 59 ktoe in 2030, while charcoal increases from 21 ktoe to 26 ktoe. Combined, these fuels contribute roughly 38% of the total services energy demand in 2030, indicating that despite rising electrification, many small enterprises and public buildings—particularly in rural areas—still rely on traditional fuels for heating and cooking. Diesel demand grows steadily, from 17 ktoe in 2025 to 22 ktoe in 2030, used mainly for backup generators and transport-linked services. Coal use remains minimal but consistent, from 2 ktoe to 2 ktoe over the same period.

By 2040, electricity demand climbs to 185 ktoe, wood to 96 ktoe, and charcoal to 43 ktoe, while diesel reaches 36 ktoe and coal reaches 3 ktoe, confirming the persistence of fuel diversity in the sector.

In 2050, electricity demand more than doubles from 2025 levels, reaching 300 ktoe and accounting for just over 50% of total services energy demand. Wood consumption rises to 157 ktoe and charcoal to 70 ktoe, together making up roughly 39.2% of the sector's energy mix. Diesel use reaches 58 ktoe, and coal grows modestly to 5 ktoe. The persistence of biomass in the long term signals the need for targeted clean energy policies in institutional and commercial buildings, including incentives for modern fuel adoption and energy efficiency measures.

Electricity generation

In the short term (2025–2030), Botswana's electricity generation in the Baseline scenario expands significantly from 4.6 TWh in 2025 to 16.69 TWh by 2030, primarily driven by increased coal-fired capacity (Figure 14) which makes Botswana a significant exporter of electricity (around 10TWh available for exports by 2030). Morupule B remains in operation providing 20% of the generation in 2033 while Morupule A is decommissioned by 2028. The commissioning of the new coal fired plants, namely Mmamabula (300MW in 2028 rising to 600MW in 2029) and Palapye (615MW in 2030), increases significantly the local electricity generation, using an indigenous energy source. Renewables also gain ground as new solar PV generation rises to 3.6 TWh by 2030. CBM (coal bed methane) contributes 0.7 TWh in 2030. Diesel units continue supplying a combined 0.42 TWh annually until they begin to phase out. This period marks the increased domestic generation of electricity, utilising local energy sources mainly coal and renewables (mainly solar) which reach a contribution of 22% in generation by 2030.

In the medium term (2030–2040), total electricity generation slightly increases from 16,69 TWh to 16.88 TWh. Mmamabula and Palapye coal plants overtake Morupule B, producing 4.2 and 4.31TWh respectively by 2040, while Morupule B remains stable at 3.4 TWh. These three plants collectively account for about 70% of electricity generation. New solar PV generation expands to 4.2 TWh, while wind stays at ~0.01 TWh, and CBM continues contributing a minor 0.7 TWh. Overall, this period sees marginal growth in renewable energy (25% share), with the system structurally reliant on legacy and new coal assets. Exports of electricity reach a level of 8.5TWh.

In the long term (2040–2050), total electricity generation also grows slowly to 17.84 TWh. The coal fired plants remain the largest sources of generation (with similar quantities to those in 2040). New solar PV increases further to 5.11 TWh, showing more robust expansion. Wind and CBM remain minor, each at 0.10 TWh and 0.7 TWh respectively. Export levels reach 5.6TWh. There are no additions of CCS or hydrogen technologies, and renewable uptake, while improving, remains modest relative to coal, leaving Botswana's electricity system fundamentally coal-based by 2050. Overall, across all timeframes, the Baseline scenario reflects a strategy of capacity consolidation around conventional coal plants, with modest renewable uptake (29% by 2050) and no further introduction of CCS, thereby locking in a carbon-intensive generation structure through mid-century.

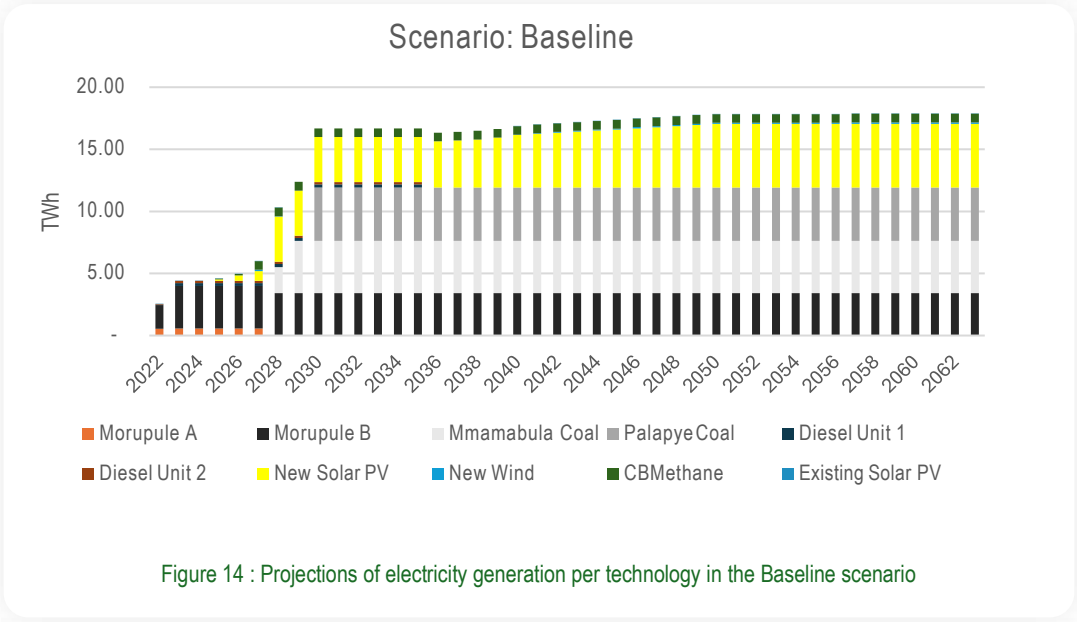


Figure 14 : Projections of electricity generation per technology in the Baseline scenario

Looking at the corresponding installed capacity, it increases significantly between 2025 and 2030, growing from 954 MW to 3,835 MW, and then continues to expand gradually through to 2050, reaching 4,489 MW under the assumptions of the Baseline scenario (Figure 15).This growth reflects the planned commissioning of both fossil and renewable energy projects. The plateau after 2030 suggests that early

expansion was designed to meet medium-term demand, but the subsequent incremental increases through to 2050 indicate a shift toward more diversified and renewable-driven capacity development.

In the short term (2025–2030), installed capacity rises from 954 MW in 2025 to 3,385 MW by 2030. This expansion is primarily driven by the introduction of 600 MW of capacity from Mmamabula coal (300 MW in 2028 and another 300 MW in 2029), and Palapye coal (615MW in 2030) establishing a total of 1615MW of coal capacity (including Morupule B 600 MW) by 2030. New solar PV begins with 50 MW in 2025, growing rapidly to 200 MW by 2026, and reaches 1658MW by 2030. Additional renewable diversification occurs in 2027 with 100 MW of new wind. Battery energy storage systems (BESS) are introduced with 140 MW in 2032 to support intermittent renewables. Diesel generators (160 MW total) persist until 2030 but are phased out afterward. CBM enters the mix with 16 MW by 2026 and reaches 100MW in 2027 remaining constant after this.

In the medium- and long-term periods (2040–2050 and beyond), total installed capacity grows from 3,835 MW to 4,089 MW in 2040 and 4,489MW in 2050, reflecting steady, incremental increases, particularly in solar PV, which expands from 1658 MW to 2332 MW by 2050. No more coal capacity is added until 2050. In conclusion, the Baseline capacity trajectory reflects a front-loaded coal-heavy expansion, followed by a gradual scale-up of solar PV capacity and supporting infrastructure. However, despite increasing renewable integration, the persistence of legacy and new coal assets limits the system's decarbonization potential.

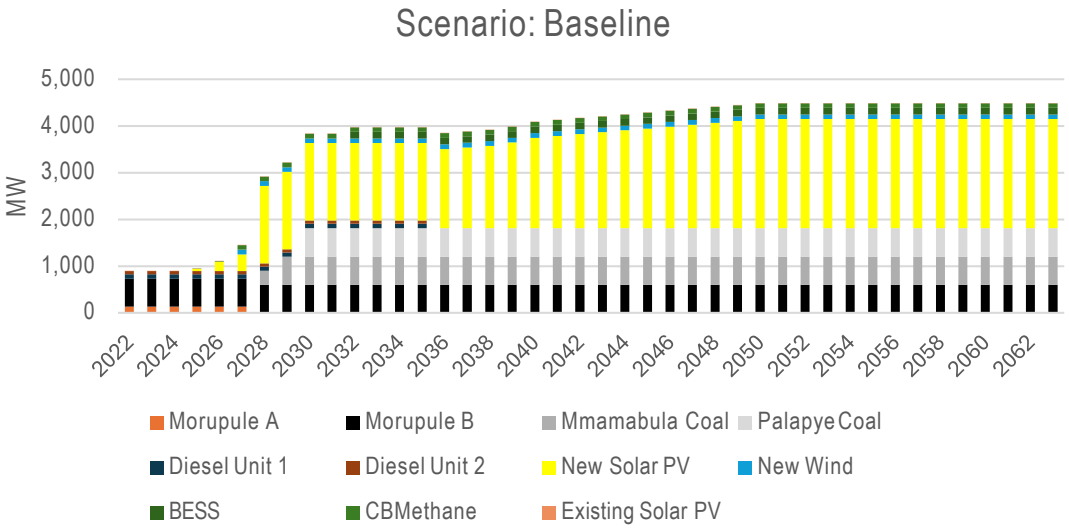


Figure 15 : Projections of on-grid electricity capacity, Baseline scenario.

Energy related GHG emissions (energy combustion activities)

Under the Baseline scenario, Botswana's energy-related GHG emissions are projected to rise significantly between 2025 and 2050, reflecting the combined effect of increasing final energy demand and a fossil fuel-dominated energy mix (Figure 16).

In the short term, from 2025 to 2030, energy GHG emissions increase from 8,497 kt CO_2eq to 16,744 kt CO_2eq, an overall rise of approximately 97%. Demand-side emissions grow from 4,108 kt CO_2eq in 2025 to 4,734 kt CO_2eq in 2030, accounting for about 28% of emissions by the end of the period. These emissions are driven primarily by rising consumption of diesel and gasoline, especially in the transport sector. Meanwhile, emissions from transformation activities, mainly power generation from coal-fired plants, rise sharply from 4,388 kt CO_2eq to 12,009 kt CO_2eq, indicating increased reliance on carbon-intensive electricity production. The sharp jump in transformation emissions in 2028 is due to the operation of the first unit of the Mmamabula coal plant (300 MW), and the next step in 2029 is due to the operation of the second unit, reaching a total of 600 MW, followed by another jump in 2030 from the operation of Palapye coal plant.

During the medium-term period from 2030 to 2040, GHG emissions rise from 16,744 kt CO_2eq to 17,985 kt CO_2eq, marking an increase of 7%. Demand-side emissions climb steadily to 6,251 kt CO_2eq by 2040, accounting for just under 35% of the total. This reflects persistent growth in fossil fuel use in transport, industry, and services. Transformation emissions increase more gradually, reaching 11.734

kt CO_2eq by 2040, suggesting the stabilization of coal-fired generation after earlier capacity additions. However, the lack of any apparent shift toward renewable or low-carbon generation means that power-sector emissions remain locked in at high levels.

In the long term, between 2040 and 2050, Botswana's GHG emissions continue to grow, reaching 20,058 kt CO_2eq by 2050, a rise of 11% from 2040. Demand-side emissions increase to 8,324 kt CO_2eq. This continued rise mirrors the sustained growth in transport fuel consumption and industrial diesel use. Meanwhile, transformation emissions reach 11,734 kt CO_2eq by 2050, suggesting a plateau in generation-related emissions, due to capacity stabilization rather than decarbonization. Still, coal remains the core fuel for electricity, and the emissions profile reflects a system heavily reliant on high-carbon sources.

The dominance of fossil fuels, particularly diesel, coal, and gasoline, across both demand and transformation sectors, underpins the trajectory of increasing emissions. The absence of major emissions mitigation in the Baseline, such as a transition to renewable energy or large-scale electrification of transport indicates that without decisive policy interventions, Botswana's emissions will continue on a steep path.

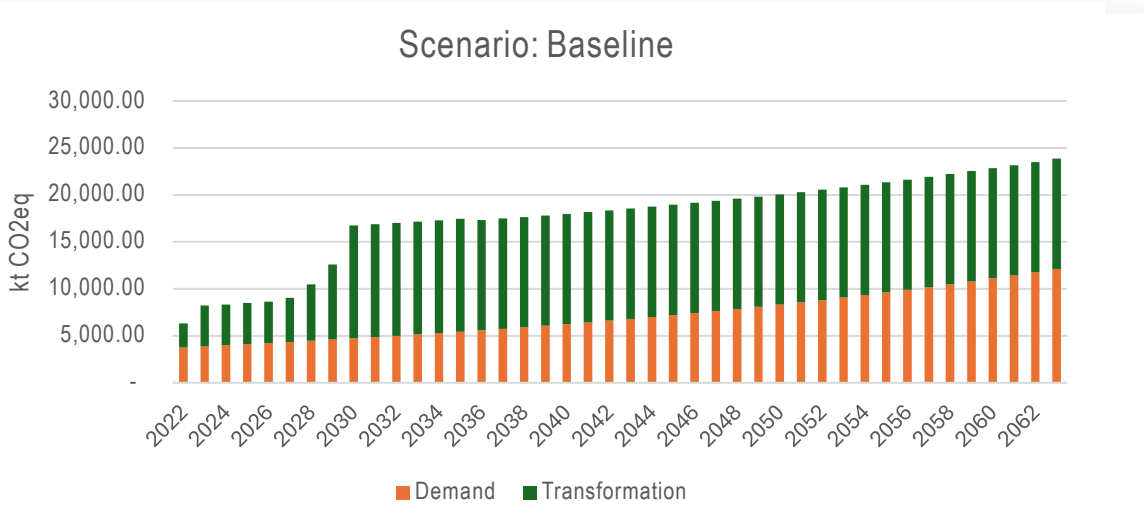
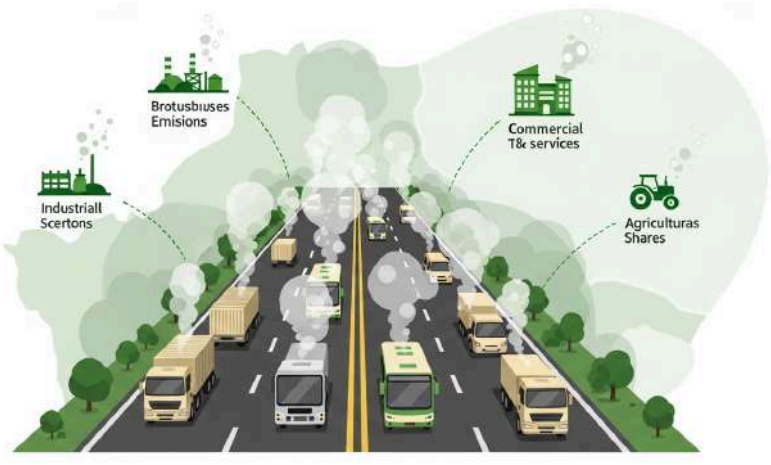


Figure 16 : Projections of energy related GHG emissions from the demand sector and transformation (electricity generation) sectors.

GHG emissions by Demand sectors

In the short term, from 2025 to 2030, transport is the primary contributor to GHG emissions throughout the entire period, accounting for 3,196 ktCO₂eq in 2025 and increasing to 3,716 ktCO₂eq in 2030, or nearly 79% of demand-side emissions (Figure 17). This growth is directly linked to increased consumption of diesel and gasoline, particularly in freight and passenger road transport, which remain entirely dependent on imported fossil fuels. Industrial emissions grow from 672 ktCO₂eq to 729 ktCO₂eq during the same period, reflecting expanding energy demand in mining, cement, and manufacturing activities, primarily powered by diesel, electricity (from coal), and coal combustion itself. The services and agriculture sectors contribute small but growing emissions, 77 ktCO₂eq to 99 ktCO₂eq, and 39 ktCO₂eq to 43 ktCO₂eq respectively, linked to modest growth in diesel and biomass use.



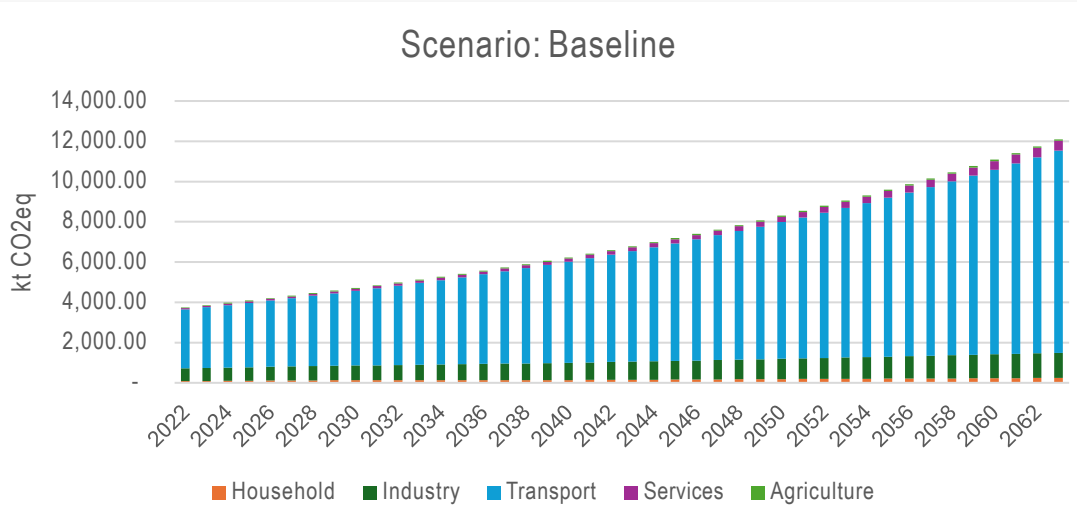


Figure 17 : Projections of energy related GHG emissions from the final energy consumption sectors.

Over the medium-term period from 2030 to 2040, transport emissions continue to rise rapidly, reaching 5,023 $ktCO_2eq$ by 2040 and representing over 80% of demand-side emissions. This trajectory underscores the sector's structural reliance on fossil fuels and the absence of electrification or modal shifts in this scenario. Industrial emissions grow to 857 $ktCO_2eq$, and household emissions to 139 $ktCO_2eq$. Emissions from the services sector rise to 161 $ktCO_2eq$, with diesel, charcoal, and wood remaining prominent fuels. The agricultural sector continues to grow slowly in emissions terms, reaching 50 $ktCO_2eq$ in 2040, largely through greater diesel use in mechanized processes.

In the long-term horizon between 2040 and 2050, the transport sector remains the overwhelming source of emissions, reaching 6,788 $ktCO_2eq$ by 2050, or over 81% of total energy demand-side emissions. The industry sector contributes 1,007 $ktCO_2eq$ in 2050, having grown consistently due to rising diesel and electricity demand. Household emissions reach 185 $ktCO_2eq$, while the services sector climbs to 261 $ktCO_2eq$. Agriculture adds 29 $ktCO_2eq$.

