



BOTSWANA

NATIONAL RENEWABLE ENERGY POWER SECTOR PLAN







FOREWORD

Botswana's energy sector is central to economic development, social progress and long-term resilience. Reliable, affordable and secure energy supports households, businesses, mining, industry, transport and public services. As demand increases, Botswana must ensure that the energy system can support growth while responding to changing technologies, energy security, regional markets and environmental priorities.

The Botswana National Renewable Energy Power Sector Plan provides an evidence-based framework for guiding this transition. It assesses how the country can meet projected demand, expand domestic electricity supply, develop renewable energy resources and reduce exposure to imported electricity and petroleum products. The Plan supports Botswana's wider development objectives, including Vision 2036, the National Energy Policy, the Integrated Resource Plan, the Nationally Determined Contribution and the Botswana Economic Transformation Programme.

Botswana's abundant renewable resources provide an important opportunity to diversify the power mix, strengthen energy security and support mining, industry, transport and household electrification. The Plan also recognizes that renewable generation must be developed together with transmission and distribution networks, battery storage, system flexibility and institutional capacity.

The scenarios presented in the Plan are intended to support informed decision-making rather than prescribe a fixed future. They illustrate the investments, costs and policy measures associated with current commitments and a stronger low-carbon pathway. Successful implementation will require collaboration among government, the private sector, development partners, communities and regional institutions.

I commend all institutions, experts and stakeholders who contributed to this Plan. It provides a strong foundation for developing a secure, affordable, diversified and increasingly sustainable energy system for Botswana.



Hon. Bogolo Joy Kenewendo
Minister of Minerals and Energy
Republic of Botswana

ACKNOWLEDGEMENT

The Botswana National Renewable Energy Power Sector Plan was developed through the collaboration of government institutions, public entities, private-sector stakeholders, development partners and technical experts. The Ministry of Minerals and Energy gratefully acknowledges all organizations and individuals who contributed data, technical input, policy guidance and stakeholder perspectives during its preparation.

The development of the Plan required the review of information across power generation, electricity networks, transport, mining, industry, buildings, household energy use, fuel supply, investment and emissions. This process was essential for ensuring that the national energy system model reflected Botswana's circumstances, existing infrastructure, committed projects and long-term development priorities.

The Ministry acknowledges the contributions of Botswana Power Corporation (BPC), the Botswana Energy Regulatory Authority (BERA), relevant ministries, departments and agencies, and representatives of the mining, industrial, transport and financial sectors. The Ministry also recognizes the valuable input provided by these institutions and representatives during the stakeholder consultation and validation workshops, where the resulting feedback helped refine the modelling assumptions, scenarios and findings presented in the Plan. Special appreciation is extended to Sustainable Energy for All's Energy and Investment Planning team for supporting the development of the model, undertaking the scenario analysis and preparing the Plan.

The Ministry recognizes that long-term planning is subject to uncertainty as economic growth, technology costs, fuel prices and regional market conditions evolve. The value of the Plan therefore lies both in its results and in the analytical framework it provides for future policy review, investment prioritization and institutional coordination.

We thank all contributors for their commitment and cooperation in producing a Plan that will support Botswana's transition towards a reliable, affordable, secure and increasingly diversified energy system.



Donald Gaetsaloe

Permanent Secretary

Ministry of Minerals and Energy,
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EXECUTIVE SUMMARY

Context

Botswana's energy system is entering a period of sustained transformation. Population increases from approximately 2.5 million in 2022 to over 3.5 million by 2050, while the urbanization rate rises from about 67 percent to more than 80 percent. Economic growth, urbanization, expanding mining and industrial activity, and increasing mobility drive higher demand for electricity, modern cooking, transport services and productive energy use. The Botswana National Renewable Energy Power Sector Plan establishes an integrated national framework for meeting this demand while strengthening energy security, developing domestic renewable resources and supporting economic diversification. The Plan links power sector expansion with transport, mining, industry, buildings and clean cooking, recognizing that electrification in these sectors will determine the scale and timing of future generation, network and storage investment. The Plan assesses two pathways. The Current Policy Scenario (CPS) reflects existing assets, committed projects and current national policies. The Renewable Energy and Electrification Scenario (REES) builds on this foundation and applies stronger low-carbon and electrification targets after 2030. Electricity imports and exports remain available in both scenarios where they support system balancing and are economically viable, with domestic demand and reliability requirements met first.

The Plan identifies three closely linked priorities:



Secure investment capital. The transition requires sustained investment in renewable generation, transmission and distribution networks, battery storage and end-use technologies. A predictable project pipeline, transparent procurement, bankable contractual arrangements and targeted public and concessional finance will be essential to mobilize private capital and deliver infrastructure at the required scale.



Enable new growth sectors. Reliable low-carbon electricity can support the expansion of mining, mineral processing, manufacturing and other productive activities. Large electricity consumers can also serve as anchor customers for renewable projects, grid reinforcement, corporate power purchase agreements and mine-site energy systems, creating opportunities for local suppliers, technical services and skilled employment.



Strengthen energy independence. Expanding domestic renewable generation reduces exposure to imported electricity and petroleum products while improving resilience to regional supply constraints and fuel-price volatility. Regional electricity trade remains an important source of flexibility and potential revenue, but domestic system adequacy and reliable supply remain the primary objectives.

The Current Policy Scenario provides the reference pathway. It reflects existing assets, committed projects and current national policies, including the agreed operating lives of Morupule A to December 2029 and Morupule B to December 2046. The results show continued renewable energy growth, declining electricity imports and gradual technological change, while coal, coal-bed methane (CBM) and petroleum products remain important in the energy system.

The Renewable Energy and Electrification Scenario demonstrates the scale of a stronger transition. It builds on CPS and combines accelerated renewable deployment with greater electrification of transport, households, mining and industry. Achieving this pathway requires coordinated action on generation, networks, storage, efficiency, finance, skills and regulation, as set out in the implementation priorities presented in this Plan.

Aims and Objectives

The Botswana National Renewable Energy Power Sector Plan provides an evidence-based framework for long-term energy planning and investment to 2050. It assesses how the national energy system could evolve under alternative policy and trade conditions, while meeting projected demand, supporting economic development and improving the security and sustainability of energy supply. The model extends to 2060 to reduce end-of-horizon effects and illustrate the longer-term trend beyond the Plan period.

The Plan assesses future energy service demand, identifies least-cost generation and infrastructure requirements, evaluates the role of renewable energy and storage, and estimates the capital and operating implications of the two pathways.

The analysis covers power generation, electricity networks, transport, mining, industry, buildings and household cooking. It also examines fuel consumption, electricity trade and energy-related carbon dioxide emissions. The modelling results are not a fixed forecast. They provide a structured basis for sequencing investment, monitoring implementation and updating the pathway as economic conditions, technology costs, project delivery and regional market conditions evolve.

The principal objectives are to assess long-term energy demand, identify least-cost generation and infrastructure requirements, evaluate the role of renewable energy and storage, and estimate the capital and operating costs associated with alternative pathways. The Plan also examines implications for fuel consumption, electricity imports and exports, emissions, transport electrification, clean cooking, and the energy transition in mining and industry.

The modelling results are intended to guide policy and investment decisions rather than provide a fixed forecast. Outcomes will depend on economic growth, technology costs, fuel prices, resource availability, project delivery and future policy choices. The Plan therefore combines quantitative results with policy implications covering procurement, grid development, storage, open access, transport, mining, industry, buildings, finance, skills and institutional coordination.

Together, these findings provide a basis for moving from individual projects and sector targets towards a coordinated national implementation programme. The Plan supports Botswana's objectives of reliable and affordable energy supply, reduced import dependence, economic diversification, regional participation and a gradual transition towards a lower-carbon energy system.