GHG Emissions by energy fuel

Having a closer look at the fuel level, diesel, coal, and gasoline are the dominant and fastest-growing contributors to GHG emissions, with only marginal contributions from alternative or cleaner fuels like LPG, CBM, and biomass (Figure 18). Coal remains the largest single source, with emissions rising from 4,252 $ktCO_2eq$ in 2025 to 11,687 $ktCO_2eq$ in 2050. The sharp increase beginning in 2028 reflects the operation of the new coal fired power plants as was discussed above. Coal is responsible for 58% of total energy emissions by mid-century in the Baseline scenario. Diesel is the second-largest contributor, rising from 2,646 $ktCO_2eq$ in 2025 to 5,003 $ktCO_2eq$ by 2050. This increase is aligned with the Baseline scenario's projections of growing diesel consumption in transport, industry, and backup generation. Diesel alone accounts for 25% of total energy-related emissions in 2050, underscoring its structural dominance in Botswana's energy system. Gasoline-related emissions see significant growth, increasing from 1,357 $ktCO_2eq$ in 2025 to 2,613 $ktCO_2eq$ in 2050, mainly driven by expanding private vehicle use. While its share of emissions is slightly smaller than diesel's, gasoline still contributes approximately 13% of total emissions by 2050. Other fossil fuels, such as residual fuel oil and jet kerosene, contribute modestly but grow steadily. Residual fuel oil increases from 43 $ktCO_2eq$ to 65 $ktCO_2eq$, while jet kerosene rises from 22 $ktCO_2eq$ to 31 $ktCO_2eq$, reflecting the growing role of air transport in national and regional connectivity. LPG, used mainly in the residential and commercial sectors, shows a steady rise in emissions from 40 $ktCO_2eq$ in 2025 to 119 $ktCO_2eq$ in 2050. Although it represents a cleaner alternative to biomass and kerosene for cooking, its contribution to total energy emissions remains under 1%. Finally, CBM enters the energy mix in 2025 with 39 $ktCO_2eq$ and grows to 391 $ktCO_2eq$ by 2050. While included as part of the Baseline scenario's transformation pathway, its emissions footprint remains small compared to conventional coal and oil fuels.

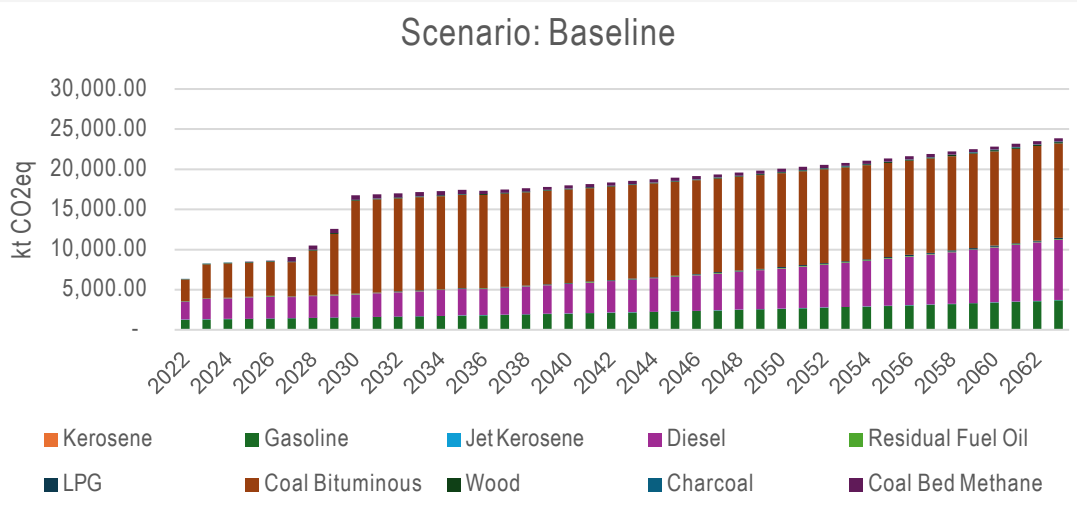


Figure 18 : Projections of energy related GHG emissions per fuel used in demand and transformation sectors.

Key Baseline conclusions

The Baseline scenario for Botswana presents an outlook on the country's energy system evolution through 2050, revealing persistent structural dependence on fossil fuels across FEC and electricity generation. Despite achieving national targets for electrification and clean cooking access, the overall energy pathway remains carbon-intensive, underlining the need for mitigation and diversification policies.

Final energy consumption more than doubles between 2025 and 2050, rising from 1,960 ktoe to 4,144 ktoe. This growth is largely driven by the transport sector, which becomes increasingly dominant, accounting for 55% of total energy demand by 2050 (2,262 ktoe out of 4,144 ktoe). Transport's reliance on diesel (1,449 ktoe) and gasoline (950 ktoe), with no transition to electricity or alternative fuels, results in substantial growth in liquid fuel use, further increasing import dependency and emissions. While the household sector shows promising signs of energy transition, with electricity becoming the primary fuel (437 ktoe, or 52.3%) and LPG gradually expanding to 49 ktoe, charcoal continues to play a major role (279 ktoe), highlighting slow behavioural shifts and affordability constraints. Industry and services both experience modest increases in energy demand, reaching 432 ktoe and 360 ktoe, respectively, by 2050, but remain anchored in diesel, coal, and biomass use, indicating limited structural transformation. Agriculture remains a minor consumer, at 46 ktoe by mid-century.

The fuel mix shows a deepening reliance on petroleum products, especially diesel, which constitutes 39% of total final energy demand in 2050. Electricity consumption more than doubles, rising from 607 ktoe in 2025 to 855 ktoe in 2050 across all sectors. Biomass, particularly wood (329 ktoe) and charcoal (224 ktoe), remains embedded in both residential and commercial sectors. Coal, LPG, and kerosene play marginal roles in overall consumption. The limited diversification toward low-carbon alternatives suggests that, without intervention, Botswana's energy system will remain vulnerable to fuel price volatility and external supply shocks.

GHG emissions follow a trajectory that closely mirrors energy demand trends. Total direct energy-related emissions double between 2025 and 2050, from 8ktCO_2eq to 13,715 ktCO_2eq. Demand-side emissions, led overwhelmingly by the transport sector, grow steadily and surpass 8,794 ktCO_2eq by 2050. Transformation emissions, dominated by coal-based power generation, rise from 2,903 ktCO_2eq to 4,714 ktCO_2eq, with a steep jump in 2028 due to the commissioning of the Jindal Coal plant. Diesel (5,003 ktCO_2eq) and bituminous coal (5,693 ktCO_2eq) are the two largest contributors to emissions, followed by gasoline (2,613 ktCO_2eq). Other fuels like LPG (119 ktCO_2eq), coal bed methane (42 ktCO_2eq), and biomass (wood and charcoal combined at ~151 ktCO_2eq) add modestly, while hydrogen remains entirely absent. The emissions intensity of the system remains high due to minimal electrification in transport and the continued expansion of coal generation.

Electricity generation more than triples between 2025 and 2050, from 4.6 TWh to 17.8 TWh, driven almost entirely by on-grid generation. Without major technological or policy shifts, Botswana's electricity supply will continue to reflect a rigid, fossil-based system. Installed capacity mirrors the generation profile: a rapid expansion from 954 MW in 2025 to 3,835 MW by 2030 is followed by slower increase

through 2050. Around 47% of the capacity mix by 2030 comes from coal (Morupule B, Mmamabula and Palapye plants), with renewables, particularly PV covering 43% of the capacity and the remaining covered by wind, CBM and BESS.

In conclusion, the Baseline scenario presents a trajectory of rapid energy demand growth paired with entrenched fossil fuel dependency. Diesel, coal, and gasoline remain central to both energy supply and emissions, while renewable energy, fuel switching, and decarbonization technologies play smaller roles. Achieving a more sustainable and resilient energy future for Botswana will require targeted policy reforms, including support for electric mobility, aggressive deployment of renewables, grid modernization, introduction of new energy carriers like hydrogen in the longer term, and energy efficiency across all sectors.

3.2. Deep Decarbonization Pathways

This section analyses the Deep Decarbonization Pathway, which explores how Botswana can transition toward a low-carbon energy system aligned with long-term climate goals. This scenario models ambitious shifts in technology, fuel use, and sectoral transformation to significantly reduce greenhouse gas emissions by 2050 and even more by 2063. It builds on the Baseline by incorporating targeted mitigation measures across all major energy-consuming sectors. Furthermore, a more ambitious decarbonisation scenario is examined, DDP LT in which the mitigation actions are intensified after 2040, leading to a reduction in the total energy related emissions, after a peak in 2040. This is achieved through higher electrification in all sectors and the penetration of renewable electricity generation technologies to the full potential identified in Botswana; CCS options for the coal fired power plants and the penetration of hydrogen options in the hard to abate industrial sectors and freight transportation.

More specifically, the main shift in the household sector comes from the change in the cooking appliances. The share of each appliance per type of household can be seen in Figure 19 for the DDP-LT scenario and is presented in more detail in Annex 1. Electric stoves are assumed to reach close to 30% in urban electrified homes and 10% in rural electrified homes, while the remaining is taken up by LPG stoves and improved wood and charcoal stoves (note that since all households are electrified by 2063, the contribution of the non-electrified households to the energy consumption is gradually diminished).

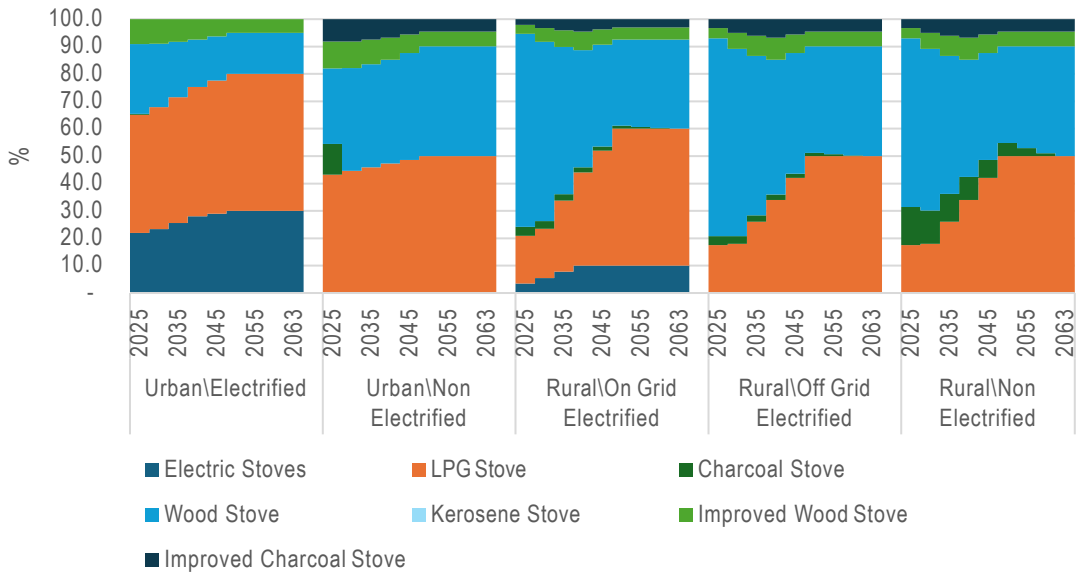


Figure 19 : Shares of cooking appliances per household type in DDP LT scenario.

In the transportation sector the assumptions for the penetration of electric vehicles are more aggressive in the DDP LT scenario compared to the DDP (Figure 20) leading to a full electrification of cars by 2050. Busses are assumed to be electrified completely in both DDP and DDP LT pathways by 2063 (Figure 21). Furthermore, 50% of freight vehicles are assumed to be electrified by 2063 in the DDP LT scenario, and the remaining 50% of heavy-duty freight vehicles is switching to hydrogen. In the DDP it is assumed that no electrification of freight road transport takes place.

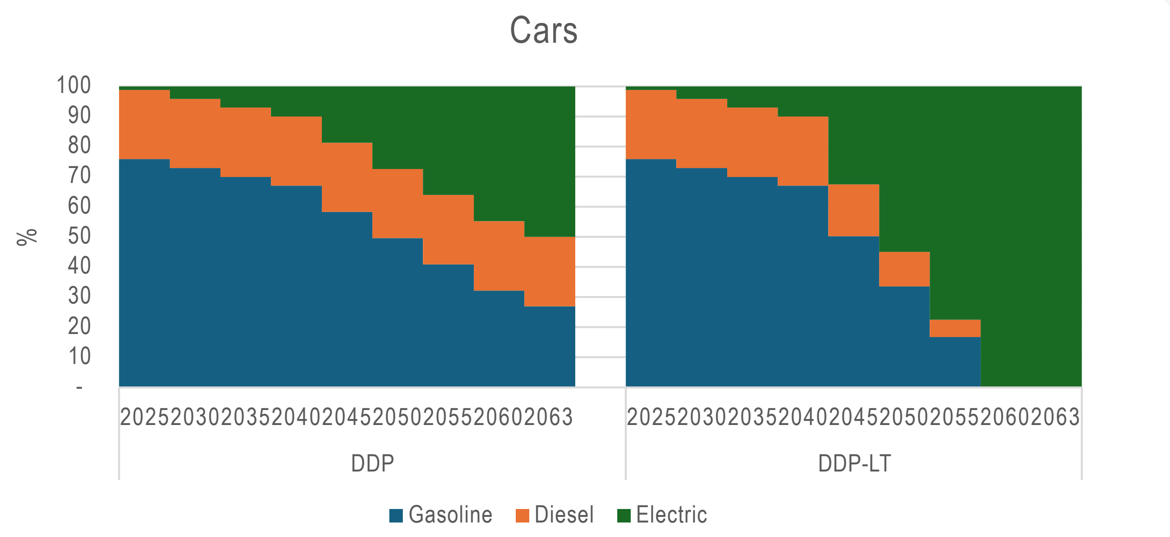


Figure 20 : Shares of cars per fuel type in the DDP scenarios.

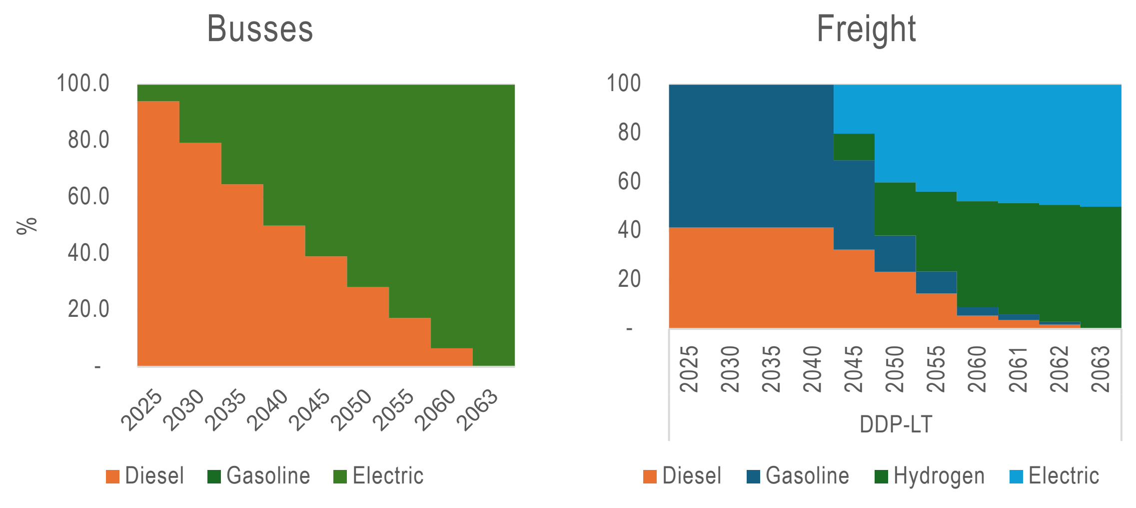


Figure 21 : Shares of busses and freight vehicles per fuel type in the DDP LT scenario.

Final Energy Consumption

The analysis of Botswana's projected FEC under the DDP, and DDP LT scenarios reveals sharply contrasting trajectories compared to the Baseline, shaped by differing levels of climate ambition and energy system transformation. While the Baseline scenario projects a business-as-usual pathway driven by fossil fuel expansion and sectoral inertia, both DDP and DDP LT model the effects of targeted mitigation interventions, with DDP LT further intensifying decarbonization efforts after 2040 to achieve post-peak emissions reductions and system-wide electrification.

In the short term, total FEC increases moderately in the DDP and DDP LT from 1,912 ktoe in 2025 to 2,120 ktoe in 2030 in both scenarios, representing a 10% increase (Figure 22). Despite similar starting points, the DDP and DDP LT demonstrate early signs of decoupling energy demand growth from emissions by limiting consumption increases, particularly in the transport and industry sectors. Transport continues to dominate FEC, reaching 1,111 ktoe (53%) in both scenarios by 2030. Household demand grows steadily to 495 ktoe, reflecting gradual electrification and LPG uptake. Industrial demand remains stable at 281 ktoe, signalling early energy efficiency improvements compared to the Baseline. Services contribute 201 ktoe in both DDP and DDP LT, while agriculture remains modest at 33 ktoe.

Between 2030 and 2040, sectoral transformations become more pronounced. FEC rises to 2,456 ktoe in DDP and 2,449 ktoe in DDP LT, reflecting significant decarbonization effects compared to the Baseline through electrification, efficiency, and behavioural shifts. While in the Baseline scenario, transport demand grows to 1,675 ktoe (55%) by 2040, it is held to 1,261 ktoe (52%) in DDP and DDP

LT by 2040. Household consumption increases more gradually, reaching 543 ktoe in DDP and 537 ktoe in DDP LT. Industrial use rises only modestly to 309 ktoe, compared to 367 ktoe in the Baseline, driven by process optimization and low-carbon fuel switching. Service sector energy use grows to 304 ktoe, with greater electrification replacing traditional fuels, while agriculture rises slightly to 39 ktoe. Overall, this period reflects the successful implementation of efficiency measures and controlled energy growth under the decarbonization pathways.

The long-term period sees a dramatic divergence. The Baseline scenario's FEC increases to 4,144 ktoe by 2050, driven predominantly by rising transport energy use. In contrast, DDP and DDP LT reach 3,059 ktoe and 3,383 ktoe, respectively, indicating the effectiveness of modal shifts, fuel switching, and systemic electrification. In DDP, transport demand rises more gradually to 1,525 ktoe, while in DDP LT it reaches 1,937 ktoe, slightly higher due to the uptake of hydrogen-fuelled freight transport. Household energy use grows to 691 ktoe in DDP and 604 ktoe in DDP LT, reflecting faster biomass phaseout and widespread adoption of efficient electric appliances in the latter. Industrial consumption diverges further, reaching 337 ktoe in both decarbonization cases, reflecting substitution with electricity and hydrogen, alongside technological improvements. Services expand to 460 ktoe in both DDP and DDP LT, remaining below the Baseline due to cleaner and more efficient energy use. Agriculture remains the smallest contributor, with energy use at 46 ktoe across both pathways.

By 2050, DDP achieves moderation in consumption across all sectors by applying mitigation across the board. DDP LT builds on this foundation but intensifies decarbonization post-2040, leveraging hydrogen in industry and freight, deepening electrification, and expanding renewables.