Principal Findings

- 1 Energy security: reduced reliance on imported fuel**

Under the more ambitious pathway (REES), Botswana's oil consumption would be reduced by nearly half by 2050, relative to continuing under current policy. This is expected to result in approximately USD 5.7 billion in fuel and import cost savings over the period, even after accounting for the additional investment required to build new clean energy infrastructure. The pathway would therefore reduce the country's exposure to volatile international fuel prices while delivering measurable cost savings.
- 2 Supporting mining growth and economic diversification**

The plan is designed to support the Government's objective of expanding and diversifying mining activity beyond diamonds, including copper, minerals processing, and related industries. Under the more ambitious pathway, electricity demand from mining would nearly double by 2050 relative to current policy. This is consistent with mining developments already underway, including Khoemacau's planned expansion of copper output to more than double current levels, and the expansion of Morupule Coal Mine's production capacity by approximately 50 percent. The energy plan is structured to accommodate this growth rather than constrain it.
- 3 Investment requirements: power sector and mining**

Achieving the more ambitious pathway would require approximately USD 11 billion in power sector investment (generation, storage, and grid infrastructure) by 2050. Most of the mining-related investment, approximately USD 3 billion, is expected to be financed by mining companies themselves, given the existing commercial incentive to electrify their operations.
- 4 Incremental cost of the more ambitious pathway**

The more ambitious REES pathway would cost approximately 6 percent more overall than continuing under current policy, equivalent to approximately USD 200 million per year on average. This presents a modest additional cost relative to the associated energy security and economic benefits. The increase in cumulative capital and operating costs is partially offset by USD 3 billion in fuel-savings over the same period (2022-2050).
- 5 Expansion of solar power and battery storage**

By 2050, solar power would account for approximately three-quarters of Botswana's total power generation capacity under the more ambitious pathway, a substantial increase from current levels. Battery storage capacity would increase approximately fourfold relative to the current policy pathway, supporting system reliability as solar becomes the dominant source of generation.
- 6 Electrification of transport, mining, industry, and households**

The plan establishes electrification targets for 2050: 70 percent of passenger and bus travel, 80 percent of household energy needs, 75 percent of mining demand, and 50 percent of industrial demand met through electricity or clean fuels. Approximately 400,000 households are expected to adopt electric cooking. Notably, despite significant growth in the economy and population, the transport sector is projected to consume less energy overall than under current practices, owing to efficiency gains from electrification.



Chapter 1

INTRODUCTION

1.1 Context

Botswana's energy sector is entering a period of significant transition. Rising electricity demand, continued economic growth, increasing urbanization and the expansion of mining and other productive sectors are expected to place greater pressure on the national energy system over the coming decades. At the same time, the country has substantial renewable energy resources, particularly solar energy, that can help to meet the growing demand while improving energy security, reducing dependence on imported fuels and electricity, and supporting the broader economic diversification agenda.

Botswana's energy transition is guided by several existing national commitments and planning frameworks. These include the National Energy Policy, the Integrated Resource Plan (IRP), the updated Nationally Determined Contribution (NDC), Vision 2036, the Botswana Economic Transformation Programme (BETP) and the country's Mission 300 commitments. Together, these frameworks aim to expand reliable electricity access, reduce dependence on electricity and petroleum imports, increase renewable energy deployment, improve energy security and support economic diversification. Existing power sector ambitions include achieving a 50 percent renewable share of installed generation capacity by 2030, deploying up to 1,500 MW of solar PV, expanding battery storage and progressively retiring older coal-fired capacity. Botswana's updated NDC also provides the national framework for reducing greenhouse gas emissions and promoting cleaner technologies across the power, transport, buildings and productive sectors.

Building on these existing commitments, the Botswana National Renewable Energy Power Sector Plan provides an integrated framework for assessing how the country's energy system could develop to 2050, with a further modelling outlook to 2060. It identifies the investment, infrastructure and policy measures required to expand domestic electricity supply, integrate higher shares of renewable energy and support the electrification of transport, households, mining and industry. The results presented in the report focus on the period to 2050, while the figures extend to 2060 to illustrate the longer-term direction of the energy system.

The Plan builds on Botswana's existing energy policy and socio-economic development framework, including national energy strategies, renewable energy targets, clean-cooking objectives, transport initiatives and long-term development priorities. It also recognizes the country's participation in the Southern African regional power system (Southern African Power Pool) and the potential role of electricity trade in strengthening system flexibility and energy security.

The Plan considers two national pathways. The Current Policy Scenario reflects existing assets, committed projects and existing measures contained in current national policies and plans. The Renewable Energy and Electrification Scenario builds on CPS and introduces ambitious renewable-energy and sector-electrification targets after 2030. Both pathways retain a focus on reliable and affordable domestic energy supply, while allowing regional electricity trade where it is technically and commercially viable.

The analysis demonstrates that the power transition extends beyond generation capacity. Its implementation is linked to transmission and distribution development, storage, transport electrification, clean cooking, productive-sector growth, finance, skills and institutional capacity. These linkages form the basis of the implementation framework presented in the Plan.

1.2 Background

Botswana's electricity system has historically depended on coal-fired generation, electricity imports and petroleum-based backup generation. While this structure has supported national demand, it has also exposed the country to fuel-price volatility, regional supply constraints and the operational performance of a relatively concentrated generation fleet.

Recent and planned investments – in solar PV, battery energy storage system (BESS) and other domestic generation technologies – provide an opportunity to diversify the power mix. Existing and committed projects are expected to reduce import dependency in the near term, while further renewable energy deployment could support longer-term domestic demand and regional exports.

The need for additional supply is anticipated on the back of projected socio-economic development. Population and GDP growth are key drivers of energy demand to 2050. Urbanization changes the location and structure of household energy consumption. Mining demand is also expected to increase as Botswana pursues diversification and expands non-diamond mining, mineral processing, supplier industries and other mining-linked economic activities. Electricity and process-heat requirements in the sector are therefore projected to grow more rapidly than under previous conservative assumptions.

Botswana's electricity system remains dominated by coal-fired generation. As of March 2025, the country had approximately 892 MW of installed thermal generation capacity, compared with a peak demand of about 678 MW in 2024. The principal generating assets are the 600 MW Morupule B and 132 MW Morupule A coal-fired power stations. Botswana also has 90 MW of diesel capacity at Orapa and 70 MW at Matshelegabedi, which are primarily used for peaking and emergency supply. Grid-connected solar PV remains limited relative to thermal capacity, although several utility-scale solar projects are under development. Coal consequently accounts for approximately 97 percent of domestic electricity generation.

Domestic electricity supply has fluctuated considerably in recent years because of the operational performance of the Morupule power stations. Morupule B's energy-availability factor improved from 36 percent in 2022 to 63 percent in 2023, but this improvement was not sustained. Its annual generation subsequently declined from approximately 3,328 GWh in 2022/2023 to 2,674 GWh in 2024/2025. Statistics Botswana also recorded an 11.2 percent year-on-year drop in domestic generation in the first quarter of 2024, followed by a further 34 percent year-on-year fall in the first quarter of 2025. Botswana therefore continues to use electricity imports from the Southern African Power Pool (SAPP) to cover the shortfall between domestic production and demand. Annual electricity consumption is currently estimated at approximately 4,800 GWh, with peak demand approaching 700 MW.

Electricity demand is concentrated in the productive sectors and in urban load centres. Mining and other large industrial customers represent a major share of electricity sales because of the electricity required for extraction, crushing, grinding, pumping, ventilation and mineral processing. Commercial and public-service buildings form another important demand group, followed by households. Electricity use in transport and cooking is currently limited, but these sectors could become important sources of additional demand as electric vehicles and electric cooking technologies are adopted. The sectoral demand distribution used in this study is presented in the model calibration section, based on the latest available BPC and national energy-balance data.

1.3 Scope and Objectives

The purpose of the Botswana National Renewable Energy and Power System Plan is to provide an evidence-based framework for long-term energy planning and investment. The Plan evaluates how Botswana can meet growing energy demand while increasing renewable energy deployment, strengthening energy security and supporting economic development.

The specific objectives of the Plan are to:

- Assess long-term energy demand across the power, transport, mining, industry and buildings sectors
- Evaluate the role of renewable energy, storage, coal, gas, imports and regional electricity trade
- Identify the generation, network and storage capacity required under alternative pathways
- Assess the implications of electrification for transport, household cooking, mining and industry
- Estimate the investment and operating costs associated with the transition
- Examine the effects of alternative pathways on fuel use, import dependency and emissions
- Identify the policies, regulations, institutions and financing mechanisms required for implementation

The Plan focuses on national policy milestones to 2050 and uses a long-term energy system model extending to 2060 to reduce end-of-horizon effects and illustrate the longer-term direction of the system. The results are intended to support policy and investment decisions rather than provide a fixed forecast. Chapter 6 translates the REES results into a national implementation framework covering renewable energy procurement, grid and storage development, open access, transport electrification, mining and industrial energy transition, clean cooking, energy efficiency, finance, skills and monitoring.





Chapter 2

METHODOLOGY

2.1 Modelling Framework

2.1.1 Modelling tool

The study utilizes the Sustainable Energy for All Energy Systems Model (SEM), a least-cost energy system expansion model that encompasses all sectors of the economy. Based on the Open-Source Energy Modelling System (OSeMOSYS) framework [1], which has been widely applied in national, regional and global energy planning studies [2], the SEM identifies the optimal combination of energy technologies and infrastructure investments that minimize total system costs while satisfying projected energy service demands and system constraints. The model can be used to evaluate alternative development pathways and policy scenarios, including increased renewable energy deployment and the achievement of Nationally Determined Contribution targets, while ensuring that future energy needs are met in line with the country's socio-economic development trajectory.