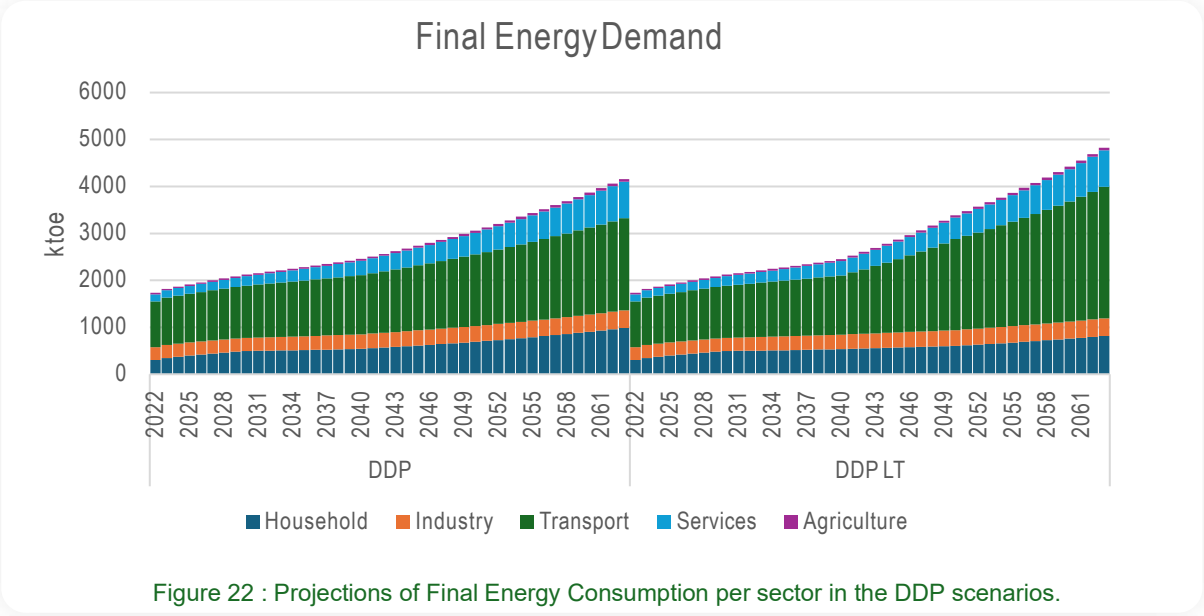


Figure 22 : Projections of Final Energy Consumption per sector in the DDP scenarios.

FEC by Fuel

The evolution of FEC by fuel across DDP and DDP LT scenarios reveals a contrast in the structure and carbon intensity of Botswana's energy system toward 2050 compared to the Baseline (Figure 23). In the DDP scenario, the share of electricity expands substantially, reaching 1,155 ktoe, or 37.7% of the total by 2030, while diesel and gasoline consumption growth is curbed at 974 ktoe (31.8%) and 324 ktoe (10.6%), respectively. Wood and charcoal consumption remain at 296 ktoe (9.7%) and 187 ktoe (6.1%), respectively, corresponding to the use of commercial fuels based on bioenergy in more efficient equipment. This reflects fuel switching, with most electrification concentrated in the buildings sector and modest penetration in transport.

In contrast, the DDP LT scenario shows a significant restructuring after 2040. Total FEC in 2050 reaches 3,390 ktoe, slightly higher than in DDP, but with electricity accounting for 2,134 ktoe, or an impressive 63% FEC share. Diesel and gasoline use are sharply reduced to 445 ktoe (13.5%) and 158 ktoe (4.8%), respectively, due to deep electrification and accelerated fuel substitution. Notably, hydrogen enters the mix meaningfully, contributing 350 ktoe (10.6%) in 2050, primarily targeted at hard-to-abate sectors such as heavy transport and industry. Charcoal and wood decline substantially to 55 ktoe (1.7%) and 164 ktoe (5%), respectively, reflecting a structural transition toward clean and modern energy sources.

In summary, the DDP scenario initiates decarbonization but retains a degree of fossil fuel and biomass reliance, while the DDP LT pathway achieves a deeper transformation, drastically increasing clean electricity and hydrogen shares and reversing long-standing fossil and biomass trends by mid-century.

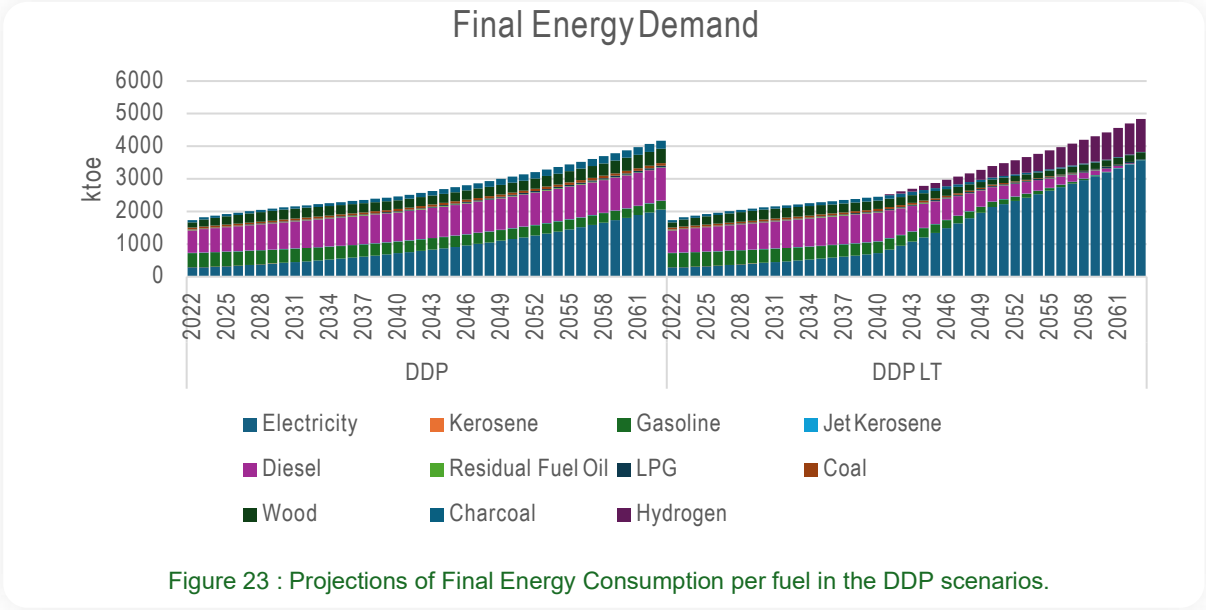


Figure 23 : Projections of Final Energy Consumption per fuel in the DDP scenarios.

FEC by sector

In the household sector, the evolution of FEC across DDP and DDP LT scenarios illustrates the pace and extent of transition toward modern and clean energy sources in Botswana (Figure 24). In the DDP scenario, a balanced transition is presented. Household energy demand grows steadily to 692 ktoe in 2050 (reaching 987 ktoe by 2063), with electricity reaching 356 ktoe and LPG expanding to 29 ktoe by 2050. Wood consumption, although still significant, declines over time, stabilizing at 174 ktoe, while charcoal continues a slow trajectory, reaching 133 ktoe by 2050. This reduction in biomass reliance—particularly the relative stabilization of wood use—indicates tangible progress in clean cooking adoption and electrification relative to the Baseline. The DDP LT scenario is more ambitious, with household energy demand reaching 537 ktoe in 2040 and 604 ktoe by 2050. Electricity becomes the main energy source, rising sharply to 357 in 2050 (and 559 ktoe by 2063), while charcoal use declines significantly to just 55 ktoe, and wood use stabilizes around 164 ktoe (in 2050), deployed more efficiently through improved technologies. Overall, DDP LT showcases a near-complete transformation of household energy use, driven by accelerated clean cooking and electrification measures, marking a strong shift away from traditional biomass.

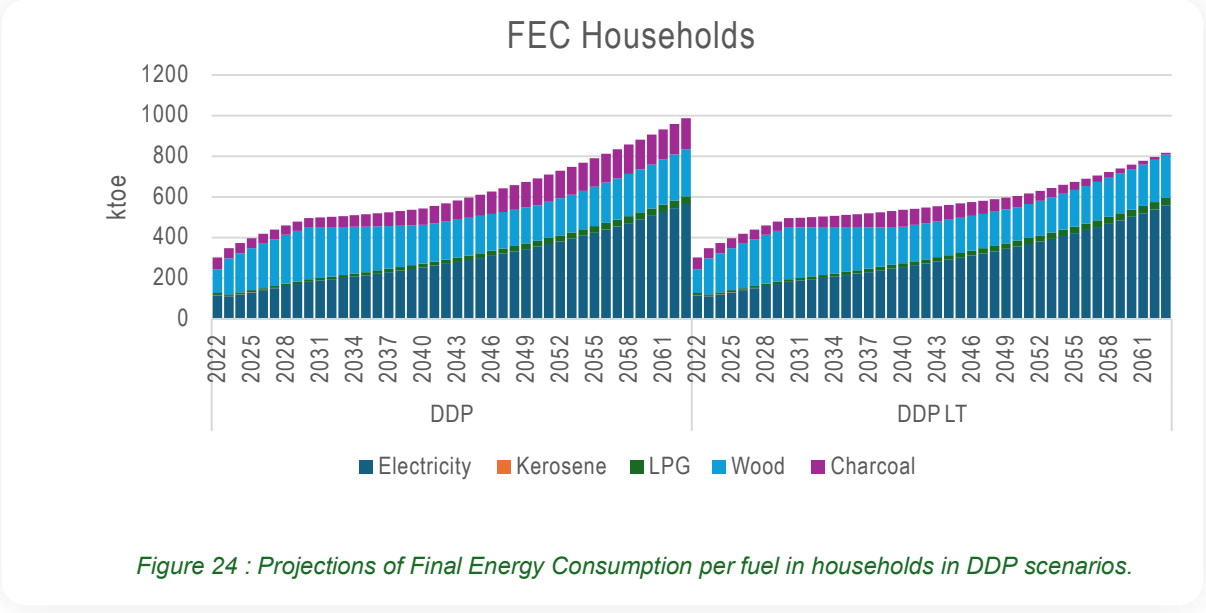


Figure 24 : Projections of Final Energy Consumption per fuel in households in DDP scenarios.

In Botswana's industrial sector, the DDP and DDP LT scenarios reflect differing levels of structural transformation, fuel switching, and decarbonization ambition after 2040 (Figure 25). In the DDP scenario, the sector follows a more efficient and electrified path compared to the Baseline. Total final energy consumption rises moderately to 337 ktoe by 2050, reflecting both efficiency gains and moderate structural shifts. Diesel retains the highest share, increasing steadily to 157 ktoe in 2050 and 175 ktoe in 2063, but its growth remains significantly more constrained than in the Baseline. Electricity expands from 80 ktoe in 2022 to 97 ktoe in 2050 and 108 ktoe in 2063, gradually becoming a stronger pillar of the sector's energy mix. Contributions from coal, residual fuel oil, and LPG remain relatively constant, with no new growth beyond current levels, and no entry of new fuels. In contrast, the DDP LT scenario introduces a much more transformative path post-2040. Although total energy demand also reaches the same level as DDP, the internal composition shifts drastically. Diesel peaks at 145 ktoe in 2040, then declines rapidly to 89 ktoe in 2050 and reaches zero by 2063. At the same time, electricity consumption more than triples, reaching 165 ktoe in 2050 and 280 ktoe by 2063, making it the dominant industrial energy source. Most notably, hydrogen enters the energy mix after 2040 and rises sharply to 37 ktoe in 2050 and 93 ktoe by 2063, primarily targeting hard-to-abate industrial uses and displacing fossil fuels. Meanwhile, coal, residual fuel oil, and LPG are progressively phased out before mid-century. This scenario highlights the deep decarbonization potential in Botswana's industrial sector, driven by aggressive electrification and the deployment of hydrogen—interventions absent from other scenarios.

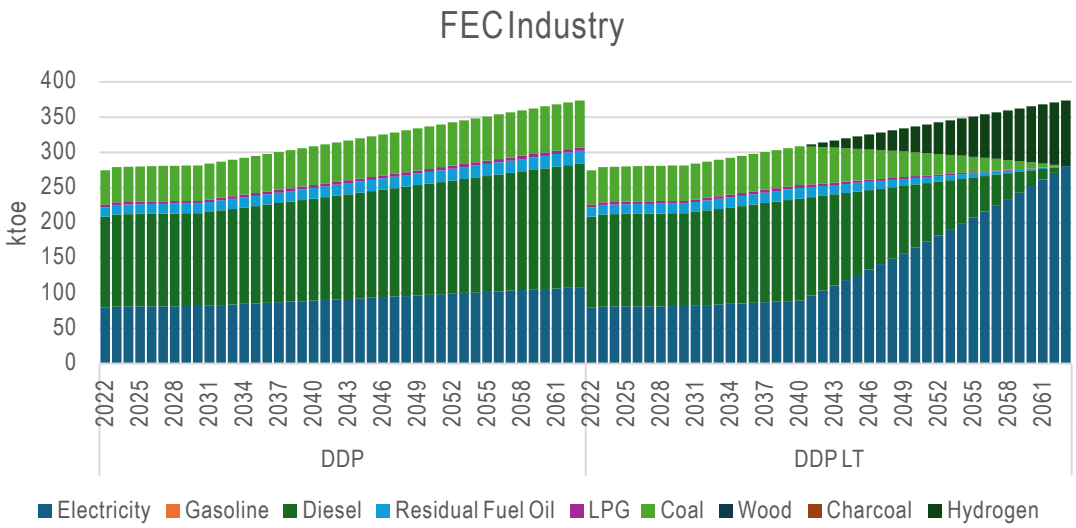


Figure 25 : Projections of Final Energy Consumption per fuel in industry in DDP scenarios.

In the transportation sector, there is a clear divergence between the two scenarios. The DDP scenario introduces gradual fuel switching, with total FEC growing to 1525 ktoe in 2050 and 1,964 ktoe by 2063. Electricity becomes increasingly significant, reaching 440 ktoe in 2050 and 951 ktoe, or about 48% of total transport energy use by the end of the period. Diesel consumption reaches around 2040 at 711 ktoe, and 760 ktoe by 2050, and then slightly declines to 745 ktoe by 2063, while gasoline use falls gradually to 323 ktoe in 2050 and 266 ktoe in 2063. This pathway reflects a shift toward electrification and reduced reliance on internal combustion engines but still retains substantial fossil fuel usage, indicating an incomplete structural transition. In contrast, the DDP LT scenario represents a transformative decarbonization of the transport system. Total final energy demand in the sector rises to 1837 ktoe by 2050 and 2,529 ktoe by 2063, with a radical shift in the fuel mix. Diesel is fully phased out by 2063, and gasoline is reduced to zero, from 356 ktoe and 158 ktoe respectively in 2050, signalling the complete removal of petroleum-based fuels. Electricity demand increases sharply to 1008 ktoe in 2050 and 1,611 ktoe in 2063, accounting for more than 63% of transport energy use, while hydrogen becomes a major contributor, rising from zero in 2040 to 313ktoe in 2050 and 915 ktoe by 2063, 36% of the total sector energy demand. This scenario embodies a comprehensive structural transition, using large-scale electrification, hydrogen deployment for freight, and the elimination of fossil fuels to meet Botswana's long-term climate goals.

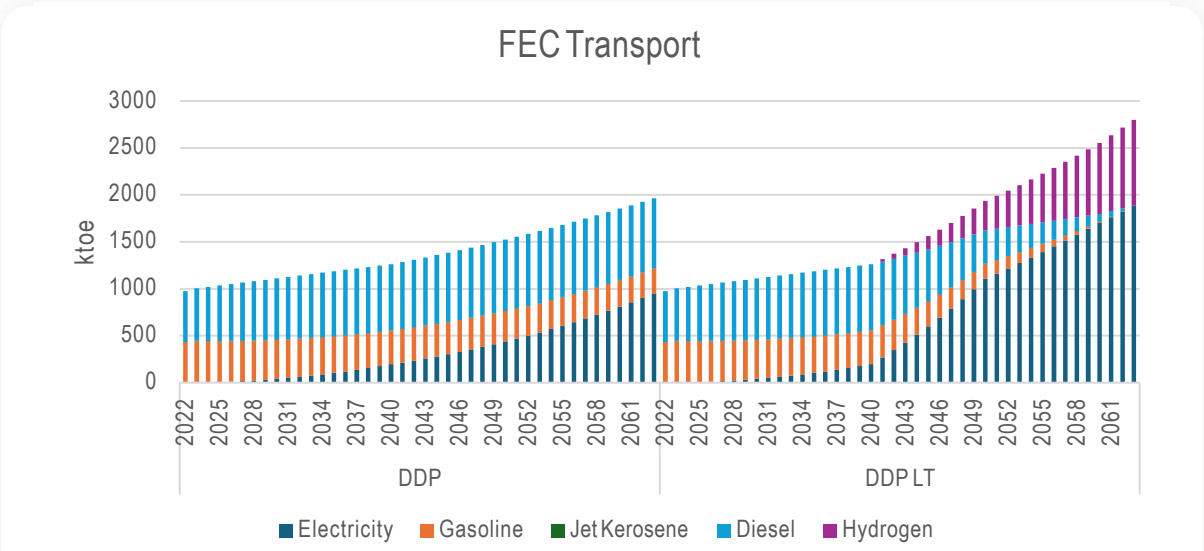


Figure 26 : Projections of Final Energy Consumption per fuel in transport in DDP scenarios.

The services sector energy demand increases steadily across all scenarios, though the pace and structure of growth vary markedly. In the DDP scenario, a more moderate trajectory than the Baseline is followed, with sectoral consumption rising from 151 ktoe in 2022 to 460 ktoe in 2050 and 778 ktoe by 2063. Electricity's role expands significantly, reaching 234 ktoe in 2050 and 396 ktoe in 2063, which represents just over 51% of total sector demand. Traditional fuels (wood and charcoal) also increase, albeit at a slower pace, reaching 122 ktoe and 54 ktoe, respectively, by 2050. Diesel consumption reaches 45 ktoe in 2050, indicating persistent use in backup generation and specific applications. This scenario reflects incremental efficiency gains and controlled demand growth, driven by modernization in energy use and mitigation interventions.

In contrast, the DDP LT scenario marks a decisive structural transformation. Between 2040 and 2050, the use of traditional fuels (diesel, wood, and charcoal) is completely phased out. By 2050, electricity alone provides 460 ktoe, accounting for 100% of the sector's energy use. This full electrification pathway reflects Botswana's deep decarbonization goals, emphasizing strong improvements in energy efficiency and the total substitution of fossil and biomass fuels with clean, modern energy carriers in commercial buildings and service applications.

Electricity generation

In DDP scenario, electricity generation expands from 4.6 TWh in 2025 to 17.7 TWh in 2030, rising further to 20.6 TWh by 2040, and reaching 24.1 TWh by 2050 (Figure 27). This continuous upward trend underscores Botswana's but consistent decarbonization efforts, marked by steady scaling of renewable electricity.

In the short term (2025–2030), coal remains dominant. Morupule B sustains output around 3.4 TWh, while from 2028, Mmamabula coal plant enters the mix, contributing 4.2 TWh by 2030 at its full capacity and Palapye coal plant contributed 4.3TWh. Renewables show a strong initial push: new solar PV ramps up from 0.1 TWh in 2025 to 4.7 TWh by 2030, and wind contributes 0.1 TWh, collectively initiating structural change in the power mix. However, coal still accounts for nearly 67% of output by 2030.

In the medium term (2030–2040), total electricity production increases from to 20.6 TWh. Solar PV continues its ascent, doubling to 7.5 TWh. The combined renewable contribution exceeds 36% of generation by 2040. Coal generation remains high at around 11TWh, though no CCS is deployed yet. This period reflects growing diversification with tangible gains in clean energy share, aligned with DDP's mitigation focus.

In the long term (2040–2050), generation grows to 24 TWh. Solar PV reaches 10 TWh, and wind holds steady at 0.4 TWh. Together, renewables provide nearly 46% of total electricity. Coal use stabilizes and contributions come from CBM at 1.2 TWh. This reflects a power system in transition—more diversified and lower-carbon but still reliant on fossil sources. In 2036 contribution of renewable electricity reaches 32% of the total generation.

In the DDP LT scenario, a sharp departure from the baseline and DDP emerges after 2040. Total electricity generation climbs to 20.6 TWh in 2040, then accelerates to 27.6 TWh by 2050, signalling a near-total system transformation. This 35% increase over DDP levels stems from deep final energy electrification. In 2036 contribution of renewable electricity reaches 36% of the total generation. Post-2040, coal plants are retrofitted with CCS. Therefore, Morupule B, Mmamabula and Palapye continue operation but with emissions control, indicating full exploitation of low-carbon generation options. This trajectory underscores the ambition of the DDP LT not only displacing unabated coal but also deploying CCS, maximizing renewables, and laying groundwork for hydrogen production.

In summary, while the Baseline scenario locks Botswana into a fossil-dependent system, the DDP scenario introduces progressive but measured decarbonisation, and the DDP LT scenario envisions a structurally transformed electricity sector by 2050. This pathway is consistent with deep emissions reductions and resilient energy security, leveraging renewables, CCS, and grid decarbonisation at scale.

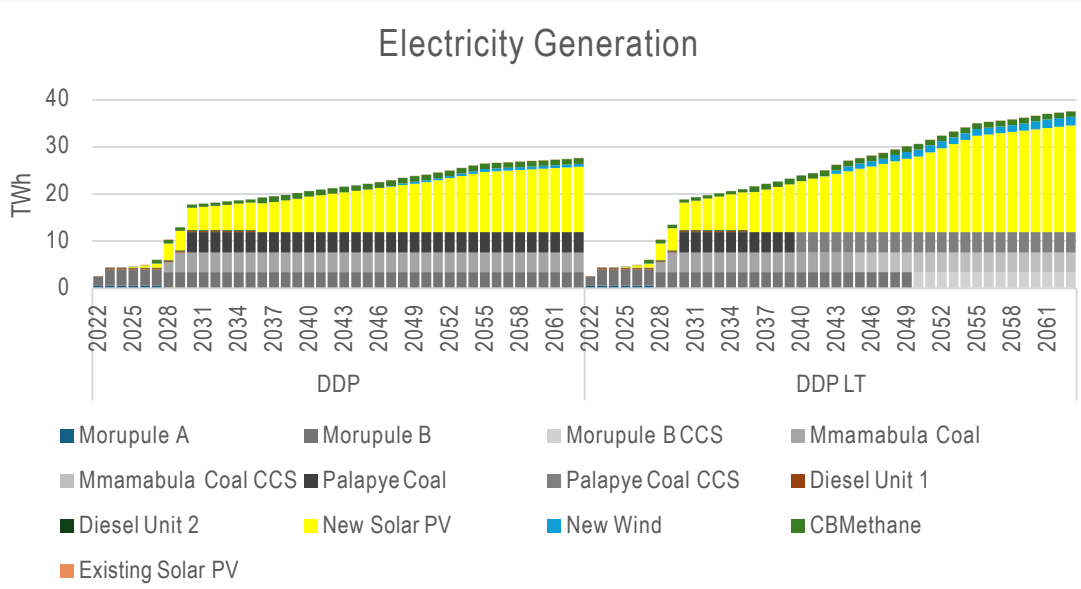


Figure 27 : Projections of electricity generation per technology, DDP scenarios.

Examining the development of the installed capacity (Figure 28) in the DDP scenario, the installed capacity expands from 954 MW in 2025 to 4,335 MW in 2030, reaching 6,159 MW in 2040, and climbing to 7,559 MW by 2050. This growth is largely driven by renewables, especially solar PV, with supportive contributions from wind, and BESS.

In the short term (2025–2030), the total capacity significantly increases, reflecting a rapid deployment of Renewable Energy Sources (RES) and planned coal plants. Solar PV rises from 50 MW in 2025 to 2158 MW in 2030, while wind enters at 100 MW in 2027. New fossil-based capacity includes Mmamabula (600MW by 2029) and Palapye (615MW by 2030). Additionally, BESS reaches 140 MW in 2032, enhancing flexibility to accommodate variable renewables.

In the medium term (2030–2040), installed capacity grows to 6,159 MW, maintaining the DDP trajectory of clean energy scale-up without disrupting fossil capacity. New solar PV more than doubles to 3,432 MW, wind capacity reaches 600 MW. Coal-fired plants hold their combined capacity of 1,815 MW, with no deployment of CCS. This reflects DDP's approach of progressive diversification without abrupt asset phase-outs.

By the long term (2040–2050), the system reaches 7,559 MW, led by continued solar PV growth—reaching 4,832 MW in 2050. Wind holds at 600 MW. There are no new fossil additions or CCS retrofits. Thus, although total capacity grows moderately, fossil capacity remains unchanged, reinforcing DDP's incremental, risk-managed pathway toward decarbonisation.

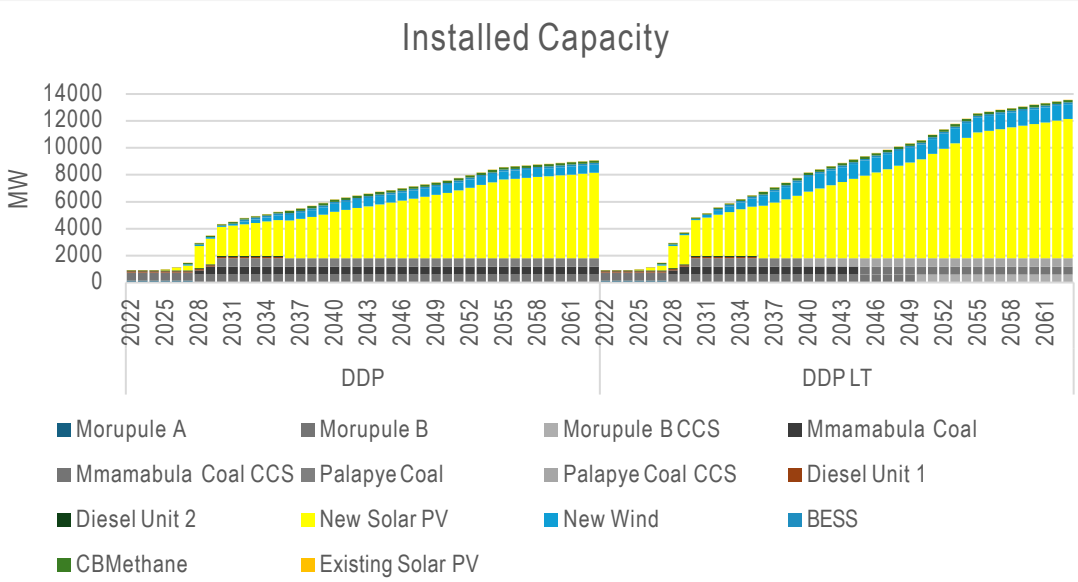


Figure 28 : Projections of on-grid electricity capacity, DDP scenarios.

The DDP LT scenario reflects a significantly more ambitious transformation. Total installed capacity expands to 8,159 MW in 2040, and reaching 10,559 MW by 2050, with continuous growth to 13,559 MW by 2063. During the short term (2025–2030), DDP LT leads to faster renewable deployment compared to DDP. Solar PV capacity climbs to 2,658 MW by 2030, 23% higher than under DDP. Between 2030 and 2040, the divergence deepens. Capacity grows to 8,159 MW, led by a solar PV reaching 4,932 MW and wind expanding to 1,100 MW. Unlike DDP, this scenario positions the system for structural decarbonisation beginning in the 2040s. In the long term (2040–2050), installed capacity soars to 10,559 MW, driven by solar PV reaching 7,332 MW, and maintained high shares of wind (1,100 MW). Crucially, CCS retrofits are introduced for Morupule B Mmamabula and Palapye which are retrofitted replacing unabated coal while maintaining firm generation. This marks a structural shift: from fossil-dominated to a renewables-led grid backed by clean firm capacity.

In summary, the DDP scenario delivers moderate renewable growth and flattens fossil capacity after 2030, achieving partial decarbonisation, while the DDP LT scenario activates the full clean energy transition with aggressive solar and wind expansion, strategic CCS adoption, almost doubling total capacity by 2050 relative to DDP and enabling a zero-carbon power system in the long term.

Energy related GHG emissions

In the DDP scenario, energy-related greenhouse gas emissions in Botswana exhibit an initially upward trajectory followed by a stabilisation (Figure 29). Emissions increase from 8,361 $ktCO_2eq$ in 2025 to 16,156 $ktCO_2eq$ in 2030, reach 16,270 $ktCO_2eq$ by 2040, and climb to 16,523 $ktCO_2eq$ in 2050. This pattern reflects an approach in which emissions are stabilised, and renewable energy grows while coal-based generation persists without carbon capture.

Between 2025 and 2030, emissions grow by 93%, with demand-side emissions rising modestly from 3,972 to 4,146 $ktCO_2eq$, while transformation sector emissions, from power generation, increase steeply from 4,388 to 12,009 $ktCO_2eq$. This escalation is due to the commissioning of new coal capacity and lower introduction of low-emission sources. From 2030 to 2040, emissions grow to 16,270 $ktCO_2eq$. Demand-side emissions remain largely flat, increasing to 4,261 $ktCO_2eq$, which suggests early impacts of efficiency measures and electrification. However, transformation-related emissions increase to 12,008 $ktCO_2eq$, indicating that coal-based generation continues to play a central role in the electricity system. During the 2040 to 2050 period, total emissions rise to 16,253 $ktCO_2eq$, driven primarily by the transformation sector. While demand emissions grow marginally by 253 $ktCO_2eq$, transformation emissions remain at the level of 12,008 $ktCO_2eq$. This underscores the structural inertia of the power sector in the absence of CCS or large-scale fossil fuel retirement.

The DDP LT scenario departs sharply from this pattern, particularly after 2040. While emissions rise from 8,361 $ktCO_2eq$ in 2025 to 16,156 $ktCO_2eq$ in 2030, they peak shortly thereafter and begin to decline, falling to 13,281 $ktCO_2eq$ in 2040 and plunging to 9,441 $ktCO_2eq$ by 2050. In the first period through 2030, both demand and transformation emissions grow, but this sets the stage for major

structural transitions. Demand emissions rise from 3,973 to 4,146 $ktCO_2eq$, while transformation emissions reach 12,009 $ktCO_2eq$. By 2040, demand emissions are virtually unchanged at 4,258 $ktCO_2eq$, while transformation emissions peak at 9,022 $ktCO_2eq$, reflecting stabilization in electricity generation emissions due to growing renewable penetration. The most dramatic shift occurs between 2040 and 2050, where total emissions drop to 5,776 $ktCO_2eq$. Demand-side emissions decrease from 4,259 to 2,172 $ktCO_2eq$, a 49% decline, while transformation emissions collapse from 9,002 to 3,604 $ktCO_2eq$, driven by the deployment of CCS at coal plants and a dominant role for renewable energy. By 2063, DDP emissions reach 16,604 $ktCO_2eq$, continuing their slow climb. In contrast, DDP LT emissions fall further to 3,818 $ktCO_2eq$, highlighting a near-complete energy sector transformation. This divergence of over 12,786 $ktCO_2eq$ underscores the scale of mitigation achievable only through structural shifts enabled by CCS, electrification, efficiency gains, and the near-total displacement of fossil fuels.

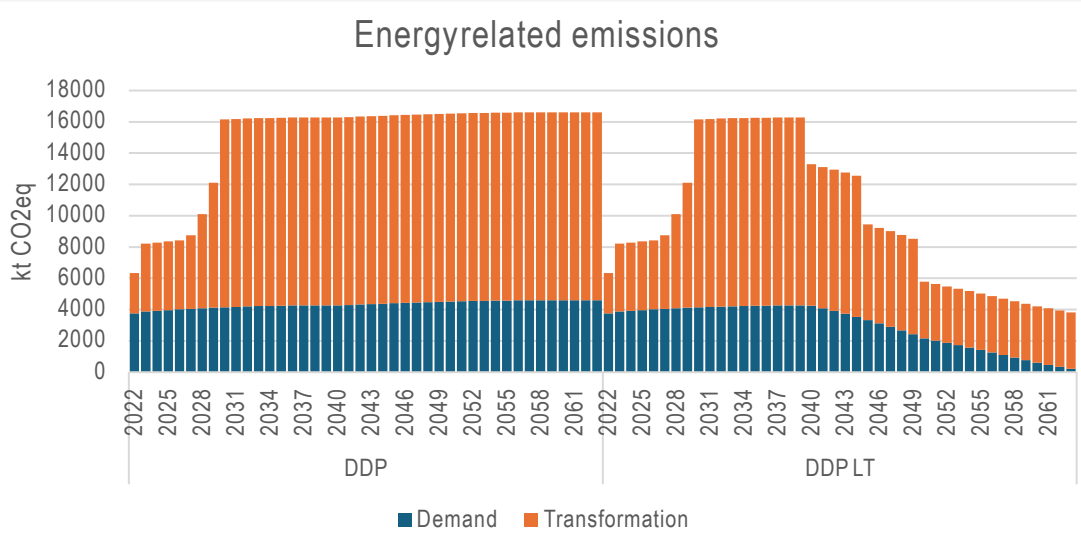


Figure 29 : Projections of energy related GHG emissions from the demand sector andtransformation (electricity generation) sectors.

Emissions from the demand sectors show continuous growth in the DDP scenario, over the 2025–2050 period (Figure 28). Starting at 3,973 kt CO_2eq in 2025, total demand-side emissions increase to 4,146 kt CO_2eq by 2030. This growth is modest but steady, with transport emissions contributing the most—over 3,200 kt CO_2eq in 2030, or nearly 78% of total demand-side emissions. Industrial emissions remain relatively stable at around 656 kt CO_2eq, while emissions from the household sector rise slowly, reflecting gradual electrification, introduction of LPG and the continued use of biomass in certain areas. Emissions from services and agriculture remain marginal but slowly trend upward. From 2030 to 2040, demand emissions grow moderately to 4,241 kt CO_2eq. Transport emissions reach their peak in 2035 at around 3,258 kt CO_2eq and begin a slow decline thereafter. The stabilization of transport emissions suggests the early impacts of vehicle efficiency improvements and the initial deployment of electric vehicles. Meanwhile, industrial and household emissions continue to grow incrementally. The services sector shows the fastest percentage growth, increasing from 89 kt CO_2eq in 2030 to 134 kt CO_2eq in 2040, though the absolute levels remain small. By 2050, total demand emissions reach 4,494 kt CO_2eq, with transport still dominant at 3,275 kt CO_2eq. However, its relative share begins to decline, marking the early effects of low-carbon technology adoption.

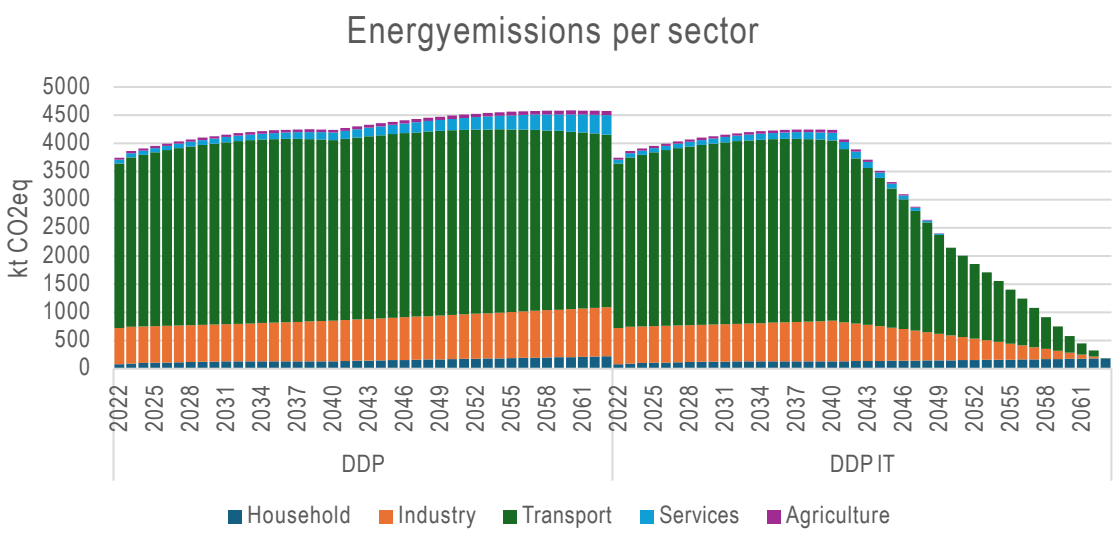


Figure 30 : Projections of energy GHG emissions from the final energy consumption sectors.

The DDP LT scenario mirrors DDP through 2030, with total demand emissions at 4,127 kt CO_2eq and similar sectoral profiles. After 2040, however, the emissions trajectories diverge dramatically. Total emissions under DDP LT fall from a peak of 4,238 kt CO_2eq in 2040 to 2,150 kt CO_2eq in 2050—a 51% reduction. This steep decline is driven primarily by the transformation of the transport sector, where emissions fall from 3,203 kt CO_2eq in 2040 to just 1,556 kt CO_2eq by 2050. The rapid scale-up of electric mobility and a declining role for fossil fuels in freight and private transport underpin this shift. Industry emissions also fall sharply from 719 kt CO_2eq to 443 kt CO_2eq in the same period, reflecting the uptake of electricity and hydrogen for process heat and operations. Household emissions decrease only slightly, remaining relatively stable near 150 kt CO_2eq. This suggests persistent reliance on traditional fuels in some areas, although overall electrification continues to rise. Services and agriculture are almost completely decarbonised by 2050, with both sectors contributing less than 10 kt CO_2eq each. By 2063, total demand emissions fall further to just 190 kt CO_2eq, highlighting a nearly complete decarbonisation of energy use in end-use sectors under the DDP LT scenario.

In the DDP scenario, diesel emerges as an important source of emissions in the short term, contributing over 2,600 kt CO_2eq by 2025 and reaching approximately 2,725 kt CO_2eq by 2040 (Figure 31). Gasoline emissions decline gradually from 1,265 kt CO_2eq in 2025 to 1,041 kt CO_2eq in 2040, largely due to improvements in fuel efficiency and the initial stages of electrification in light-duty transport. However, coal emissions exhibit the most significant growth, rising from 4,246 kt CO_2eq in 2025 to 11,562 kt CO_2eq in 2030, then climbing steadily to 11,574 kt CO_2eq by 2040 and ultimately surpassing 11,615 kt CO_2eq by 2050. This trajectory is driven by continued reliance on coal-based power generation and industrial fuel use. Over the medium term, emissions from coal solidify their position as the largest contributor to national GHG totals, while diesel remains consistently high at around 2,700 kt CO_2eq. Other fuels such as LPG, residual fuel oil, and biomass (wood and charcoal) contribute relatively minor but rising shares due to increased end-use in rural and commercial sectors. Coal bed methane begins to feature after 2025, reaching 665 kt CO_2eq by 2040, reflecting its integration into the power mix and fuel substitution strategies.