The development of a country-specific SEM model follows a structured process to ensure it accurately represents the national energy system and provides a robust basis for scenario analysis. The main steps include:

1. Collecting and mapping emissions using the national greenhouse gas (GHG) inventory
2. Collecting the national energy balance table from official or other credible sources
3. Developing representative model time slices
4. Defining the energy system structure by identifying sectors, subsectors and technology options
5. Calibrating the model to reproduce the base-year energy system
6. Setting up the model within the input file interface
7. Running the model for each scenario
8. Undertaking post-processing and further analysis of the results

The following sections describe each step of the model development process in more detail.

2.1.2 Model development

The Botswana SEM is a national, bottom-up, technology-rich energy system model developed to represent the country's entire energy system. The model adopts a reference energy system (RES) approach, capturing the complete energy supply chain from primary energy resources through conversion, transmission and distribution to final energy demand. It includes technologies across power, hydrogen, liquid fuel production, transport, industry and buildings sectors. Both existing and future technology options are represented, enabling the assessment of least-cost pathways for decarbonization and long-term energy system development. A complete list of technologies and the RES diagram are provided in Appendix A.

Existing assets and current and committed generation projects are represented in the model on the basis of the information available at the close of data validation. Projects identified in the Integrated Resource Plan and other official planning documents are treated as proceeding according to the stated schedule unless they have been explicitly cancelled, withdrawn or superseded.

Where plant-specific technical data were unavailable, common technology parameters were applied consistently across comparable units. Existing coal plants are represented using installed capacity as the capacity basis, together with the availability, minimum operating and lifetime assumptions set out in Appendix B. This treatment provides a consistent national planning representation and can be refined in future updates when disaggregated operating data become available.

Natural gas technologies in the model represent the potential development of Botswana's coal-bed methane resource. Their selection is conditional on resource confirmation, commercial supply, enabling infrastructure and project delivery. The results therefore indicate the role that dispatchable CBM-based generation could play under the stated assumptions rather than a predetermined investment commitment.

The emissions accounting within the SEM covers energy-related direct emissions (Scope 1) from the sectors represented in the model, including power generation, transport, industry and buildings. The model does not include emissions or removals from land use, land-use change and forestry (LULUCF) sectors, as these fall outside the scope of the energy system analysis.

The model has a national spatial resolution, representing Botswana as a single geographic region. Cross-border electricity and fuel imports and exports are represented through dedicated import and export technologies, allowing the model to capture international energy trade while not explicitly representing sub-national transmission networks or regional variations within the country.

The modelling period extends from 2020 to 2060, with the analysis presented in this report focusing primarily on results to 2050, in line with national climate policy timeframes. Extending the modelling horizon beyond the main analysis period reduces end-of-horizon effects, whereby the optimization may underinvest in long-lived technologies approaching the end of the study period. By modelling for an additional decade, investment decisions made up to 2050 better reflect the full operational lifetime of infrastructure assets.

To capture seasonal and short-term variations in electricity demand and renewable energy availability while maintaining a computationally tractable model, each year is represented by 30 time slices. The year is divided into two seasons (a wet season and a dry season), with each season represented by two representative day types: a low-wind day and a high-wind day. In addition, a worst-case day, representing periods of high electricity demand and/or low renewable energy availability, is modelled separately and is not assigned to either season. Each representative day is divided into six four-hour time blocks, resulting in a total of 30 time slices ((2 seasons × 2 day types × 6-time blocks) + (1 worst-case day × 6 time blocks)). This temporal structure allows the model to capture seasonal demand patterns and renewable resource variability while maintaining a balance between temporal resolution and computational efficiency.

2.1.3 Model calibration and validation

Model calibration aligns the base-year representation with national energy statistics, electricity data, asset information and available sector datasets. Where plant-specific operating data are unavailable, common technology parameters are applied consistently across comparable units. Existing coal plants are represented using installed capacity as the capacity basis together with the availability, minimum-operating and lifetime assumptions in Appendix B. This treatment can be refined in future updates when disaggregated dependable-capacity and performance data become available.

The modelling framework and data requirements were reviewed through two stakeholder consultations:

1. The first consultation, in September 2025, confirmed the model structure, time-slice approach, scenario framework and data-request process. Stakeholders agreed that demand projections would be refined using updated national and sectoral information.
2. The second consultation, in April 2026, reviewed BAU and CPS results for the power, transport and buildings sectors with representatives from government institutions, BPC, BERA, Statistics Botswana, the mining and transport sectors, research institutions and the private sector. Feedback was incorporated into the final modelling approach, the final scenario design was agreed, and the validated input dataset was subsequently frozen for the final model runs.

2.2 Scenarios

To assess Botswana's potential energy transition pathways, two independent scenarios were developed based on differing policy and development assumptions: the Current Policy Scenario (CPS) and the Renewable Energy and Electrification Scenario (REES) (Table 1). Each scenario is evaluated under two variants: Domestic, in which the model meets Botswana's domestic energy demand only, and Export, in which additional generation capacity can be deployed to satisfy both domestic demand and regional electricity export opportunities.

The CPS implements existing plans, committed projects and officially announced measures, including measures from the National Energy Policy [4], Integrated Resource Plan (IRP) [5], NDC 2.0 [6], Mission 300 Compact [7], Vision 2036 [8] and the Botswana Economic Transformation Programme [9], with capacity expansion focused on meeting Botswana's domestic electricity requirements. It includes the existing and committed power fleet, a 50 percent renewable share of installed capacity by 2030, 600 to 1,500 MW of solar PV, 100 MW of wind, 100 MW of CBM and biogas, and 140 MW of BESS. Morupule A is assumed to remain available until December 2029 and Morupule B until December 2046. The scenario also includes the committed 600 MW Mmamabula coal IPP, the national clean-cooking objective and moderate uptake of electric vehicles, hybrids, biofuels and public transport. No additional long-term decarbonization constraint is imposed. Electricity imports and exports remain available where economically justified, but no additional export-driven capacity expansion is assumed. This scenario provides a reference pathway for assessing the evolution of the energy system under existing policy commitments. The CPS Export scenario retains the same policy assumptions as CPS Domestic but enables additional regional electricity export opportunities. The model is permitted to invest in additional generation and storage capacity where exports are economically attractive, allowing an assessment of how Botswana's current policy framework performs under increased regional electricity trade.

The REES builds on CPS and applies stronger renewable energy and electrification targets after 2030. By 2050, it targets 70 percent low-carbon installed power capacity, 70 percent electrification of passenger-km and bus-km, a minimum of 70 percent of freight-km supplied through electricity and clean fuels, 80 percent of household final energy supplied through electricity and clean fuels, 75 percent of mining demand supplied by electricity, and 50 percent electrification of industrial demand. No new unabated coal capacity is introduced beyond committed projects, while solar, storage and other low-carbon technologies expand more rapidly. Capacity expansion also remains primarily driven by domestic demand and system reliability. The REES Export scenario combines the REES Domestic scenario assumptions with increased regional electricity export opportunities. The model invests in additional renewable generation, BESS (four-hour storage capacity) and supporting firm capacity to satisfy both domestic demand and export requirements. This scenario evaluates whether Botswana can simultaneously achieve a domestic renewable transition while becoming a regional exporter of low-carbon electricity.

It is important to note that REES is not directly comparable with the CPS scenarios, as increased electrification results in substantially higher electricity demand. Consequently, differences in generation and capacity requirements reflect both the low-carbon transition and the greater demand, rather than changes in the supply mix alone. Capacity expansion is therefore driven by the need to meet higher domestic electricity demand while maintaining system reliability. Therefore, the results of the scenarios are presented in separate chapters (3 and 4) rather than side by side.