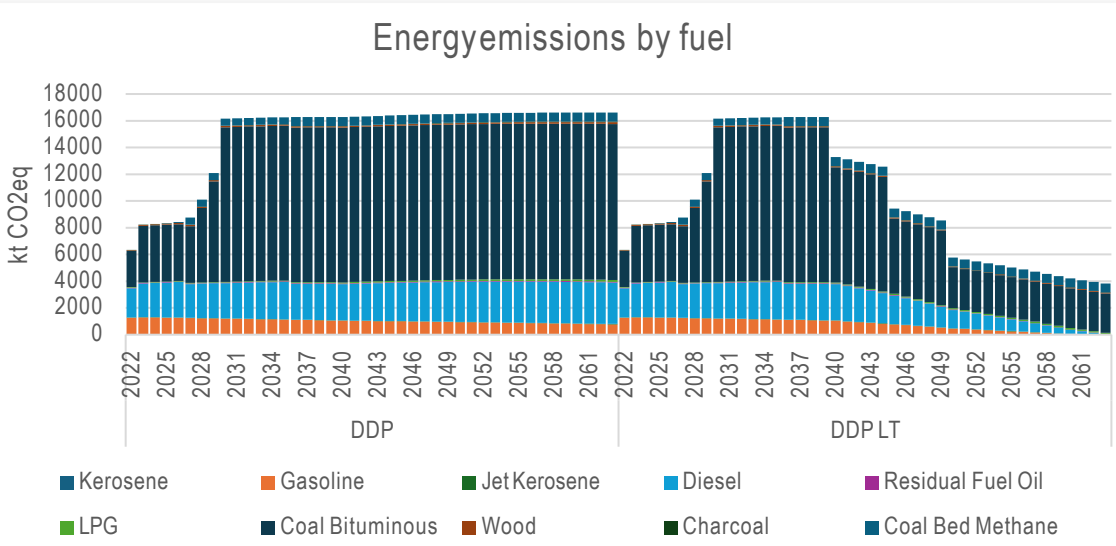


Figure 31 : Projections of energy related GHG emissions per fuel used in demand and transformation sectors.

In the DDP LT scenario, fuel-wise emissions closely track the DDP profile until 2040. However, significant reductions unfold after 2041, particularly for diesel and gasoline. Diesel emissions fall from 2,621 kt CO_2eq in 2041 to just 1,275 kt CO_2eq by 2051, while gasoline declines even more sharply, from 988 kt CO_2eq to 417 kt CO_2eq. This trend is consistent with accelerated transport electrification and the retirement of internal combustion engine vehicles. Coal emissions, which rise to 8,592 kt CO_2eq by 2040, decline steeply after that point due to the installation of carbon capture and storage in power plants. By 2050, coal-related emissions drop to 3,072 kt CO_2eq, a nearly 73% reduction compared to the DDP scenario. Residual fuel oil, LPG, and biomass sources show more gradual reductions, reflecting improvements in efficiency and substitution with low-carbon energy carriers. By 2050, total fuel-based emissions under DDP LT are down to 5,776 kt CO_2eq—over 10,000 kt CO_2eq lower than in DDP—demonstrating the dramatic mitigation enabled by fuel switching, electrification, and CCS deployment.

Key Scenario Conclusions

The analysis of Botswana's energy transition through the DDP and DDP LT scenarios highlights two different trajectories for the country's energy system and its alignment with long-term climate goals. While both pathways depart from the Baseline scenario's fossil-heavy trajectory, DDP LT achieves a structural transformation compatible with net-zero ambitions by mid-century.

In the short term (2025–2030), energy demand and emissions continue to increase in both the DDP and DDP LT scenarios, though signs of early mitigation are visible. Final energy consumption rises modestly to just under 2,122 ktoe by 2030 in both pathways, below the Baseline projection of 2,324 ktoe. This decoupling is enabled by early electrification in households and industry, as well as moderated transport growth through greater reliance on public and non-motorised transport. Energy emissions in both scenarios increase to approximately 16,156 ktCO_2eq in DDP and in DDP LT by 2030. Though fossil fuels still dominate, the energy mix begins to evolve, since coal bed methane appears as a minor but growing source, and electricity from solar and wind begins to scale up. Electricity's share in final energy consumption rises to 20% in DDP, higher from the 18% seen in the Baseline.

During the medium term (2030–2040), the divergence between the scenarios becomes increasingly pronounced. In DDP, final energy consumption grows moderately to around 2,462 ktoe, and emissions climb to 16,270 ktCO_2eq, with fossil fuels remaining prominent. By contrast, DDP LT exhibits a critical inflection point. Energy emissions peak at 13,282 ktCO_2eq in 2040, already below DDP's level, and total consumption remains below 2,400 ktoe. This signals the onset of a systemic energy shift, with electrification accelerating and efficiency gains beginning to limit fossil fuel use. Electricity's share surpasses 29% in DDP LT, supported by the expansion of clean power generation and the deceleration of oil-derived fuel consumption.

In the long term (2040–2050), the energy transition becomes fully realised under DDP LT. While total energy consumption reaches 3,065 ktoe in DDP and emissions increase to 16,523 ktCO_2eq, fossil fuels continue to dominate. Electrification alone is not sufficient to offset the entrenched fossil fuel use. In

sharp contrast, DDP LT achieves a transformative reconfiguration as emissions decline steeply to 5,776 $ktCO_2eq$, a 65% reduction relative to DDP, driven by the widespread deployment of carbon capture and storage, fuel switching, and demand-side electrification. Electricity use in final energy consumption exceeds 2,134 ktoe, and hydrogen reaches 350 ktoe, displacing fossil fuels in transport and industry.

By 2050, electricity generation under DDP LT is nearly 1.5 times that of DDP, reaching 24.1 TWh compared to 17.8 TWh, as solar PV (10.6 TWh), wind (0.4 TWh) and CCS-equipped coal (11.9 TWh) become central pillars of supply. In industry, fossil-based process energy is replaced by electricity and hydrogen. In transport, electric and hydrogen vehicles dominate. In the services sector, full electrification is completed.



In conclusion, the DDP scenario achieves moderation in energy and emissions growth but does not reach decarbonization, while the DDP LT aligns the energy system with climate goals, enabling post-2040 emissions decline, energy diversification, and long-term sustainability.

3.3. Scenario Comparisons and Key Insights

In this section a comparative analysis of the three scenarios is presented and the key insights are identified.

Final Energy Consumption

The comparative evolution of total final energy demand under the Baseline, DDP, and DDP LT scenarios illustrates the progressively divergent energy futures shaped by the degree of policy ambition and systemic transformation (Figure 32).

In the short term, by 2030, total final energy consumption reaches 2,324 ktoe under the Baseline scenario, while it remains lower in both DDP and DDP LT, at 2,122 ktoe. This reflects a 9.1% reduction in energy demand in the decarbonisation pathways relative to the Baseline, driven primarily by moderated demand growth in transport and industry. Transport energy use, while still the largest end-use component, is 1,111 ktoe in the DDP scenarios compared to 1,241 ktoe in the Baseline, representing a 10.5% decline attributable to early impacts of transport electrification and modal shifts. Industrial energy use declines from 312 ktoe in the Baseline to 281 ktoe in DDP and DDP LT, a reduction of 10%, reflecting early efficiency gains and low-carbon process integration. Household demand shows a smaller decline, from 515 ktoe to 495 ktoe, indicating the beginning of electrification and improved appliance standards. Services and agriculture exhibit similar levels across all scenarios.

In the long term, by 2050, final energy demand under the Baseline climbs to 4,144 ktoe, largely due to continued expansion in transport and households. In contrast, DDP limits demand to 3,059 ktoe, and DDP LT reaches 3,383 ktoe. Relative to the Baseline, this reflects a 26.2% reduction in DDP and a 20.7% reduction in DDP LT. Transport demand reaches 2,262 ktoe in the Baseline but is curtailed to 1,525 ktoe under DDP and 1,936 ktoe in DDP LT, representing reductions of 36% and 28%, respectively. Household energy use is 691 ktoe in DDP, a 15% reduction from the Baseline (813 ktoe), while DDP LT achieves an even larger reduction to 604 ktoe, almost 25% below Baseline levels, due to widespread efficiency upgrades. Industrial demand in both decarbonisation scenarios stabilises at 336 ktoe, down nearly 22% from the Baseline's 432 ktoe. Service and agriculture sector growth continues, but at a moderated pace under both DDP and DDP LT, reflecting the effects of electrification, technology substitution, and energy efficiency mandates.

Overall, these results demonstrate that while the Baseline scenario reflects unchecked energy growth and persistent fossil fuel reliance, both DDP and DDP LT manage to significantly contain demand growth across all sectors. DDP achieves broad-based moderation through electrification and efficiency, whereas DDP LT intensifies these efforts after 2040, deploying deeper technological shifts including hydrogen and full-sector electrification. By 2050, this leads to a structurally transformed energy system, with final energy demand decoupled from economic and demographic growth.

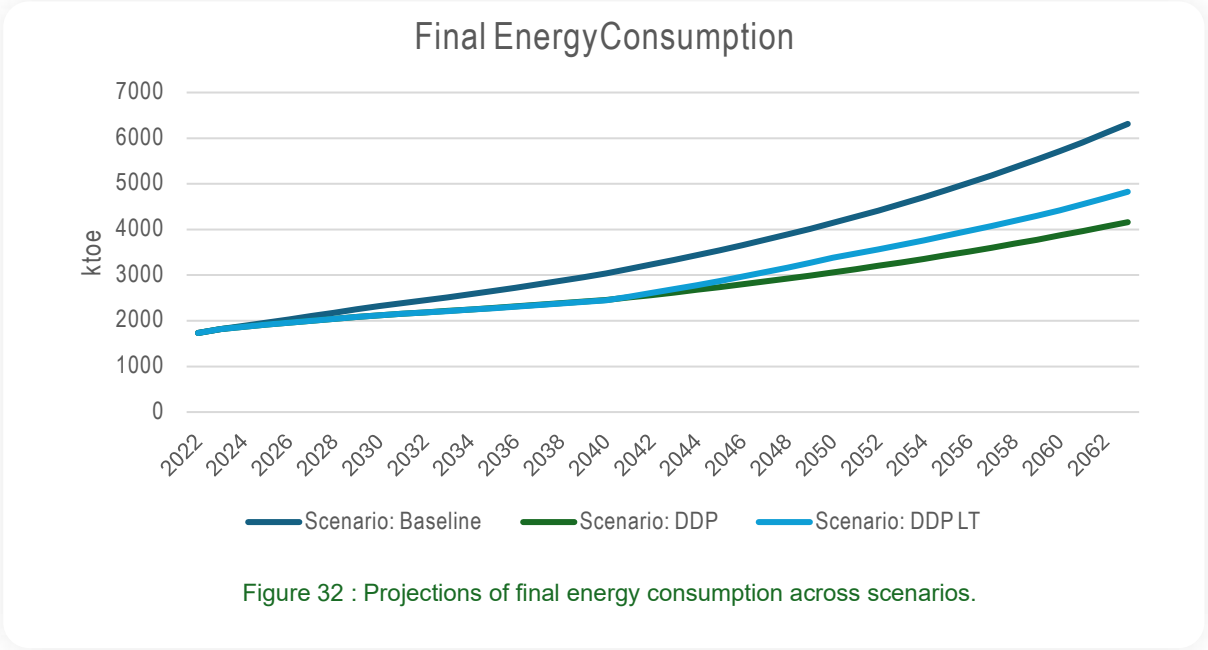


Figure 32 : Projections of final energy consumption across scenarios.

The comparison of FEC per sector and fuel across the Baseline, DDP, and DDP LT scenarios reveals the structural and technological shifts necessary for Botswana's energy system to achieve long-term decarbonisation targets.

In the household sector, the Baseline scenario projects FEC rising from 515 ktoe in 2030 to 813 ktoe by 2050, driven predominantly by biomass use—particularly wood and charcoal—which together account for over 60% of the sector's energy (Figure 33). Electricity use expands steadily, reaching 436 ktoe by 2050, while LPG remains marginal at just 32 ktoe. Under the DDP scenario, household FEC grows more modestly to 692 ktoe by 2050. The role of electricity becomes more prominent (355 ktoe), LPG use is slightly higher (30 ktoe), and biomass, while still significant, stabilises at lower levels. Charcoal use grows gradually but does not dominate, and wood consumption levels of around 178 ktoe. In the DDP LT scenario, household energy use reached 536 ktoe in 2040 604 ktoe in 2050. Electricity becomes the main fuel, rising to 357 ktoe by 2050 (and continuing to increase to 559 ktoe by 2063). Charcoal use undergoes a rapid decline, dropping to 55 ktoe in 2050 (and just 9 ktoe by 2063), and wood use declines in parallel, indicating a nearly complete transition to modern, cleaner fuels.

In the industry sector, the Baseline trajectory maintains a fossil-fuel-heavy mix, with FEC growing to 432 ktoe by 2050 (Figure 34). Diesel remains dominant at over 202 ktoe, followed by electricity, coal, and residual fuel oil. There is no shift to alternative fuels. In contrast, DDP limits industrial demand to 337 ktoe in 2050 through improved efficiency and restrained diesel growth, which reaches 157 ktoe. Electricity use remains steady around 97 ktoe. DDP LT presents a transformative path: although total FEC remains similar (337 ktoe in 2050), diesel demand peaks and then falls to zero by 2063. Electricity becomes the primary industrial energy carrier, increasing to 165 ktoe by 2050 and 280 ktoe by 2063. Most notably, hydrogen is introduced post-2040 and grows rapidly, supplying 37 ktoe in 2050 and 93 ktoe by 2063. This represents the most transformative shift in the sector, which in DDP LT becomes nearly fully decarbonised by mid-century. (2050)

In the transport sector, the Baseline scenario sees relentless fossil fuel growth, with FEC reaching 2,262 ktoe by 2050 (Figure 35). Diesel and gasoline dominate with no sign of electrification. In DDP, transport FEC is contained at 1,525 ktoe by 2050. Electricity use expands substantially to 440 ktoe, while diesel and gasoline combined are moderated to around 1,083 ktoe. Though electrification gains ground, internal combustion engines still account for the majority of energy consumption in transportation. In DDP LT, transport energy transitions completely. Electricity becomes the primary fuel, reaching 1,107 ktoe in 2050 and rising further to 1,882 ktoe by 2063. Hydrogen is deployed in freight applications beginning in the 2040s and expands to 313 ktoe in 2050 and 915 ktoe by 2063. By mid-century, gasoline and diesel use is nearly eliminated, marking a radical transformation of the transport sector toward zero-emission fuels.

The services sector follows similar divergent paths. In the Baseline, FEC grows to 590 ktoe by 2050 and 1,111 ktoe by 2063, still relying heavily on traditional fuels (Figure 36). Wood and charcoal remain significant contributors—accounting for over 225 ktoe in 2050—and diesel use also grows. Electricity's share expands but not sufficiently to decarbonise the sector. DDP flattens services demand, which rises only to 460 ktoe by 2050, with electricity reaching 234 ktoe and biomass and diesel declining slowly. The most dramatic shift is in DDP LT, where the sector becomes fully electrified by 2050. Electricity reaches 460 ktoe by 2050 and grows to 778 ktoe by 2063. Diesel, wood, and charcoal are completely phased out after 2050, signifying a full clean energy transition for commercial and services buildings.

Across all sectors, the fuel-wise comparison illustrates consistent patterns. In the Baseline, fossil fuels dominate, while electricity and clean fuels grow slowly. In DDP, these trends begin to reverse, with electricity gaining ground in all sectors and fossil fuel growth slowing. In DDP LT, electrification is systemic, clean fuels (hydrogen) emerge, and fossil fuels are largely phased out by 2050. DDP LT thus offers a structurally distinct energy future, marked by high electrification, clean fuel substitution, and deep energy system transformation.

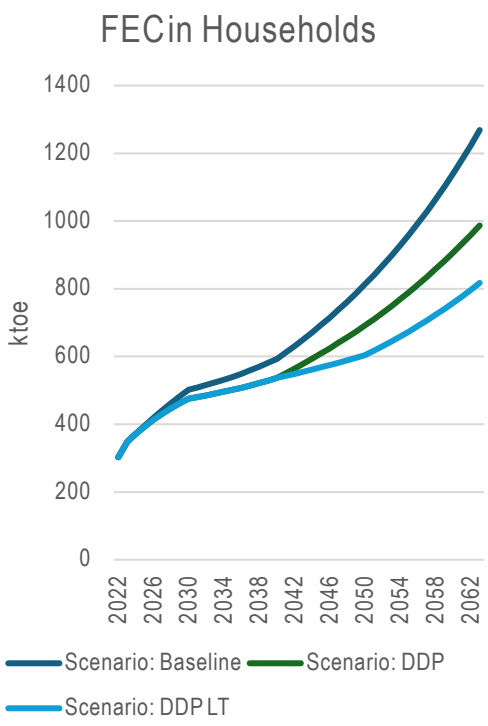


Figure 33 : Projections of final energy consumption in households across scenarios.

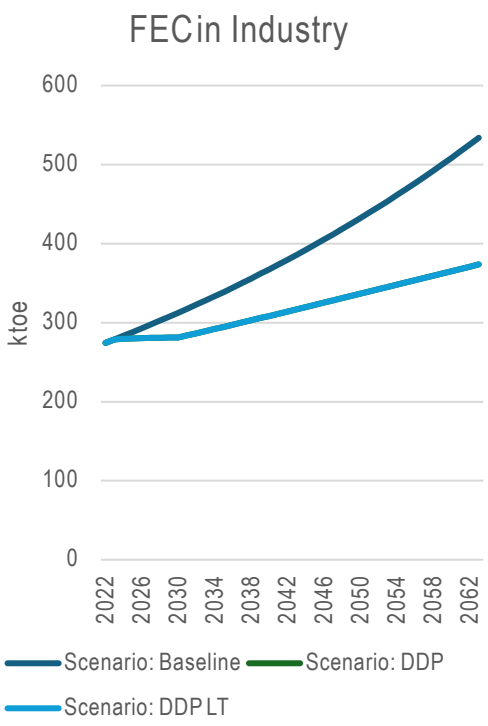


Figure 34 : Projections of final energy consumption in industry across scenarios.

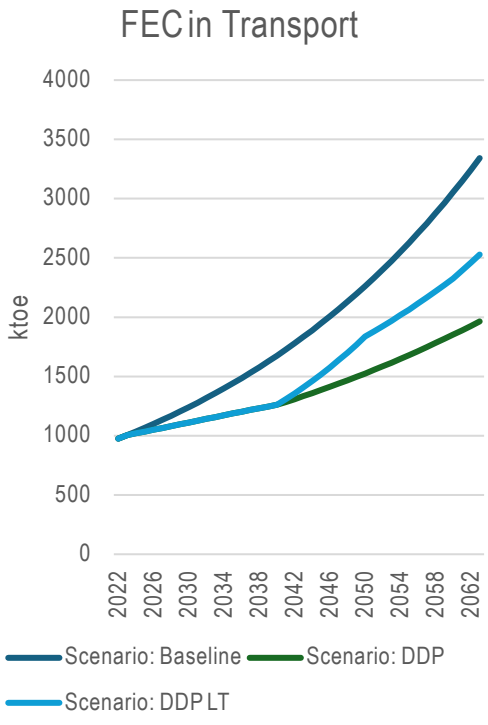


Figure 35 : Projections of final energy consumption in transport across scenarios.

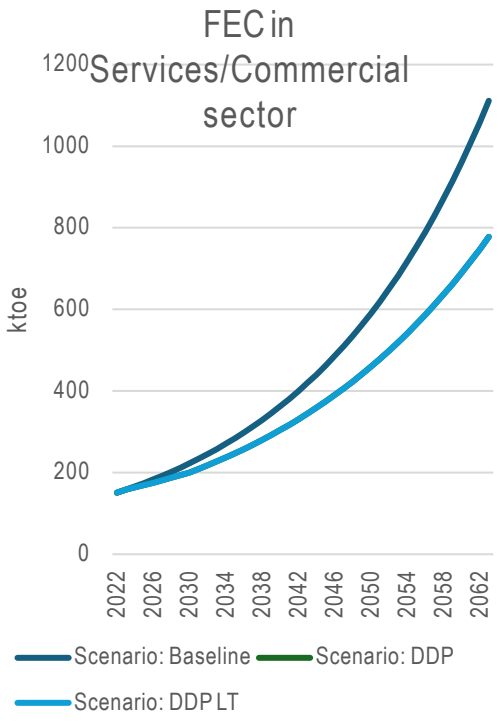


Figure 36 : Projections of final energy consumption in services/commercial sectors across scenarios.

Electricity generation

The trajectory of total electricity generation diverges significantly across the Baseline, DDP, and DDP LT scenarios (Figure 37).

In the Baseline scenario, total electricity generation grows moderately, from 2.55 TWh in 2022 to 16.6 TWh by 2030, 16.9 TWh by 2040, and 17.8 TWh by 2050. The rapid increase in generation until 2030 is connected with the plan of new capacity additions according to the updated Integrated Resource Plan projects. This pathway reflects an initial increase in capacities and generation until 2030, with changes driven by continued reliance on coal-based plants and penetration of solar PV. Renewables, expand with solar PV reaching 5.11 TWh and wind 0.1 TWh by 2050. As a result, fossil fuels continue to dominate the electricity mix well into mid-century, and the system remains structurally carbon intensive.

Under the DDP scenario, the growth in electricity generation is more pronounced after 2030. Generation rises to 17.8 TWh by 2030, 20.6 TWh by 2040, and 24.1 TWh by 2050. The composition of this expansion changes as the system begins to diversify; solar PV reaches 10.6 TWh by 2050, and wind adds an additional 0.4 TWh. This results in a renewable generation total of approximately 11 TWh in 2050, or 46% of the total mix, a substantial increase over the Baseline. The continued operation of the coal fired plants ensures that fossil fuels still play a large role, but with coal's dominance slowly declining. Coal bed methane also emerges but its contribution is relatively small.

The DDP LT scenario embodies a fundamental transformation. While generation levels in 2030 (18.8 TWh) and 2040 (23.9 TWh) mirror the DDP trajectory, the pace of change accelerates sharply after 2040. By 2050, total electricity generation reaches 30.6 TWh, a 27% increase over DDP. This growth is enabled by widespread deployment of CCS at all the coal fired plants, alongside a full-scale build-out of renewables. By 2050, solar PV alone contributes 16 TWh, while wind contributes 1.45 TWh. Combined renewable generation totals 17.5 TWh, accounting for 57% of the electricity mix. By 2063, generation exceeds 37 TWh, of which more than 22 TWh are from renewables, supporting deep electrification and large-scale green hydrogen production.

Between 2030 and 2040, renewable electricity generation under DDP grows from 4.7 TWh to 7.5 TWh, increasing its share from 26% to 36%. In DDP LT, renewables rise from 5.8 TWh (31% share) in 2030 to 10.8 TWh in 2040 (45% share). The decade from 2040 to 2050 marks the inflection point. In DDP, renewables reach 11 TWh (45% share), while in DDP LT, they soar to 17.5 TWh (57% share). This shift is powered by an aggressive renewable scale-up and the integration of CCS, replacing traditional coal capacity and positioning the electricity sector as the backbone of economy-wide decarbonization.

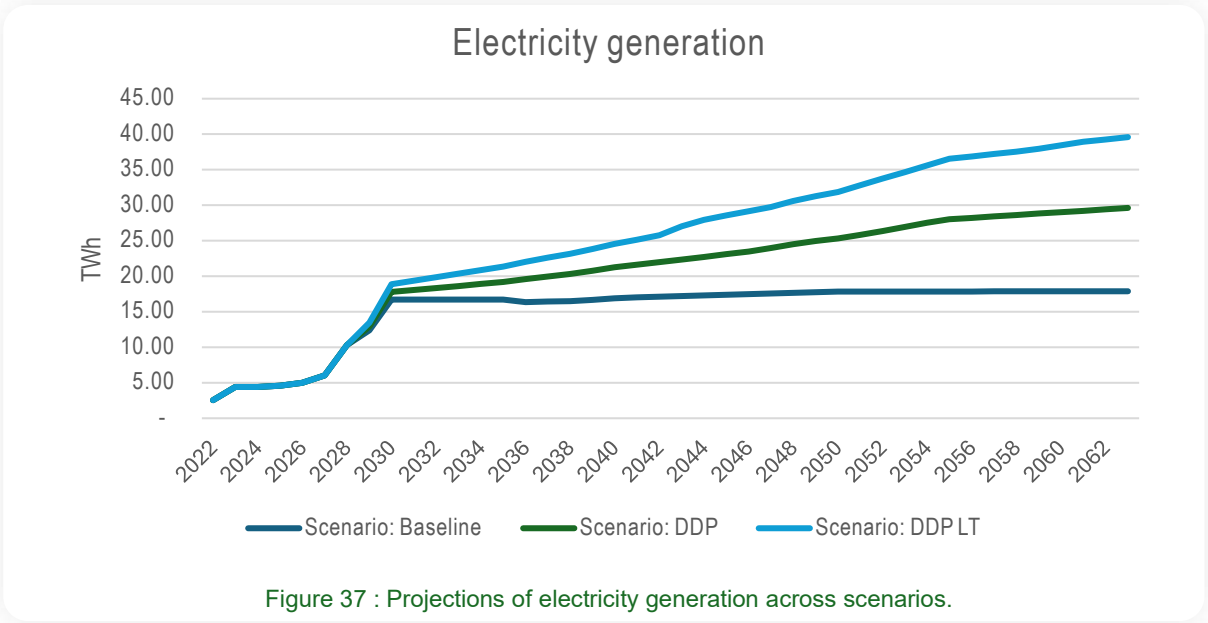


Figure 37 : Projections of electricity generation across scenarios.

Energy related GHG emissions

Energy related GHG emissions in Botswana follow contrasting pathways under the Baseline, DDP, and DDP LT scenarios, illustrating the scale of systemic change required to meet long-term climate neutrality targets (Figure 38).

Under the Baseline scenario, emissions grow steadily from 8,497 $ktCO_2eq$ in 2025 to 16,744 $ktCO_2eq$ by 2030, 17,985 $ktCO_2eq$ by 2040, and 20,058 $ktCO_2eq$ in 2050. This trajectory reflects unmitigated increases in both demand-side and transformation emissions. Transformation emissions rise from 4,388 $ktCO_2eq$ in 2025 to 11,734 $ktCO_2eq$ in 2050, driven by continued expansion of unabated coal-fired generation. At the same time, demand-side emissions rise from 4,108 $ktCO_2eq$ in 2025 to 8,324 $ktCO_2eq$ by 2050, as fuel switching and electrification remain limited. By 2063, total GHG emissions under this scenario reach 23,853 $ktCO_2eq$, nearly triple the 2025 level.

The DDP scenario slows this rise in emissions. From 8,497 $ktCO_2eq$ in 2025, total emissions reach 16,156 $ktCO_2eq$ in 2030, 16,270 $ktCO_2eq$ by 2040, and 16,523 $ktCO_2eq$ in 2050. Compared to the Baseline, this pathway delivers a significant emissions reduction of nearly 3,535 $ktCO_2eq$ by mid-century. This is achieved through moderated growth in demand (from 3,973 $ktCO_2eq$ in 2025 to 4,515 $ktCO_2eq$ in 2050) and a slower increase in transformation emissions, which rise from 4,388 $ktCO_2eq$ to 12,008 $ktCO_2eq$ in the same period. However, fossil power plants continue to operate without CCS, and total emissions under DDP continue rising post-2040, albeit at a slower rate. By 2063, emissions reach 16,604 $ktCO_2eq$, almost double compared to 2025.

The DDP LT scenario achieves a fundamental shift. Total emissions peak at 16,156 $ktCO_2eq$ in 2030 and 13,281 $ktCO_2eq$ in 2040, before falling sharply to 5,776 $ktCO_2eq$ by 2050, a 56% reduction in just one decade. This is enabled by a dramatic decline in transformation emissions from 9,022 $ktCO_2eq$ in 2040 to 3,604 $ktCO_2eq$ in 2050, following the rapid deployment of CCS in coal plants. Demand-side emissions also contract significantly, from 4,259 $ktCO_2eq$ in 2040 to just 2,172 $ktCO_2eq$ in 2050, driven by widespread electrification and the replacement of fossil fuels in households, transport, and industry. By 2063, emissions are reduced further to 3,818 $ktCO_2eq$, nearly 84% below the Baseline and 77% below DDP, demonstrating the decisive impact of post-2040 mitigation policies and technology shifts.

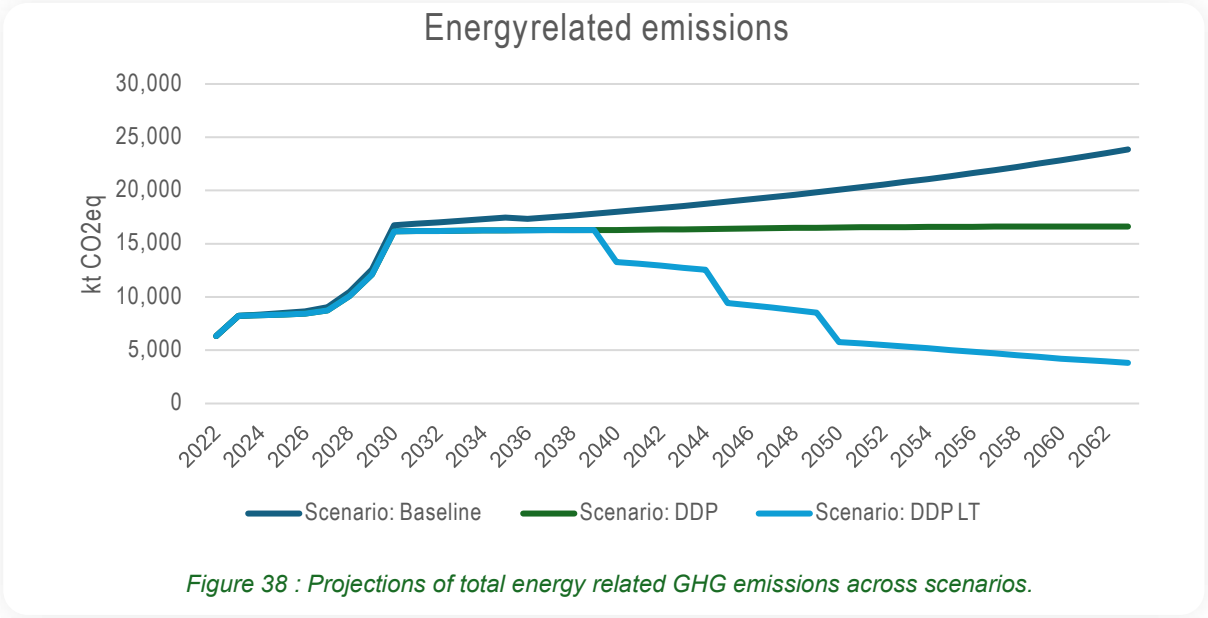


Figure 38 : Projections of total energy related GHG emissions across scenarios.

An analysis of GHG emissions by final energy demand sector shows that in the Baseline scenario, transport remains the dominant source of emissions throughout the period. Gasoline and diesel use continue to climb, with gasoline-related emissions increasing from 1,357 $ktCO_2eq$ in 2025 to 2,613 $ktCO_2eq$ in 2050, and diesel from 4,252 $ktCO_2eq$ to 5,003 $ktCO_2eq$. These increases reflect minimal vehicle electrification and continued dependence on internal combustion engines. Industrial emissions also rise steadily, primarily through growing use of coal and residual fuel oil. Coal emissions mainly in electricity generation increase from 2,782 $ktCO_2eq$ in 2025 to 11,687 $ktCO_2eq$ by 2050, with coal combustion forming the largest single source of non-transport emissions. Households remain dependent on traditional biomass and fossil fuels, with wood and charcoal emissions rising from 92 $ktCO_2eq$ in 2025 to 150 $ktCO_2eq$ by 2050.

The DDP scenario moderates these trends, particularly post-2025. Gasoline emissions peak at 1,276 $ktCO_2eq$ in 2024, then steadily decline to 937 $ktCO_2eq$ in 2050. Diesel follows a similar trajectory, peaking around 2,793 $ktCO_2eq$ in 2035 before declining modestly to 2,992 $ktCO_2eq$ by 2050, reflecting limited vehicle electrification and modal shifts. Industrial emissions also show signs of moderation. Coal

emissions plateau around 11,600 $ktCO_2eq$ in 2050. Household emissions remain relatively stable, with wood and charcoal contributing 130 $ktCO_2eq$ by 2050, lower than in the Baseline but still indicative of slow electrification uptake. Overall, the DDP scenario demonstrates partial mitigation but does not deliver absolute sectoral emissions reductions.

A fundamental transformation occurs under the DDP LT scenario, particularly after 2040. Until that point, fuel use patterns align closely with the DDP pathway. However, from 2041 onward, deep decarbonisation begins. Gasoline emissions fall from 1,041 $ktCO_2eq$ in 2040 to just 459 $ktCO_2eq$ by 2050, and nearly zero by 2063, as electric vehicles and hydrogen-fuelled mobility dominate the transport landscape. Diesel consumption in industry contracts significantly, with emissions dropping from 2,725 $ktCO_2eq$ in 2040 to 1,367 $ktCO_2eq$ by 2050 and zero by 2063, as fuel switching and process electrification take hold.

Emissions from coal are sharply curtailed as fuel substitution and CCS are deployed. Coal emissions fall from 8,602 $ktCO_2eq$ in 2040 to 3,072 $ktCO_2eq$ in 2050. In the residential sector, emissions from wood and charcoal drop modestly but steadily, reaching 62 $ktCO_2eq$ by 2050, then continuing downward. This decline reflects progressive electrification and the uptake of modern fuels such as LPG. By 2063, household-related emissions are under 70 $ktCO_2eq$, compared to over 225 $ktCO_2eq$ in the Baseline.

Cost comparison across scenarios

The analysis of annualized costs of the energy system development, reveals important insights regarding the economic implications of the alternative energy pathways discussed above (Figure 39). The total cost aggregates three key components: investments in the demand sectors (households, industry, transport, services, agriculture), investments in the transformation sector (mainly electricity generation), and expenditures on imported fossil fuels (labelled “Resources” in the graph). In the following analysis these are expressed in constant 2022 USD millions.

The key metric for assessing the economic cost of alternative scenarios is the difference in total cost compared to the Baseline scenario (Figure 39). This difference reflects both the additional investment required for new technologies and the potential savings from reduced fossil fuel imports. This is discussed in detail in the following paragraphs.

Over the short-term period to 2030, the DDP scenario generates cumulative savings compared to the Baseline, with cumulative total cost reductions of around $1033 million. These come predominantly from fossil fuel import savings, amounting to $1032 million, coupled with demand-side investment decrease of about $45 million and a cumulative increase in investments in the electricity generation at the level of $46 million which this is more than compensated by fuel savings. DDP thus delivers an overall cost reduction of about 4% relative to the Baseline over the period 2025-2030. DDP LT mirrors these savings closely in the short term, achieving total reductions of $987 million, underpinned by a $1032 million decrease in imported fuel costs and slightly higher investments than DDP in transformation, in anticipation of deeper long-term decarbonization (Figure 39).

Between 2030 and 2040, the divergence in cost structures becomes more pronounced (Figure 39). The DDP scenario, produces cumulative savings of $6.3 billion (12% below Baseline costs), due to sustained fuel substitution and energy efficiency impacts, which cut fossil imports by $6.1 billion despite transformation investments rising by $1.1 billion. DDP LT reaches $5.2 billion in total savings compared to the Baseline. While transformation investments are significantly higher by roughly $2 billion over the decade and demand side technologies investment lower by $1.2 billion, these are offset by fuel savings of over $6.1 billion, resulting in a net benefit of 10% below Baseline cost levels.

In the long-term horizon from 2040 to 2063, the cumulative impact of structural energy transformation is unmistakable (Figure 39). The DDP delivers cumulative savings of $59 billion over the period 2040 - 2063, corresponding to 29% savings compare to the Baseline, reflecting the effects of decarbonization. Fuel import costs are reduced by $50 billion, despite additional investment of $5.8 billion in transformation. DDP LT yields economic advantages, cutting total costs by $14 billion, which is 7% lower relative to the Baseline. Fuel imports alone are reduced by $39 billion over this period. However, these gains need the additional $7.4 billion in demand-side investments and the $16 billion spent in the transformation sector, much of which reflects large-scale deployment of renewables and end uses switching to electrification and hydrogen.

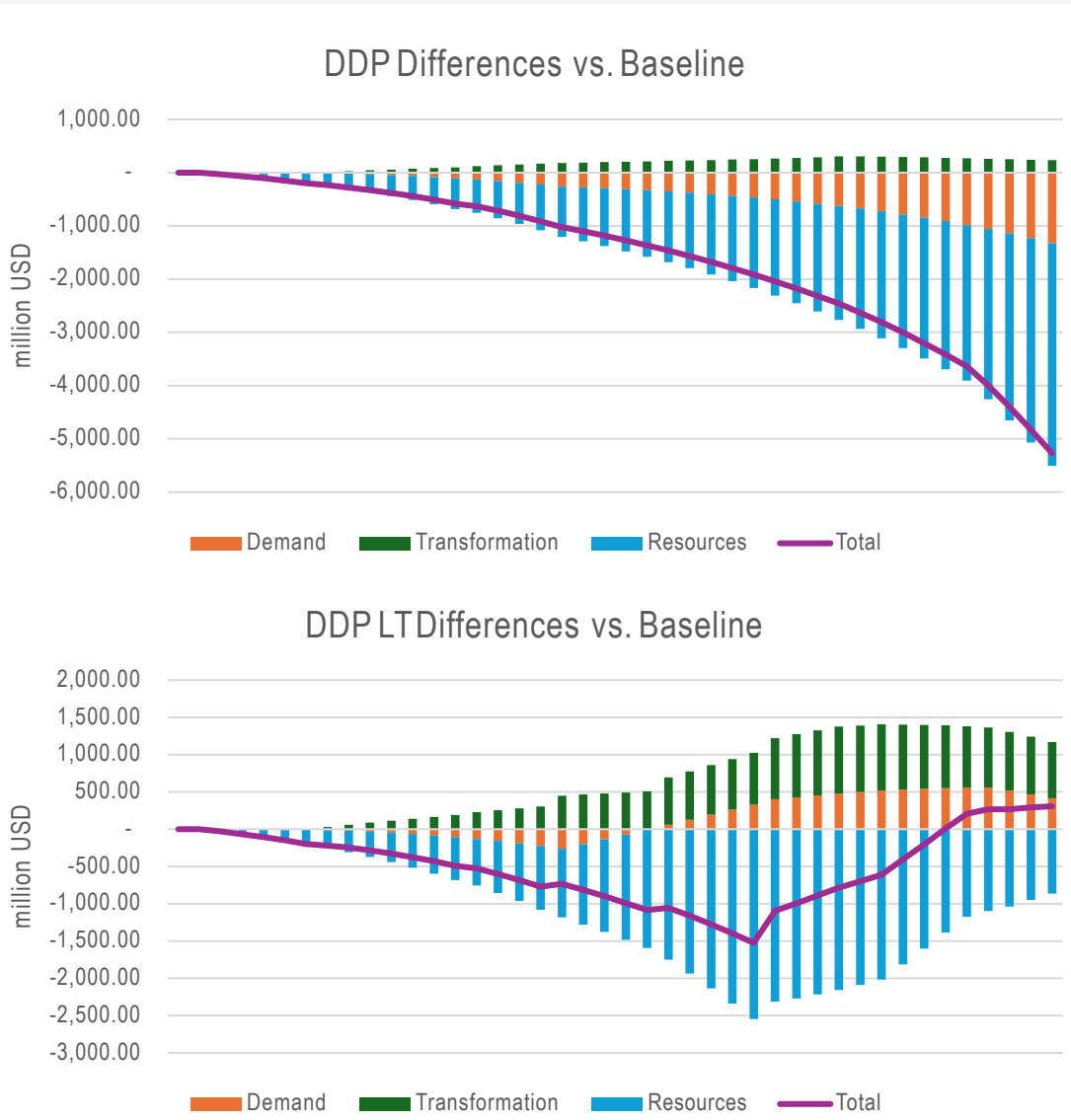


Figure 39 : Projections of annualised costs differences between the Baseline and DDP scenarios

Key Comparative Scenario Analysis Conclusions

The comparative assessment of Botswana's energy future under the Baseline, DDP, and DDP LT scenarios reveals a decisive break between fossil-fuel dependence and climate-aligned transformation. The Baseline scenario reflects persistent growth in energy demand, fossil fuel reliance, and GHG emissions, while the DDP scenario introduces moderate electrification and efficiency measures. Finally, the DDP LT scenario demonstrates the deep structural changes required to place Botswana on a pathway towards a zero-carbon energy system.