TABLE 1

The two scenarios framing Botswana's power sector future

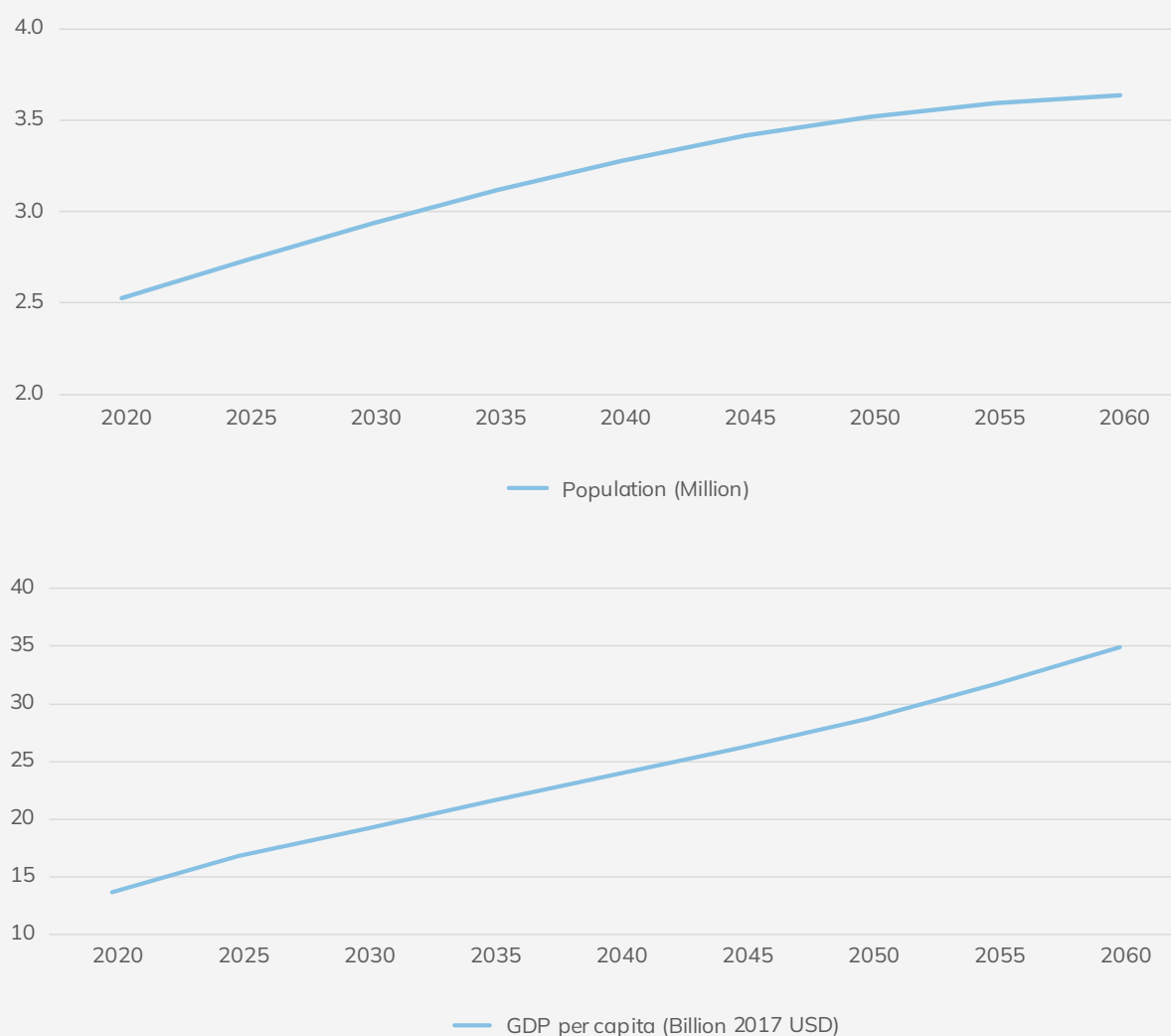
CPS – CURRENT POLICY SCENARIO Implements existing plans and policies	REES – RENEWABLE ENERGY AND ELECTRIFICATION SCENARIO Goes beyond current policy to accelerate decarbonization
WHAT IT ASSUMES • All existing power generation, transport fleet and industrial consumption assets and committed power projects • 50% RE capacity share by 2030; up to 1,500 MW solar PV • Morupule A retires 2029; Morupule B retires 2046; 300 MW coal IPP Phase 1 (see Table 11 for a list of current power plants) • Current coal power plants retained in the mix; 10% per decade EV and biofuel uptake	WHAT IT ADDS AFTER 2030 • 70% low-carbon electricity generation capacity by 2050 • No new unabated coal beyond committed projects • 70% of passenger-km and bus-km electrified by 2050 • 80% of household energy from electricity and clean fuels • 75% of mining and 50% of industry energy use electrified by 2050
BY 2030 • 50% renewables capacity share, subject to system and export requirements • 90% clean-cooking access	BY 2050 • 70% low-carbon generation capacity • 70% of passenger-km (both public and private) with renewable energy by 2050 • Minimum of 70% freight-km using electricity and clean fuels • 80% of household energy from electricity and clean fuels • 75% of mining-energy demand electrified • 50% of industrial demand electrified

Note: The increase in installed capacity and generation between the scenarios is a result of increased electrification driving higher electricity demand in REES compared to CPS.

2.3 Demand Assumptions

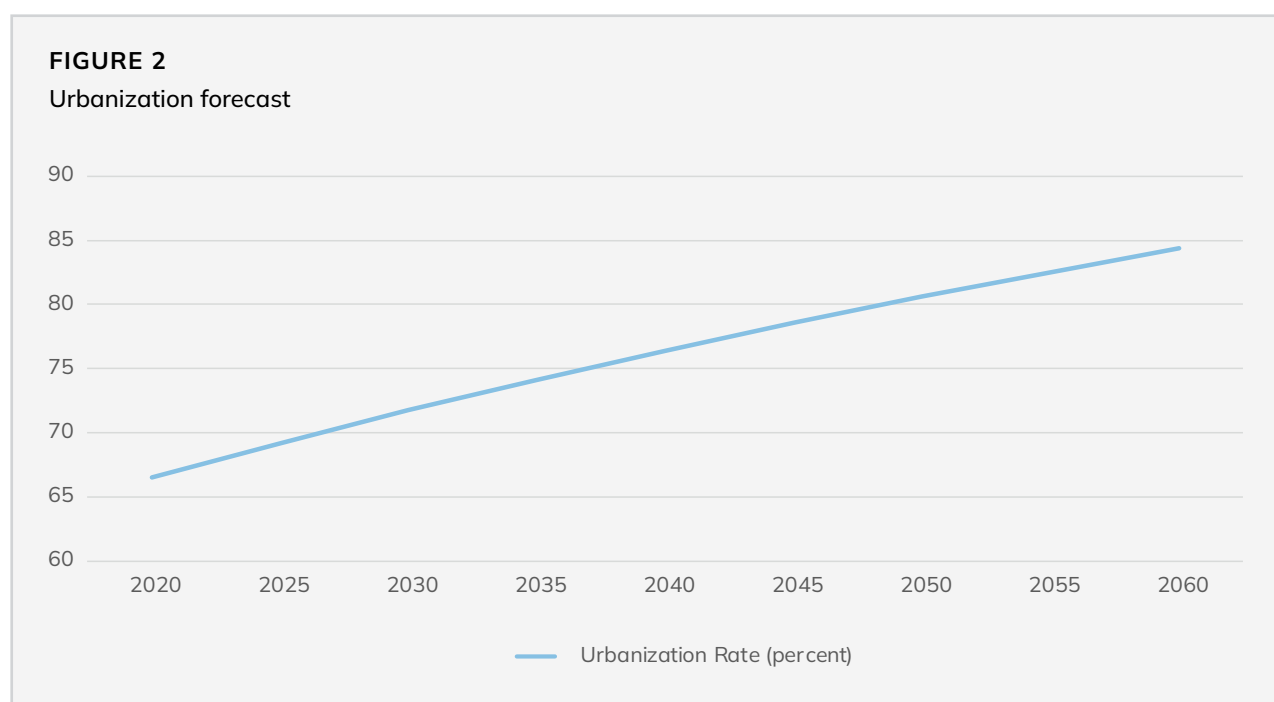
The SEM requires projections of future energy service demand as key inputs to determine the least-cost evolution of the energy system. These demand projections are estimated using a polynomial regression driven by exogenous socio-economic assumptions, with population and gross domestic product (GDP) projections to 2060 based on the Shared Socioeconomic Pathway 2 (SSP2) dataset developed by the International Institute for Applied Systems Analysis (IIASA) [10] (Figure 1). SSP2 was selected as it represents a “middle-of-the-road” future, assuming moderate population and economic growth without strong shifts towards either highly sustainable development (SSP1) or fossil-fuel-intensive development (SSP5). As a neutral baseline, SSP2 is widely used in long-term energy system modelling and provides a credible reference for projecting Botswana’s future energy service demands.

FIGURE 1
GDP and population forecast



Population increases from approximately 2.5 million in 2022 to 3.52 million by 2050. GDP in purchasing power parity (PPP) terms increases almost fourfold, while urbanization rises from approximately 67 percent to 80.6 percent. These drivers shape electricity demand, mobility, household formation, cooking patterns and productive-sector activity.

The urbanization rate is projected using the IIASA SSP2 dataset [10] and is a key driver of future energy demand, particularly in the buildings and transport sectors (Figure 2). The population, GDP growth and urbanization rates are all calibrated and benchmarked against recorded data from Statistics Botswana [3].

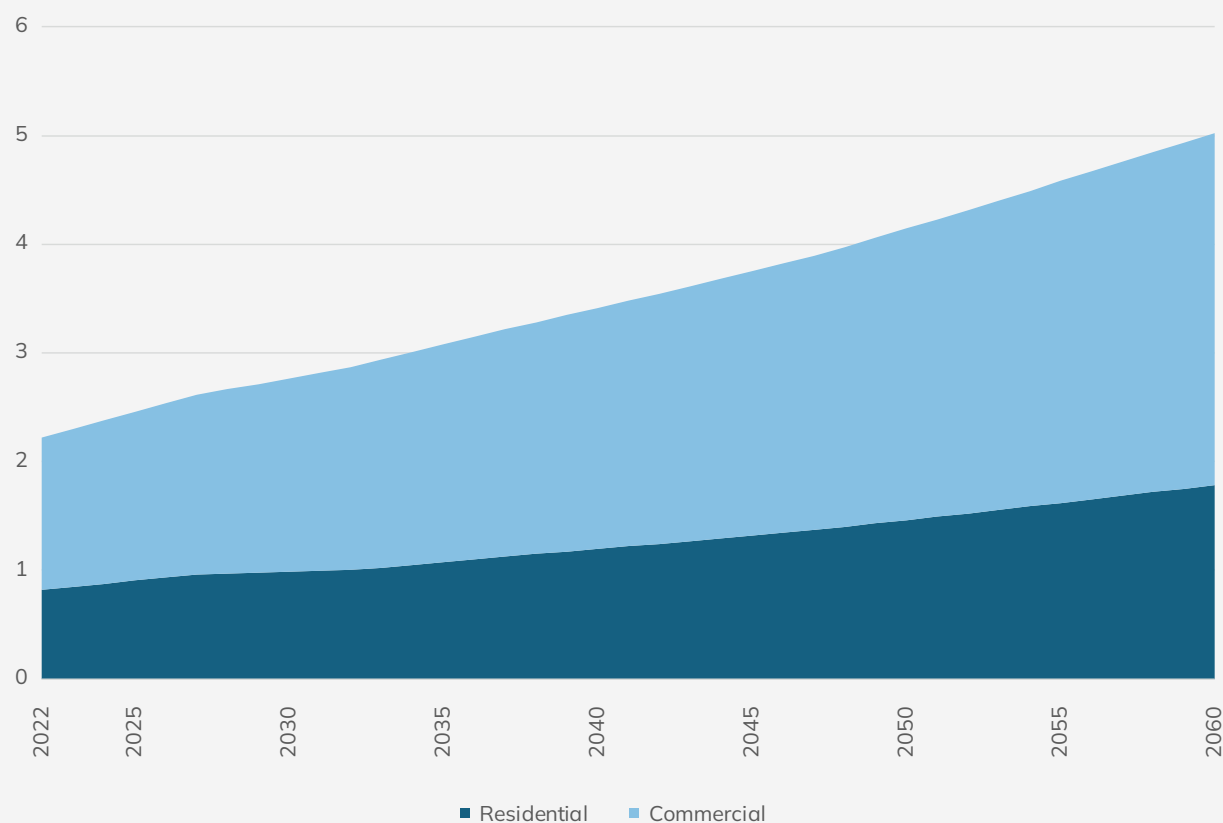


2.3.1 Electricity demand

Electricity demand from the residential and commercial sectors is included and is assumed to grow at an average annual rate of 2.3 percent from 2022 to 2060 (Figure 3). Commercial electricity demand increases from approximately 1.5 TWh to nearly 3 TWh, while residential electricity demand rises from 1 TWh to 1.5 TWh in the same period. These trajectories reflect population, urbanization and GDP-per-capita growth and form the common underlying demand outlook before scenario-specific electrification measures are applied.

FIGURE 3

Residential and commercial electricity demand (TWh)

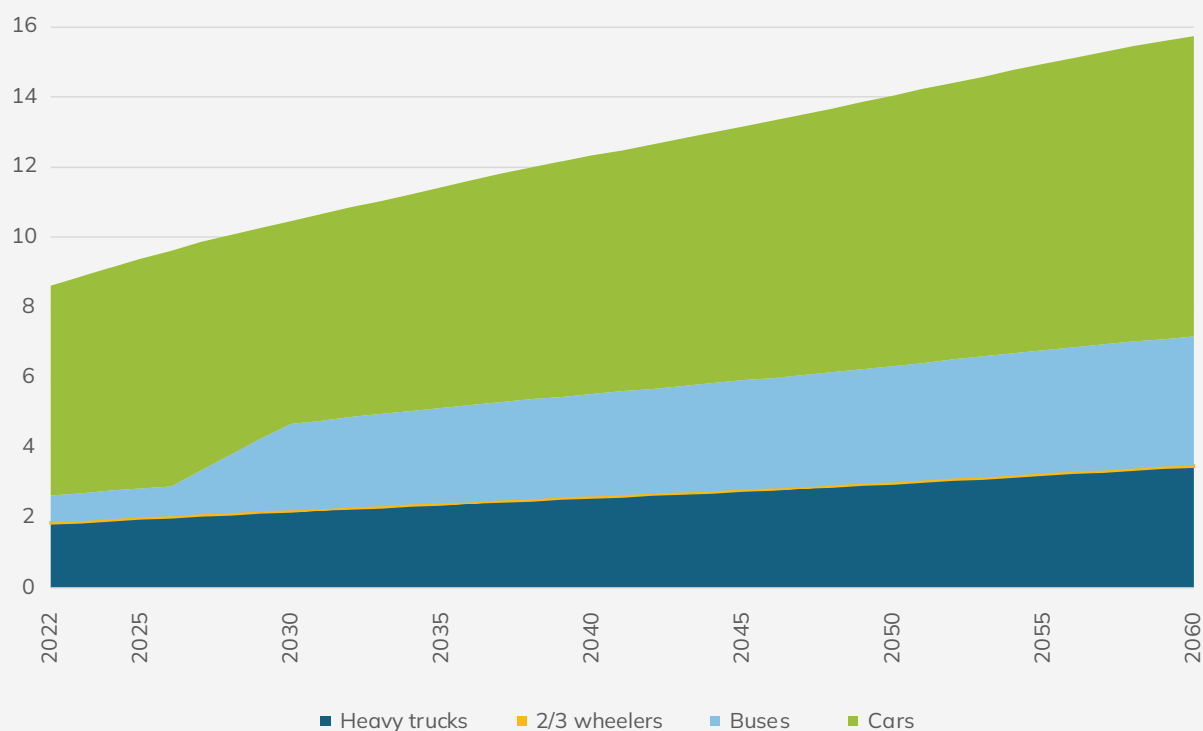


2.3.2 Transport demand

Transport demand for trucks, 2/3 wheelers, buses and passenger cars is assumed to grow at an average annual rate of 1.6 percent from 2022 to 2060 (Figure 4). Under this assumption, transport activity reaches approximately 3.0 billion vehicle-km for trucks, 0.03 billion vehicle-km for 2/3 wheelers, 7.7 billion vehicle-km for passenger cars and 3.3 billion vehicle-km for buses by 2050. Passenger cars remain the largest road-transport mode, while bus activity records the strongest proportional growth. The bus trajectory incorporates the policy objective of increasing the public transport modal share. Freight activity increases with GDP, trade and mining-led development, while motive mining demand rises with mining output.