Electrification emerges as the cornerstone of transformation in both DDP and DDP LT. Final energy demand under DDP reaches 3,059 ktoe by 2050, 26% lower than the Baseline, illustrating the success of electrification and efficiency measures. Sectorally, electricity becomes the dominant final energy in households (356 ktoe by 2050), and services (234 ktoe) by 2050, and in transport and industry by 2063, whereas in the Baseline, fossil fuels and biomass remain predominant. This shift is underpinned by a leap in electricity generation: while the Baseline grows to 17.8 TWh by 2050, DDP increases to 25.3 TWh and DDP LT surges to 31.8 TWh, driven by renewable energy and CCS equipped coal plants. Renewable electricity generation reaches 30% in 2030 in the DDP and 36% in 2040. In DDP LT, renewables rise to 32% in 2030 to 45% in 2040. Furthermore, from 2040 to 2050 an even higher increase is seen reaching 46% in DDP and 57% in DDP LT.

Fuel switching plays a crucial role across sectors. In industry, diesel and coal dominate under the Baseline, but in DDP fossil use is considerably reduced and in DDP LT it is phased out entirely by 2063, replaced by electricity and hydrogen. Hydrogen adoption, absent in the Baseline and only marginal in

DDP, rises to over 93 ktoe in industry and 915 ktoe in transport under DDP LT, enabling decarbonisation in hard-to-abate segments. In transport, the Baseline projects 2,262 ktoe of diesel and gasoline use in 2050, while DDP reduces this by 52% and DDP LT by 77%, with a complete transformation of the fuel mix since fossil fuels are nearly eliminated post-2050 and replaced by electricity and hydrogen.

GHG emissions trends reflect these structural shifts. Under the Baseline, emissions rise from 8,497 $ktCO_2eq$ in 2025 to 20,058 $ktCO_2eq$ by 2050, while DDP slows the increase, reaching 16,253 $ktCO_2eq$. In contrast, DDP LT peaks emissions at 13,281 $ktCO_2eq$ in 2040 and then reduces them to 5,776 $ktCO_2eq$ by 2050, a 56% decline in a decade. By 2063, emissions under DDP LT fall to 3,818 $ktCO_2eq$, compared to 23,853 $ktCO_2eq$ in the Baseline. These reductions are largely attributable to post-2040 deployment of CCS in coal plants, systemic electrification, and fuel switching in all demand sectors.

Economically, DDP LT proves to be a prudent long-term investment. In the short term (to 2030), both DDP and DDP LT achieve cost savings of around $1 billion compared to the Baseline, primarily through reduced fossil fuel imports. Between 2030 and 2040, DDP saves $6.3 billion and DDP LT $5.2 billion, despite higher transformation costs in the latter. From 2040 to 2063, DDP yields $59 billion in cumulative savings while DDP LT yields $14 billion.

In conclusion, DDP offers a significant improvement over the Baseline by stabilising emissions and lowering costs, while DDP LT delivers deep emissions reductions, with clean technology integration, system-wide electrification, and a 57% renewable electricity share by 2050, but at a higher cost compared to DDP.



4. Key Policy & Action Areas

4.1. Introduction

The preceding chapters have reconstructed each national energy system in detail and have projected its evolution under defined decarbonisation pathways. This chapter descends from scenario trajectories to the ground level decisions that unlock those trajectories. This Chapter therefore assembles a portfolio of short term, actionable interventions for Botswana that correspond to the seven ETSAP subsectors: electricity, industry, transport, buildings, oil & gas, agriculture, and clean cooking. They are the "hinge points" where policy intent meets regulatory engineering, and where private capital receives the confidence signal it needs to mobilise at scale.

4.2. Development of the action list

The action list is derived from the long inventory of measures embedded in the ETSAP and its companion document, the Guidelines for Low Hanging Fruit and High Impact Activities. That inventory is deliberately expansive, capturing the full spectrum of possibilities across fifty-five Member States. Yet an undifferentiated continental list, however comprehensive, risks being either too abstract or too prescriptive when transposed into specific national contexts. Accordingly, the project team and the national stakeholder working groups undertook a filtration process whose objective was to distil a first set of actions per sector tailored to the realities of Botswana.

The filtration followed a three-step logic. **Relevance** asked whether the measure addressed an identified bottleneck in the baseline: high network losses, regulatory gaps, obsolete building codes, or the absence of standards for flare reduction where applicable. **Feasibility** examined institutional maturity, fiscal headroom and political appetite, acknowledging that some ideas are premature until prerequisites—like, a robust grid code or a functioning metering backbone—are in place. **Catalytic leverage** weighed the ratio of policy design effort to downstream private investment or emissions savings; in a resource constrained setting, actions that trigger large follow-on flows rank highest. Finally, it is implied that when specific technologies are investigated for use, this investigation will utilize Life Cycle Analysis (LCA) data. If data is not available in international literature this gap will be flagged to set the ground for subsequent work on LCA.

4.3. Consultative architecture

Ensuring both national ownership and regional and continental comparability required a deliberate engagement approach. We therefore adopted a four-layer process that is common to all three countries, yet sufficiently flexible to capture their diversity:

1. **Bilateral consultation rounds**: Specialists from the project team met separately or in small groups with regulators, utilities, relevant ministries and civil society monitors. These encounters surfaced granular constraints—informal tariff discounts, permit bottlenecks, missing data fields - often invisible in formal reports.
2. **Preselection and initial appraisal**: Drawing on those bilateral, an initial list of potential activities was compiled, each accompanied by a first cut impact estimate harvested from international experience or rough techno economic calculations. These estimates were deliberately conservative - the aim was to frame a conversation, not pre-empt it.
3. **National multi stakeholder workshop:** The draft actions and their indicative impacts were exposed to the full working group in physical workshops. Participants interrogated assumptions, proposed alternative delivery mechanisms, and refined quantitative targets.
4. **Cooling off and ratification window:** Within forty-eight hours the refined slide deck and a concise record of workshop deliberations were circulated electronically. Stakeholders then had a one-week comment window. Silence after that period counted as assent. Only after this window closed were the activities deemed approved and therefore ready for integration into the DDP scenario set up.

This protocol serves three purposes. First, it provides a transparent audit trail for future reference and donor due diligence. Second, it balances inclusivity with decision speed - preventing iterative paralysis while respecting legitimate voices. Third, it anchors each activity in a public record of co-creation, thereby protecting forthcoming policy instruments against the criticism of technocratic imposition.

4.4. Design philosophy of the activity cards

Because the interventions are predominantly soft - laws, regulations, standards, capacity programmes - they do not carry the billion-dollar price tags associated with power station builds or grid backbones. Their primary resource requirement is technical expertise: economists, lawyers, engineers and social engagement specialists who can draft, benchmark, consult and finalise the instruments. It has to be highlighted that the budget presented for each activity is a lump sum estimate only for the consulting work required for implementing “soft” activities like the implementation of supporting studies and the development of regulations. Pilot / demonstration projects stemming from these activities are not included in these budgets. For budgeting purposes, we have therefore adopted a deliberately simple metric: total person days required, multiplied by an all-inclusive professional rate of USD 1,000 per day. This approach may appear reductive, yet it achieves three advantages: clarity, comparability and rapid scalability once more precise scoping becomes possible.

Each activity is captured in a two-section card. Section 1 delivers an executive synopsis—a statement of rationale, intervention description, headline 2030 impact, implementation horizon, indicative budget and institutional mapping. Section 2 expands the technical substance, enumerates milestones, highlights critical enablers and risks, and sketches a light touch monitoring arrangement.

Inter-ministerial coordination among all involved stakeholders is essential and is considered as a prerequisite for all the activities presented below.

4.4.1. Temporal alignment with modelling horizon

The modelling horizon for the Deep Decarbonisation Pathway extends to 2063, aligned with Agenda 2063. Yet in policy praxis the decisive spur lies in the next election cycle or fiscal planning window. Hence this Chapter confines its quantitative ambition metrics to 2030, mirroring the first implementation phase of ETSAP and the time frame used in the AU low hanging fruit guidance. By compressing the horizon, we make monitoring credible, lessen forecast error, and produce KPIs that can be directly inserted into Medium Term Expenditure Frameworks or National Development Plans.

That is not to suggest that the actions cease to matter after 2030. Rather, they are conceived as platform enablers - once enacted, they propagate benefits through the medium and long term: renewable procurement rules remain in force, building energy labels continue to steer consumer choices, flare reduction standards safeguard methane budgets. Thus, a modest consultancy outlay in the present decade can lock in structural emissions declines and investment flows for thirty years or more.

4.4.2. Interfacing with scenario analytics

Although this Chapter is self-standing, its architecture has been designed in full alignment with the scenario analysis. Each headline KPI - loss reduction, renewable share, appliance efficiency index—feeds directly into the parameter files of the LEAP model. Reciprocally, the LEAP results inform the plausibility checks on each KPI. If the model shows that even a maximal smart meter roll out could only shave losses by ten percentage points, the activity cannot promise fifteen. This handshake between qualitative insight and quantitative accuracy is the chapter’s hidden framework.

GHG impact accounting remains anchored in Chapter 3. Readers will find cumulative emissions savings, marginal abatement costs and investment curves there. This Chapter sets out who must do what, by when, and with which modest resource envelope to render those savings real.

4.4.3. High level monitoring and reporting

Given the nascent state of energy data systems in Botswana, monitoring must tread lightly. Each activity card therefore prescribes a single annual progress review to the National Energy Transition Steering Committee (NETSC), or comparable organ decided in each country, with a short summary transmitted to AFREC for insertion into the continental ETSAP dashboard. The committee will judge success primarily against binary or easily verifiable markers “regulation gazetted,” “tariff instrument published,” “first cohort of auditors certified.” Where richer datasets exist (smart meter roll out, NEV registrations), they will be exploited, but the monitoring regime refrains from inventing metrics that agencies cannot presently sustain.

In the end, the reader should possess a clear, country specific yet continentally harmonised map of immediate actions—actions that are small enough to be financed through a routine consultancy line, yet potent enough to bend emissions curves, attract private capital, and embed a culture of efficiency

and innovation across Africa's energy landscape. In the architecture of the Deep Decarbonisation Pathway, these policies are the foundations.

The action list applied to Botswana is presented in the tables below.

4.5. Electricity Sector

Executive Synopsis

Activity Name	Promoting the Uptake of Renewable Energy for Grid & Distributed Generation Systems
Sector / High-level Pursuits	Electricity · Universal Access & Clean Energy Mix
Rationale	More than 70 % of domestic generation is coal-fired, yet Botswana enjoys one of the planet's highest Direct Normal Irradiance (DNI) values (> 2 200 kWh m-² yr-¹). Diesel for off-grid mines and villages further drains foreign exchange. Unlocking solar, wind and battery projects is the quickest lever to cut imports and diversify the grid.
Core Intervention	Draft and gazette a Renewable-Energy Procurement & Direct-Supply Regulation allowing independent power producers (IPPs) to sign standardised power purchase agreements (PPAs), commercial and industrial (C&I) customers to procure power directly, and small producers (< 1 MW) to net-bill surplus into the grid. Include a battery-storage tariff adder to incentivise battery capacity.
Expected 2030 Impact	15% decrease in fossil fuel use while an overall increase in energy consumption is observed supporting the universal access to electricity target for 2030.
Implementation Horizon	Start Q3 2025 Completion Q4 2027
Indicative Budget	60 working days (WD) × USD 1 000 = USD 60 000
Lead & Partners	Ministry of Mineral Resources & Energy (lead) • Botswana Energy Regulatory Authority (BERA) • BPC • Business Botswana

Technical Detail

Detailed Description	Regulation defines competitive auctions (price ceiling indexed to avoided coal cost), a direct-supply framework for mines, and net-billing for rooftop PV. Battery adder is operationalized for a four-hour or more storage. Standardised PPAs include partial risk guarantee via a development bank.

Key Outputs & Milestones	Budget secured	Q4 2025	Tender notice announced
	Zero-draft regulation circulated	Q2 2026	Draft submitted to ministry
	National consultation workshop	Q3 2026	Publication in the Government Gazette
	Cabinet approval & gazette	Q3 2027	Draft submitted to ministry
	First IPP tender launched	Q4 2027	Request for proposal (RfP) issued for 20 MW solar
Critical Enablers	• Political backing • Grid-code update		
Risks management analysis	**Risks**	**Mitigation Measures**	
	PPA bankability doubts.	Development bank partial-risk guarantee.	
	Land acquisition delays	Pre-zoned solar parks	
Monitoring & Reporting	• Annual update to National Energy-Transition Steering Committee • RE capacity progress uploaded to AFREC dashboard.		
Next Immediate Steps	• Endorse Terms of Reference (ToR) • Secure budget • Launch consultant expression of interest (EOI) on BERA portal • Inception mission scheduled for January 2026		

Table 4: Promoting the Uptake of Renewable Energy for Grid & Distributed Generation Systems

Executive Synopsis

Activity Name	Enforcing Standards for Smart Distribution Grids
Sector / High-level Pursuits	Electricity · Infrastructure Modernisation & Energy Efficiency
Rationale	Technical and non-technical losses hover round 14 %, weak visibility hampers RE integration. Smart-grid standards will cut losses, improve revenue and create headroom for variable renewables.
Core Intervention	Issue a BERA-led “Smart Grid Code” mandating: (i) phased deployment of Advanced Metering Infrastructure (AMI) meters, (ii) supervisory control and data acquisition (SCADA) integration, (iii) cyber-security protocols, (iv) loss-reduction incentive scheme.
Expected 2030 Impact	Decrease in network losses to 10% due to improved efficiency. Increase in intermittent renewables penetration by 10% due to smart metering and flexibility.
Implementation Horizon	Start Q3 2025 Completion Q4 2027
Indicative Budget	80 WD × USD 1 000 = USD 80 000
Lead & Partners	BERA (lead) • BPC • MoMRE

Technical Detail

Detailed Description	The Code will prescribe functional specifications (DLMS/COSEM compliant meters, General Packet Radio Service (GPRS)/4G/5G communication), set quarterly roll-out quotas, and establish a loss-reduction target curve linked to a tariff-setting incentive. Cyber-security rules will align with ISO 27 001.		
Key Outputs & Milestones	Budget secured	Q4 2025	Tender notice announced
	Draft Code completed	Q2 2026	Published for comment
	Pilot AMI roll-out (1 000 meters)	Q2 2027	95 % read-success rate
	Code gazetted & enforcement begins	Q4 2027	Publication in the Government Gazette

Critical Enablers	• Donor co-financing for meters • Telecommunication coverage	
	Risks	**Mitigation Measures**
Risks management analysis	Resistance from informal users	Social tariff- design
	Meter tampering	Tamper--proof seals
Critical Enablers	Loss-factor audit verified annually by BERA and uploaded to AFREC.	
Next Immediate Steps	• Approve ToR • Engage meter-specification consultant • Launch public-consultation port	

Table 5: Enforcing Standards for Smart Distribution Grids

Executive Synopsis

Activity Name	**Develop Electrification Plan for Rural Areas**
Sector / High-level Pursuits	Electricity · Universal Access to Electricity
Rationale	Sparsely populated settlements rely on diesel mini-grids or remain un-electrified. A geospatial plan will rationalise grid extension vs. solar-hybrid mini-grids and solar-home systems, enabling productive-use businesses and paving the way towards universal access to electricity
Core Intervention	Produce a Geospatial Electrification Plan integrated with the forthcoming National Energy Masterplan; establish a flexible regulatory window for mini-grid tariffs and eventual grid interconnection.
Expected 2030 Impact	5% increase in primary energy consumption increasing access to electricity rate with zero added emissions.
Implementation Horizon	Produce a Geospatial Electrification Plan integrated with the forthcoming National Energy Masterplan; establish a flexible regulatory window for mini-grid tariffs and eventual grid interconnection.

Indicative Budget	100 WD × USD 1 000 = USD 100 000
Lead & Partners	MoMRE (lead) • BPC • BERA

Technical Detail

Detailed Description	A geospatial least-cost analysis will overlay settlement density, existing MV lines, solar insolation, groundwater tables and road access to decide—village by village—between grid extension, solar-hybrid mini-grids (< 50 kW) and solar-home systems. The Plan will quantify capital needs, sequence projects to 2030, and embed a “flexible productive-use window” that licenses agro-processing, cold-storage and ICT services in mini-grid zones. It will also define technical standards for eventual grid interconnection (IEEE 1547-based) and propose a results-based subsidy keyed to verified new connections. Community-engagement guidelines ensure local buy-in and operator training, while an investment prospectus packages bankable clusters for private developers.

Key Outputs & Milestones

Budget secured	Q3 2025	Tender notice announced
National geographic information system (GIS) data collection complete	Q2 2026	Clean, georeferenced database on MoMRE server
Draft least-cost electrification map	Q4 2026	Interactive map published for consultation
Stakeholder validation workshops	Q1 2027	Workshop reports with agreed revisions
Final Plan and investment prospectus	Q3 2027	Cabinet-approved document; public release
Regulatory window for mini-grid tariffs issued	Q4 2027	Direct issued

Critical Enablers

- High-resolution population data (Statistics Botswana)
- Donor appetite for rural access
- Emerging local engineering, procurement and construction (EPC) firms.

	Risks	**Mitigation Measures**
Risks management analysis	Resistance from informal users	Social tariff- design

	Meter tampering	Tamper--proof seals
Monitoring & Reporting	• MoMRE uploads quarterly progress (connections, mini-grid commissioning) to the Ministry. • AFREC dashboard receives annual KPI update on access rates and technology mix.	
Next Immediate Steps	• Approve Terms of Reference • Release procurement notice • Mobilize GIS and regulatory experts • Schedule inception mission.	

Table 6: Develop Electrification Plan for Rural Areas

4.6. Clean Cooking Sector

Executive Synopsis

Activity Name	Innovate & Plan for Clean Cooking Solutions
Sector / High-level Pursuits	Clean Cooking · Universal Access & Health
Rationale	In rural settlements roughly 45 % of households still rely on traditional biomass. Urban LPG adoption is rising but lacks a cohesive distribution policy, while rapidly falling PV costs make e-cooking viable for grid-connected towns. A unified roadmap will synchronise fuels, finance and behaviour-change
Core Intervention	Draft and publish a Clean-Cooking Strategy 2026-2030 integrating. 1. LPG/e-cooker results-based subsidies, 2. Pilot distribution of efficient biomass cookstoves 3. Carbon-credit aggregation facility, and 4. Gender-centred awareness campaigns delivered through health-extension networks.
Expected 2030 Impact	100% Access by 2030
Implementation Horizon	Start Q4 2025 Completion Q4 2027
Indicative Budget	40 WD × USD 1 000 = USD 40 000

Lead & Partners	Ministry of Mineral Resources & Energy (lead) • Ministry of Health • BERA • Women's NGO Coalition

Technical Detail

Detailed Description	The strategy quantifies regional demand, maps LPG and sustainable biomass supply chains, and sets phased targets: 60 % modern-fuel access by 2028, 100 % by 2030. A results-based financing (RBF) window will reimburse distributors USD 20 per verified LPG cylinder/efficient biomass cooker/e-cooker connection. A revolving credit line supplies working capital to last-mile retailers. A Gold-Standard-compliant carbon-aggregation platform monetises emissions savings, feeding 50 % of proceeds into continued subsidies. Health-extension workers deliver demonstrations, while communication campaigns challenge entrenched fuel-wood norms.

Key Outputs & Milestones

Budget secured	Q3 2025	Tender notice announced
Zero-draft strategy circulated	Q4 2026	≥ 100 comments incorporated
National consultation completed.	Q4 2026	≥ 100 comments incorporated
Cabinet approval & gazette	Q1 2027	Workshop reports with agreed revisions
RBF window operational	Q3 2027	Cabinet-approved document; public release
Regulatory window for mini-grid tariffs issued	Q4 2027	Direct issued

Critical Enablers	• concessional LPG-storage loan • existing women's micro-finance

	Risks	Mitigation Measures
Risks management analysis	Supply-chain disruptions	Bulk-import parity pricing formula
	Subsidy leakages.	Digitised voucher tracking.

Monitoring & Reporting	• Annual household-survey module on cooking fuel. • Summary sent to AFREC.

Next Immediate Steps	• Issue ToR • Engage clean cooking specialist • Inception workshop February 2026

Table 7: Innovate & Plan for Clean Cooking Solutions

4.7. Building Sector

Executive Synopsis

Activity Name	**Energy Labelling for Buildings**
Sector / High-level Pursuits	Buildings · Energy Efficiency
Rationale	Space-cooling demand is projected to triple by 2035. Without clear consumer information, developers default to low-spec thermal envelopes. An energy label allows buyers and banks to differentiate asset quality and primes the market for mandatory codes later. While the country has high solar irradiation, the deployment of solar water heating systems remains low.
Core Intervention	Design and roll out a Voluntary-then-Mandatory Building Energy-Label Scheme (Classes A–G), bundled with a green-mortgage discount and municipal-rate rebate for Class A–C buildings.
Expected 2030 Impact	10% decrease in primary energy consumption due to improved efficiency
Implementation Horizon	Start Q1 2025 Completion Q1 2028
Indicative Budget	100 WD × USD 1 000 = USD 100 000
Lead & Partners	Ministry of Infrastructure & Housing (lead) • Botswana Bureau of Standards (BOBS) (Standards) • Botswana Green Building Council • Southern African Development Community Centre for Renewable Energy and Energy Efficiency (SACREEE)

Technical Detail

Detailed Description	The scheme sets seven classes based on kWh m-² yr-¹, calibrated for climate zone hot-desert climate (BWh) (semi-arid hot). Digital registry lists approved simulation tools (e.g., Design Builder) and certified auditors. Roll-out: 2028 voluntary for hotels, offices, malls; mandatory for all new commercial/residential builds from 2030. Property-transfer deeds must include label from 2031.

Key Outputs & Milestones			
	Budget secured	Q1 2026	Tender notice announced
	Zero-draft strategy circulated	Q4 2026	Technical specification posted for comment
	Auditor-training curriculum approved	Q2 2027	20 auditors certified
	Voluntary label launched	Q4 2027	First 10 projects registered
	Mandatory phase begins	Q1 2030	Regulation in Gazette

Critical Enablers	• green-mortgage facility • property-tax by-law revisions

Risks management analysis	**Risks**	**Mitigation Measures**
	Insufficient auditor capacity	**Phased introduction**
	Developer push-back	Public-recognition awards

Monitoring & Reporting	• Annual registry audit. • kWh/m² data integrated into national energy-statistics yearbook.

Next Immediate Steps	• Convene technical committee • Align with SADC/SACREEE comparable activities • Secure donor support for training

Table 8: Energy Labelling for Buildings

Executive Synopsis

Activity Name	Comprehensive National Guidelines for Energy Performance in Buildings
Sector / High-level Pursuits	Electricity · Universal Access & Clean Energy Mix
Rationale	**Existing byelaws ignore insulation and orientation, locking in heating, ventilation and air conditioning (HVAC) oversizing and do not include the use of solar water heaters. Guidelines will codify passive-design measures and minimum equipment standards, enabling financiers and inspectors to enforce efficiency at scale, including the use of solar energy for water heating.**
Core Intervention	**Draft, consult and publish Energy Performance Guidelines covering envelope insulation values, solar-shading ratios, daylighting targets, Minimum energy performance standard (MEPS) for HVAC & lighting, and mandatory audits for > 1 000 m² floor area.**
Expected 2030 Impact	Additional 10% decrease in primary energy consumption due to improved efficiency beyond **Energy Labelling for Buildings** gains.
Implementation Horizon	**Start Q3 2026** **Completion Q1 2027**
Indicative Budget	40 WD × USD 1 000 = USD 40 000[1]
Lead & Partners	Ministry of Infrastructure & Housing (lead) • BOBS • Architects Association • SACREEE

Technical Detail

Detailed Description	Guidelines employ adaptive comfort model for hot-dry climate; prescribe roof U-value ≤ 0.35 W m-² K-¹, SHGC ≤ 0.30. Audits every five years for large buildings; compliance manual illustrates passive archetypes. Green-bond eligibility tied to guideline adherence.

Key Outputs & Milestones

Budget secured	Q3 2026	Tender notice announced
Consultation workshops in the country	Q2 2027	Regional events realized for extensive consultation
Draft guidelines prepared	Q1 2028	**Guidelines published**

	Validation of guidelines	Q4 2027	Draft Guidelines on ministry website
Critical Enablers	Donor Technical Assistance (TA) for thermal-simulation training		
Risks management analysis	**Risks** Cost concerns by developers.	**Mitigation Measures** Phased compliance Fiscal incentives	
Monitoring & Reporting	• Bi-annual survey of permit approvals tagged “compliant” • Summary to Ministry of Petroleum an Energy		
Next Immediate Steps	• Draft ToR • Secure technical assistance grant • Initiate baseline energy-intensity study.		

Table 9: Comprehensive National Guidelines for Energy Performance in Buildings

4.8. Industry Sector

Executive Synopsis

Activity Name	**Energy-Efficiency Regulatory Framework for Industrial Decarbonisation**
Sector / High-level Pursuits	Industry · Energy Efficiency & Competitiveness
Rationale	Mining, beverages and agro-processing already account for roughly one third of national electricity; demand will rise with beneficiation plans for coal-bed methane and copper. Early efficiency rules will lock in low-carbon competitiveness and curb grid stress.
Core Intervention	Draft and enact an Industrial Energy Efficiency (EE) Regulation that mandates ISO 50001-aligned energy audits every three years for facilities > 1 GWh yr-¹, requires management action plans, and rewards over-compliance with tradable “energy-saving certificates” redeemable against corporate tax.
Expected 2030 Impact	10% decrease in primary energy consumption due to improved efficiency

Implementation Horizon	Start Q1 2026 Completion Q2 2028
Indicative Budget	100 WD × USD 1 000 = USD 100 000
Lead & Partners	**Ministry of Trade & Industry (lead) • MoMRE • BERA • Botswana Chamber of Mines • SACREEE**

Technical Detail

Detailed Description	Regulation sets reporting templates, auditor-qualification criteria and certificate-trading mechanics; BERA hosts registry. Pilot audits in five high-load plants (diamond cutting, brewery, abattoir, copper concentrator, cement kiln) refine benchmarks. The regulation will further include the installation of solar water heaters when heat is needed in the industrial process.

Key Outputs & Milestones

Budget secured	Q1 2026	Tender notice announced
Draft regulation & guidelines	Q3 2026	Circulated to industry
Pilot audits (5 plants)	Q4 2026	Reports submitted
Regulation gazetted	Q1 2027	Regulation in Gazette
First certificate issuance	Q3 2028	Certificates posted on government website

Critical Enablers

- Technical support
- Tax-authority buy-in

Risks management analysis

Risks	Mitigation Measures
Audit fatigue	Phased thresholds
Audit Limited local expertise	Auditor-training grants

Monitoring & Reporting

- Annual audit-compliance report compiled by BERA
- Aggregate energy-savings data forwarded to AFREC

Next Immediate Steps	• Create inter-ministerial drafting task-force • Secure funding • Launch pilot-audit tender

Table 10: Energy-Efficiency Regulatory Framework for Industrial Decarbonisation

4.9 Transport Sector

Executive Synopsis

Activity Name	**Scoping, Piloting & Rolling-out NEVs**
Sector / High-level Pursuits	Transport Improved public transportation system, Decarbonisation & Air-Quality
Rationale	Transport burns 34 % of national petroleum and drives urban particulate matter (PM) 2.5. Falling battery costs and abundant solar make electric mobility attractive, but investors lack policy clarity.
Core Intervention	Deliver a National NEV Roadmap, enact an E-Mobility Incentive Decree (0 % import duty, registration rebate), and pilot two e-bus corridors plus 15 direct current (DC) fast chargers along Gaborone–Francistown spine road.
Expected 2030 Impact	• 10% of new sales of 4W vehicles to be electric • Multi-modal activities implemented to reduce by 30% the increase in transportation demand • For busses 25% increase in comparison to Baseline due to switch from private cars and new customers.
Implementation Horizon	Start Q1 2026 Completion Q4 2027
Indicative Budget	50 WD × USD 1 000 = USD 50 000
Lead & Partners	Ministry of Transport (lead) • BERA • BPC • City of Gaborone

Technical Detail

Detailed Description	Roadmap analyses total cost of ownership (TCO) parity, grid impact and local-assembly prospects. Decree grants five-year duty waiver and scaled registration rebates. Pilots: 40 e-buses (two routes), 15 fast chargers (50–150 kW) solar-backed. Data telemetry feeds BPC load-management system.		
Key Outputs & Milestones	Budget secured	Q1 2026	Tender notice announced
	Draft regulation & guidelines	Q3 2026	Report approved
	Pilot audits (5 plants)	Q4 2026	Regulation in Gazette
	Regulation gazetted	Q4 2027	≥2 e-bus routes
	First certificate issuance	Q4 2027	15 chargers operational
Critical Enablers	• Grid-capacity upgrades • Concessional bus finance		
Risks management analysis	**Risks**		**Mitigation Measures**
	Power outages		Battery backup at chargers to support the grid with potentially distributed PVs also installed if feasible-.
	Consumer range anxiety		Auditor-training grants
Monitoring & Reporting	• Quarterly vehicle-registration data and charger-utilisation reports submitted to Ministry of Transport.		
Next Immediate Steps	• Draft ToR • Secure grant • Convene automotive importers round-table		

Table 11: Scoping, Piloting & Rolling-out NEVs

Executive Synopsis

Activity Name	**Development of Bio-energy Supply Chains**
Sector / High-level Pursuits	Agriculture · Renewable Fuels & Rural Jobs
Rationale	Crop residues (sorghum stalks, maize cobs), livestock manure and encroaching bush are under-utilised. Structured collection and conversion to biogas/briquettes can displace diesel and fuelwood, create rural jobs and support off-grid electrification. The ongoing biodiesel activities in Act 9, include BERA as an institution that should also act by revising the regulation for blending biodiesel to higher shares than B20, utilizing also the work of the University of Botswana (Biodiesel Powering the Nation Initiative).
Core Intervention	Establish three regional biomass hubs, pilot 10 modular biogas digesters (50 m³ each) powering mini-grids, and publish a Sustainable Biomass Standard governing feedstock extraction.
Expected 2030 Impact	10% increase in primary energy consumption supporting the universal access to electricity target by 2030 with zero added emissions.
Implementation Horizon	Start Q2 2026 Completion Q4 2028
Indicative Budget	70 WD × USD 1 000 = USD 70 000
Lead & Partners	Ministry of Agriculture (lead) • Farmers Union • FAO • SACREEE

Technical Detail

Detailed Description	GIS mapping identifies residue hot spots within 40 km of milling centres as well as encroaching bush affected areas. Hubs house shredders, dryers and briquettes; digesters feed 50 kW mini grids. Biomass standard sets maximum extraction rates and traceability for voluntary carbon markets.

Key Outputs & Milestones	Budget secured	Q2 2026	Tender notice announced
	Biomass atlas completed	Q4 2026	Atlas uploaded
	Sustainability standard drafted	Q2 2027	Draft online
	Hub sites secured & MoUs signed	Q1 2028	≥ 2 MoUs
	Sustainability standard drafted	Q4 2028	≥ 50 m³ unit operational
Critical Enablers	• Extension-service network • Carbon-credit demand		
	Risks		**Mitigation Measures**
Risks management analysis	Feedstock seasonality		Long-term offtake contracts
	Land-tenure disputes		Community land agreements
Monitoring & Reporting	• Annual audit of biomass throughput and digester runtime • Summary to Ministry of Energy.		
Next Immediate Steps	• Engage consultant • Initiate stakeholder mapping • Draft sustainability-standard outline		

Table 12: Development of Bio-energy Supply Chains

Executive Synopsis

Activity Name	**Deploy Renewable-Energy-Powered Microgrids for Farming Applications**
Sector / High-level Pursuits	Agriculture · Productive Uses of Energy & Rural Jobs
Rationale	Irrigation pumps, milling and cold-stores in remote cattle posts rely on diesel at > USD 0.40 kWh-¹. Solar-hybrid microgrids can slash operating expenses (OPEX) and enable value addition, yet there is no standardised deployment framework.
Core Intervention	Develop Microgrid Deployment Guidelines, identify 20 high-priority agro-clusters, and create a concessional loan window via a development bank for solar-hybrid systems (20–200 kW) with productive-use appliances.
Expected 2030 Impact	• 10% increase in primary energy consumption supporting the universal access to electricity target by 2030 with zero added emissions.
Implementation Horizon	Start Q2 2026 Completion Q2 2029
Indicative Budget	80 WD × USD 1 000 = USD 80 000
Lead & Partners	Ministry of Agriculture (lead) • BPC Rural Electrification • National Development Bank • Green Climate Fund (GCF)

Technical Detail

Detailed Description	Guidelines cover technical specs (PV-hybrid + Li-ion + genset), tariff models, O&M training. GIS analysis selects 20 agro-clusters (≥ 50 kW load). New Development Bank (NDB) concessional window: 5-year grace, 6 % interest. Productive-use package lists pumps, mills, refrigeration.		
Key Outputs & Milestones	Budget secured	Q2 2026	Tender notice announced
	Guidelines drafted	Q4 2026	Guidelines online
	Priority-site list published	Q2 2027	Draft online

	NDB loan window live	Q1 2028	Circular
	First 2 microgrids commissioned	Q2 2029	≥ 100 kW
Critical Enablers	• Extension-service network • Carbon-credit demand		
Risks management analysis	**Risks**	**Mitigation Measures**	
	Repayment default	Appliance-lease model	
	Technical O&M gaps	Remote monitoring	
Monitoring & Reporting	Semi-annual performance reports (kWh, diesel displaced) to Ministry and AFREC.		
Next Immediate Steps	• Engage consultant • draft loan-product terms • community outreach.		

Table 13: Deploy Renewable-Energy-Powered Microgrids for Farming Applications

4.11.Oil And Gas Sector

Executive Synopsis

Activity Name	**Best-Practice Emissions Standards for CBM Development**
Sector / High-level Pursuits	Oil & Gas · Emissions Management
Rationale	Two flagship CBM projects—Tlou Energy's Lesedi Power and Botala Energy's Serowe Gas—are approaching commercial production. If left to generic upstream rules, routine venting and high-pressure flaring could lock in methane intensities > 1 %. A bespoke standard, grounded in Oïl and Gas Méthane Partnership (OGMP) 2.0 Tier-3 measurement and World Bank "Zero-Routine-Flaring" principles, will future-proof the industry, safeguard carbon revenues and bolster investor confidence.
Core Intervention	Draft and gazette a CBM Emissions-Performance Standard (CEPS) that: (i) caps methane intensity at < 0.2 % of marketed gas, (ii) bans routine flaring after well-clean-up, (iii) mandates quarterly Leak detection and repair (LDAR) using optical gas imaging (OGI) cameras and satellite cross-checks, (iv) requires flare-gas utilization or electricity co-generation plans, and (v) introduces a sliding-scale royalty discount for verifiable over-performance.
Expected 2030 Impact	All CBM wells certify Tier-3 methane data (no impact in the modelling exercise).
Implementation Horizon	Start Q1 2026 Completion Q2 2028
Indicative Budget	30 WD × USD 1 000 = USD 30 000
Lead & Partners	Ministry of Minerals and Energy • BERA

Technical Detail

Detailed Description	The CEPS will define permissible gas-handling practices from drilling to processing. Operators must submit life-of-field flare-elimination plans and install continuous methane monitors (site-level & satellite-validated). Quarterly LDAR surveys employ OGI cameras; findings feed a national methane registry. A royalty-

	rebate schedule (e.g., max 10 % discount) rewards methane intensity below 0.1 %. The standard also specifies green-power co-generation options (micro-turbine, ORC) for flare-gas utilisation. Compliance audits will be conducted by third-party verifiers accredited under OGMP 2.0.		
Key Outputs & Milestones	Draft CEPS circulated for comment	Q3 2026	Draft standard made public
	Biomass atlas completed	Q4 2026	Workshop report; agreed revisions
	Cabinet approval & gazette	Q2 2027	Legal Notice No. ⟨…⟩
	First compliance audit templates released	Q4 2027	Templates online
	Royalty-rebate mechanism activated	Q2 2027	Ministry of Finance (MoF) circular issued
Critical Enablers	• International Oil Companies / producer support • Satellite data access • Global Gas Flaring Reduction Partnership (GGFRP) expertise		
	Risks		**Mitigation Measures**
Risks management analysis	Weak enforcement		Third-party verification
	Cost push-back from junior operators		royalty-rebate offset. royalty-phased compliance for wells drilled pre-2026.
Monitoring & Reporting	• Ministry of Minerals and Energy publishes annual “CBM Emissions Dashboard” (flare volumes, methane intensity) verified by satellite. • Aggregate data forwarded to AFREC for ETSAP tracking.		
Next Immediate Steps	• Secure GGFR advisory support • Engage consultant		

Table 14: Best-Practice Emissions Standards for CBM Development

5. Annex 1 : Detailed model inputs

This Annex is included as an embedded excel file. Please click this icon to access it.



6. Annex 2 : Detailed model results

This Annex is included as an embedded excel file. Please click this icon to access it.



7. LEAP Model





Location

Fairgrounds Office Park in Gaborone. The specific address is Block C, Plot No 50676, Machel Drive, opposite Stanbic Bank.