FIGURE 4

Transport activity demand (billion vehicle-km)

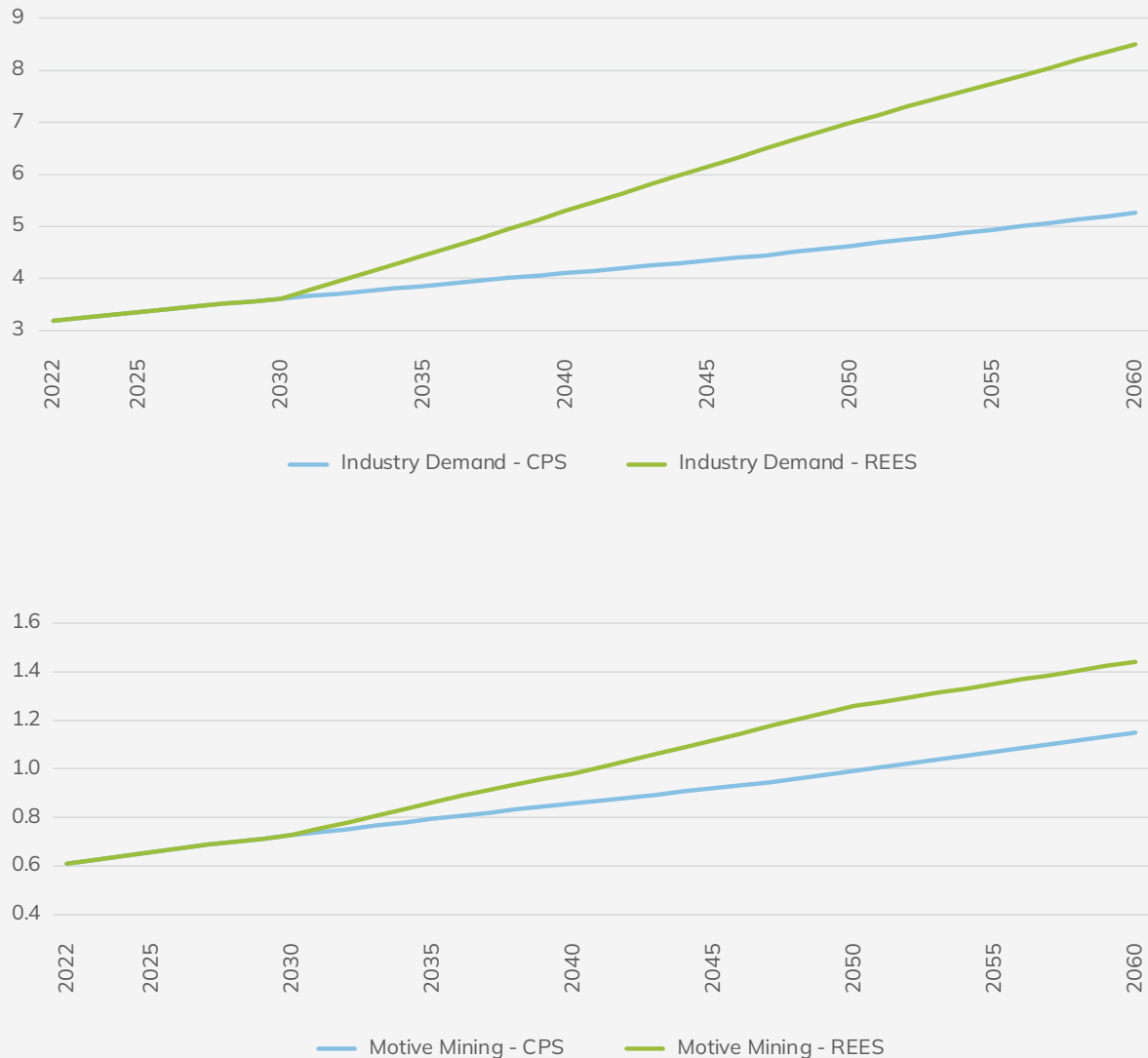


2.3.3 Industry and mining demand

Industrial energy demand is assumed to grow at an average annual rate of 1.3 percent from 2022 to 2060, reaching approximately 4.6PJ by 2050 (Figure 5). Motive energy demand in the mining sector is assumed to increase at an average annual rate of 1.7 percent, reaching approximately 1.0 billion vehicle-km by 2050. CPS mining-process demand rises gradually with economic activity.

FIGURE 5

Industry (PJ) and motive mining (billion vehicle-km) demand

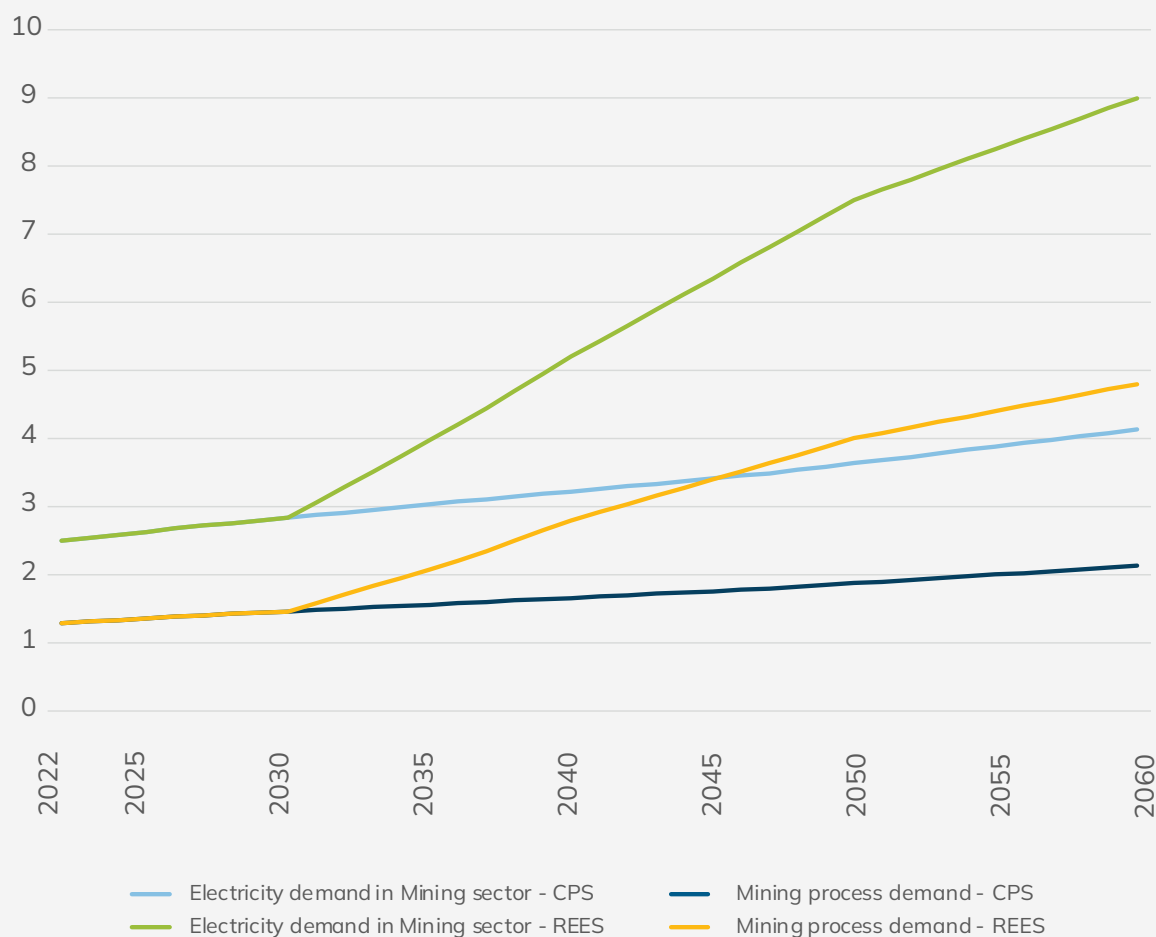


REES assumes stronger expansion of non-diamond mining, mineral processing, supplier clusters and domestic value addition. By 2050, mining electricity demand reaches approximately 7.5 PJ under REES nearly double the CPS level. Mining-process demand reaches approximately 4 PJ under REES, compared with around 2 PJ under CPS (Figure 6).

Mining demand is represented in both scenarios, but the REES assumes faster growth in mining-related activity than the CPS to reflect a structural shift towards non-diamond mining, expanded supplier clusters, greater domestic value addition, mineral processing and mine support services (Figure 6). Steam and process heat demand also grows more rapidly under the REES, reflecting increased mining-linked manufacturing, including the local production of mining inputs, chemicals and downstream mineral processing.

FIGURE 6

Mining demand forecast (PJ)

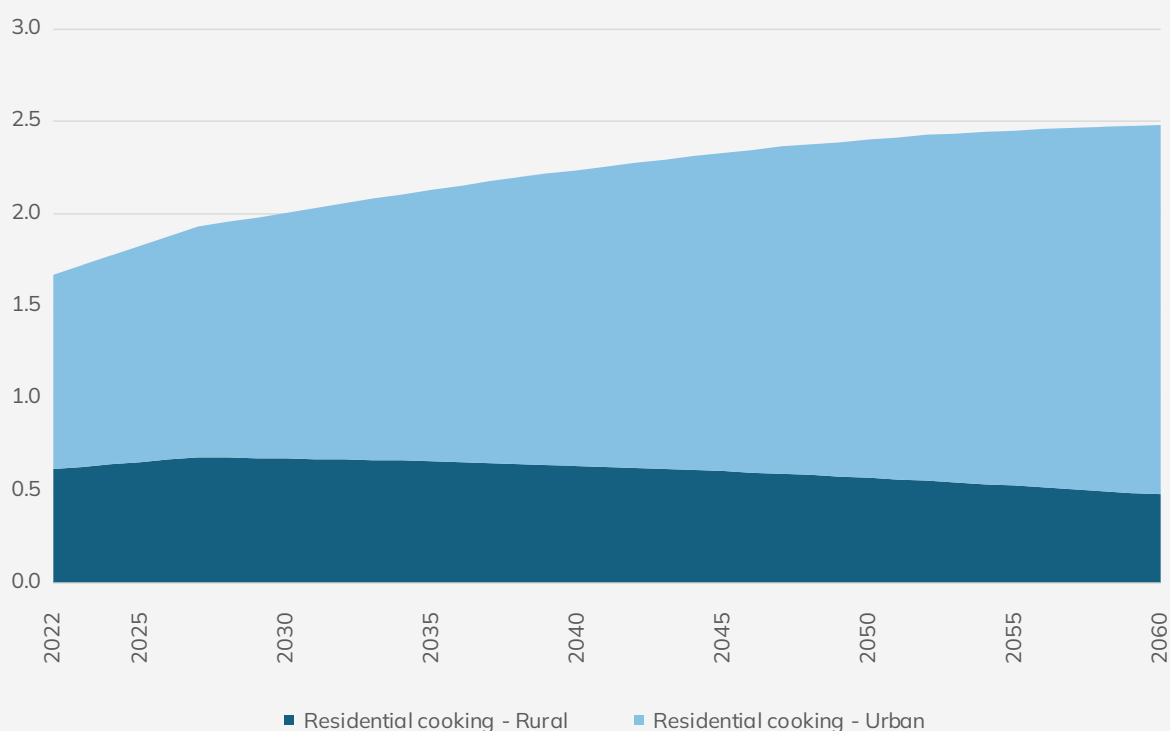


2.3.4 Cooking demand

Cooking energy demand is assumed to grow at an average annual rate of 1.0 percent between 2022 and 2060 (Figure 7). By 2050, rural cooking demand reaches approximately 0.6 PJ, while urban cooking demand is higher at around 1.8 PJ. Although total cooking demand increases over time, rural cooking demand gradually stagnates as a result of urbanization, while urban cooking demand continues to increase with the growing urban population.

FIGURE 7

Urban and rural cooking demand (PJ)



2.4 Cost Assumptions

As the SEM is a least-cost optimization model, cost assumptions play a critical role in determining technology investment and operational decisions. Table 2 and Table 3 summarize the capital, fixed operation and maintenance (O&M) and fuel costs for the technologies and fuels represented in the model. Overall, capital and fixed costs stay flat for coal but decline for solar, wind and storage, shifting the relative economics of generation over time. The remaining technical assumptions, including technology performance parameters and operational characteristics, are provided in Appendix B.

TABLE 2

Capital cost and fixed O&M cost assumptions (USD millions/GW 2020)

	Capital cost				Fixed cost			
	2020	2030	2050	2060	2020	2030	2050	2060
Coal – subcritical	1,300	1,300	1,300	1,300	45	45	45	45
Coal – ultra-supercritical	1,850	1,850	1,850	1,850	70	70	70	70
Coal – supercritical	1,600	1,600	1,600	1,600	55	55	55	55
Coal – with CCS	4,500	4,500	4,500	4,500	175	173	169	167
Hydrogen	900	860	780	740	13.5	12.9	11.7	11.1
Large hydropower	1,790	1,750	1,712.5	1,712.5	37.7	36	34.25	34.25
Natural gas combined cycle	700	700	700	700	25	25	25	25
Natural gas combined cycle with CCS	2,450	2,450	2,450	2,450	85	85	85	85
Nuclear	4,150	4,150	4,150	4,150	170	170	170	170
Nuclear with small modular reactor (SMR)	6,115	6,115	6,115	6,115	170	170	170	170
Oil	700	690	670	670	9	8.75	8.45	8.45
Geothermal	4,000	3,440	3,140	3,140	50	43	39.3	39.3
Biomass	1,800	1,600	1,400	1,400	49.5	45.5	39.6	39.6
Utility-scale solar PV	1,040.4	924.5	636	636	16	16	16	16
Onshore wind	2,383	2,285	2,171	2,171	36	36	36	36

TABLE 3

Fuel cost assumptions (USD millions/PJ)

	2020		2020
Coal (high calorific value)	3.80	Coal imports	10.25
Crude oil	6.89	Natural gas imports via pipeline	12.78
Natural gas	5.17	LNG imports via terminal	13.80
Uranium	0.81	Crude oil imports	8.61
Biomass	10.00	Uranium imports	1.01
Traditional biomass	1.00	Kerosene imports	10.34
Electricity imports	30.56	Oil imports	9.85
Electricity exports	-27.50		

Transmission and distribution investment is linked to electricity-demand growth, new generation capacity and the expansion of system connections. The cost representation is applied consistently across both scenarios and captures aggregate national network requirements rather than a project-level transmission plan.

Electricity trade prices are based on the available World Bank and UN Comtrade electricity-trade data. In the absence of long-term power purchase agreement (PPA) data and an agreed forward price series, a constant real trade price is applied throughout the modelling period. Import and export results, including the annex sensitivity, should consequently be interpreted as scenario outputs under the assumed price rather than as contracted trade volumes or revenues.

Battery storage is represented in both power and energy terms. Capacity results are reported in GW, with a four-hour duration used to determine the corresponding GWh rating. Charging demand, round-trip losses, state-of-charge constraints and asset lifetimes are included in the energy balance and investment calculation.

2.5 Model Limitations

The results are national least-cost planning outputs and should be interpreted together with the model's spatial and operational limitations. Botswana is represented as a single national node. The model therefore does not resolve individual transmission corridors, distribution constraints, unit commitment, sub-hourly reserves, stability requirements or detailed contingency conditions. The generation and storage pathways provide a basis for subsequent power-system adequacy, dispatch, grid-integration and network-development studies.

Plant-level operating data were not available for every existing coal unit. Comparable coal units are therefore represented using common technical parameters and installed capacity as the capacity basis. The treatment can be refined in future planning cycles using dependable capacity, unit-specific heat rates, outage histories and energy-availability factors.

The model represents CBM-based gas generation as a potential source of dispatchable flexibility. Its deployment depends on proven resource availability, commercial supply, infrastructure and implementation timing. Similarly, regional electricity exports depend on market demand, interconnector capability, wheeling arrangements, PPAs and settlement conditions that are not modelled as a detailed regional market forecast.

The set of flexibility options is limited relative to a full operational power-system model. This may increase the amount of BESS selected for balancing and solar shifting. Hydrogen technologies are available in the model but are not selected under the assumptions applied, reflecting the relative economics of direct electrification, solar PV, storage and available transitional fuels.

The emissions analysis covers direct energy-related CO₂ emissions from the sectors represented in the model. It does not include other greenhouse gases or emissions and removals from land use, land-use change and forestry. The results are therefore not directly comparable with Botswana's economy-wide NDC inventory without appropriate boundary adjustments.

2.6 Report Structure

As REES is not directly comparable to CPS owing to their different underlying demand assumptions (see Chapter 2.2, Scenarios), the results are presented separately. The CPS results are presented first, followed by the REES results. Each scenario chapter begins with a whole-system overview, including primary energy supply, final energy consumption, and CO₂ emissions, to provide a broad picture of the energy transition. This is followed by a detailed assessment of the power sector, covering electricity generation, installed capacity, BESS and electricity trade. For both the CPS and REES, results are presented for the Domestic and Export variants to support the development of Botswana's National Renewable Energy Power Sector Plan.

The analysis also considers the transport, mining, industry and residential cooking sectors, as developments in these sectors directly influence future electricity demand. For example, greater uptake of electric vehicles, electric cooking and the electrification of industrial and mining processes increases electricity demand, requiring additional generation, storage and network infrastructure. Results are discussed up to 2050, while figures extend to 2060 to illustrate longer-term system trends beyond the primary analysis period.

The report concludes with an assessment of investment requirements under each scenario, followed by an evaluation of financing strategies and sources of capital to support implementation. The final chapter presents policy implications and the path forward to achieve REES.



Chapter 3

CURRENT POLICY SCENARIO

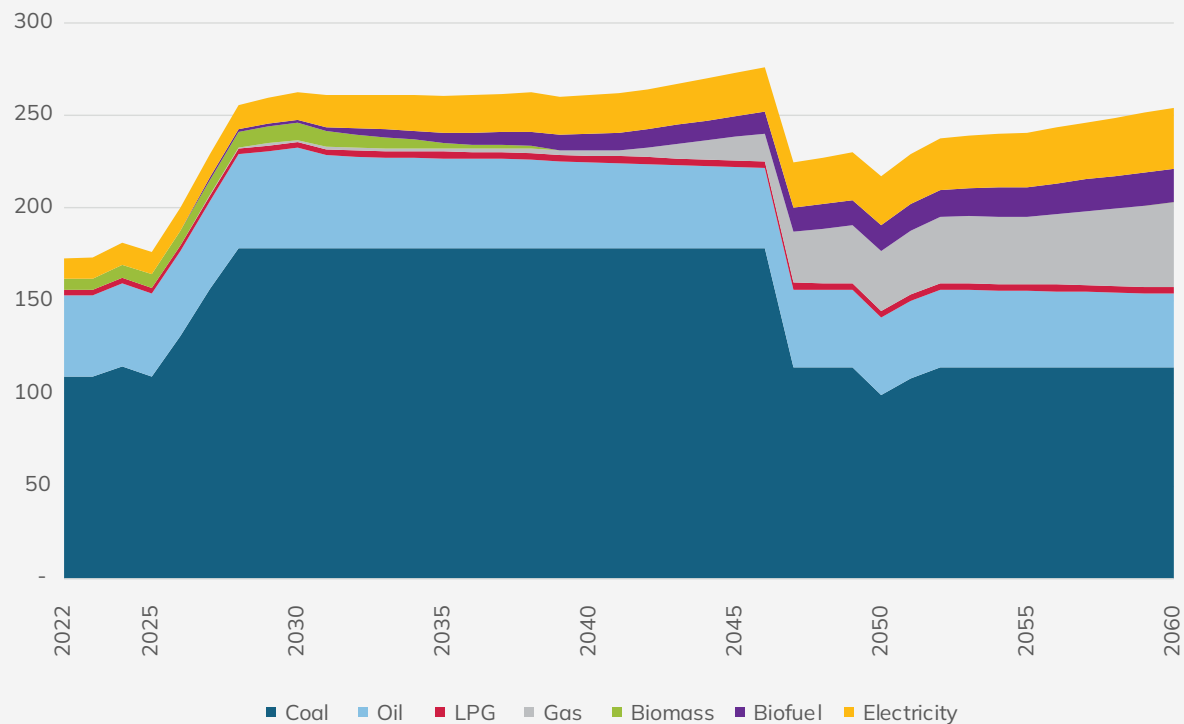
3.1 Overview

Under CPS, total fuel consumption reaches approximately 217 PJ by 2050. (Figure 8) Coal remains the largest primary fuel at 99.0 PJ or over 45% of total, followed by oil at 42 PJ and coal-bed methane at about 32.5 PJ. Electricity use reaches 26.4 PJ, biofuel use reaches 13.9 PJ and LPG reaches 3.6 PJ. The result reflects gradual electrification under current policy while coal and petroleum products retain significant roles. Coal's large share of primary fuel use partly reflects the conversion losses associated with thermal generation and should not be compared directly with final electricity consumption. The coal-bed methane result represents a modelled flexibility option and remains subject to resource confirmation and commercial development. Overall, CPS diversifies the system relative to the base year but does not deliver the same reduction in oil use or the same level of end-use electrification as REES.

The changes in the fuel trajectory reflect the commissioning and retirement schedule of major power plants. Morupule A remains available until December 2029 and Morupule B until December 2046. The marked reduction after 2046 reflects the retirement of Morupule B and its replacement by solar PV, coal-bed methane generation, storage and other energy carriers. Because the model represents existing coal plants on an installed-capacity basis with common technology parameters, the timing and operational implications should be refined through plant-specific adequacy and condition assessments. The central retirement dates reflect the planning information confirmed by BPC Generation. An earlier-retirement sensitivity, in which Morupule A retires in 2027 and Morupule B in 2030, indicates that the timing of coal retirement materially affects cumulative costs and emissions. Under the model assumptions, the earlier case lowers cumulative system costs by approximately USD 1.7 billion and avoids about 23.8 Mt CO₂ through 2060. This sensitivity does not replace the central dates and would require confirmed replacement capacity, network readiness and a managed transition plan.

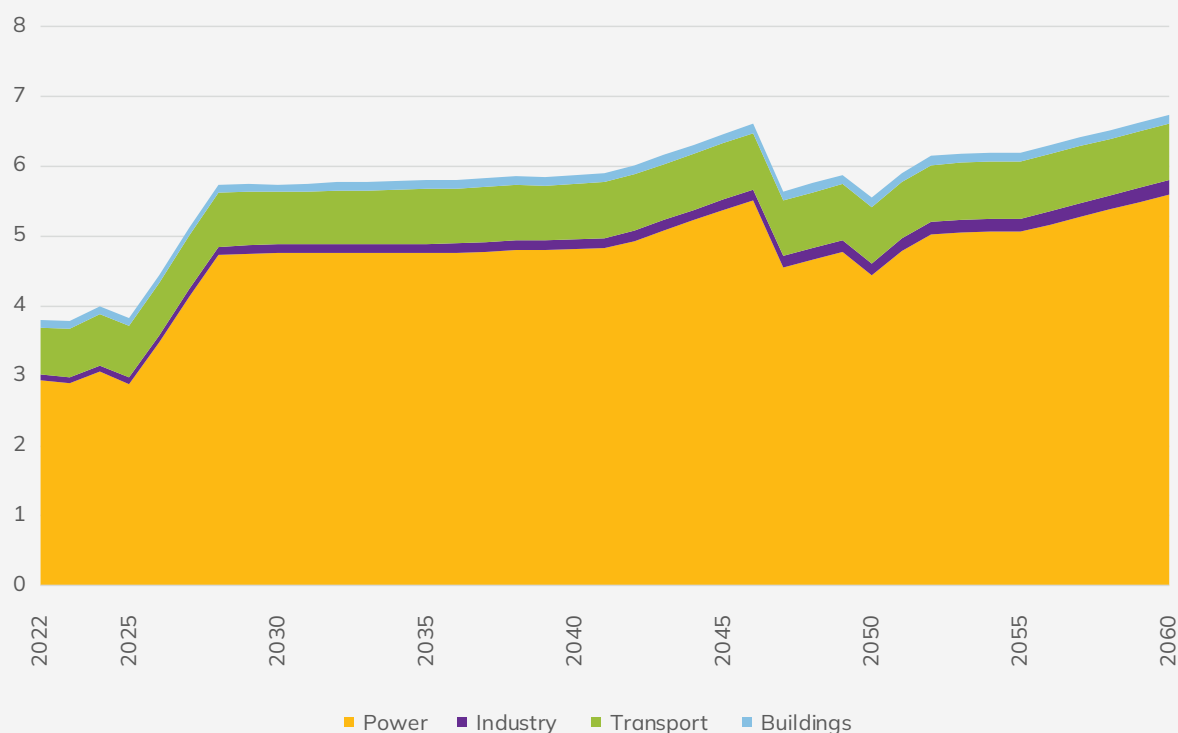
FIGURE 8

Total fuel consumption for CPS (PJ)



Botswana's NDC provides the national reference pathway for economy-wide GHG emissions, projecting total emissions of approximately 22.7 Mt CO₂e in 2030, with mitigation measures reducing emissions by approximately 4.1 Mt CO₂e [6]. The SEM emissions presented below represent only energy-related CO₂ emissions from the sectors included within the model (power, industry, transport and buildings) and therefore are not directly comparable with the economy-wide NDC inventory, which includes additional GHGs and sectors such as LULUCF.

As shown in Figure 9, energy-related CO₂ emissions reach approximately 5.55 Mt CO₂ in 2050 under CPS, compared with approximately 3.8 Mt CO₂ in 2022. The power sector remains the largest source, contributing approximately 4.44 Mt CO₂ in 2050, followed by transport at approximately 0.81 Mt CO₂, industry at 0.17 Mt CO₂ and buildings at 0.13 Mt CO₂. Emissions increase as electricity and productive-sector demand grow while coal and coal-bed methane remain in the generation mix. The SEM results cover direct energy-related CO₂ emissions only and are therefore not directly comparable with Botswana's economy-wide NDC inventory.

FIGURE 9Total energy-related CO₂ emissions for CPS (Mt CO₂)

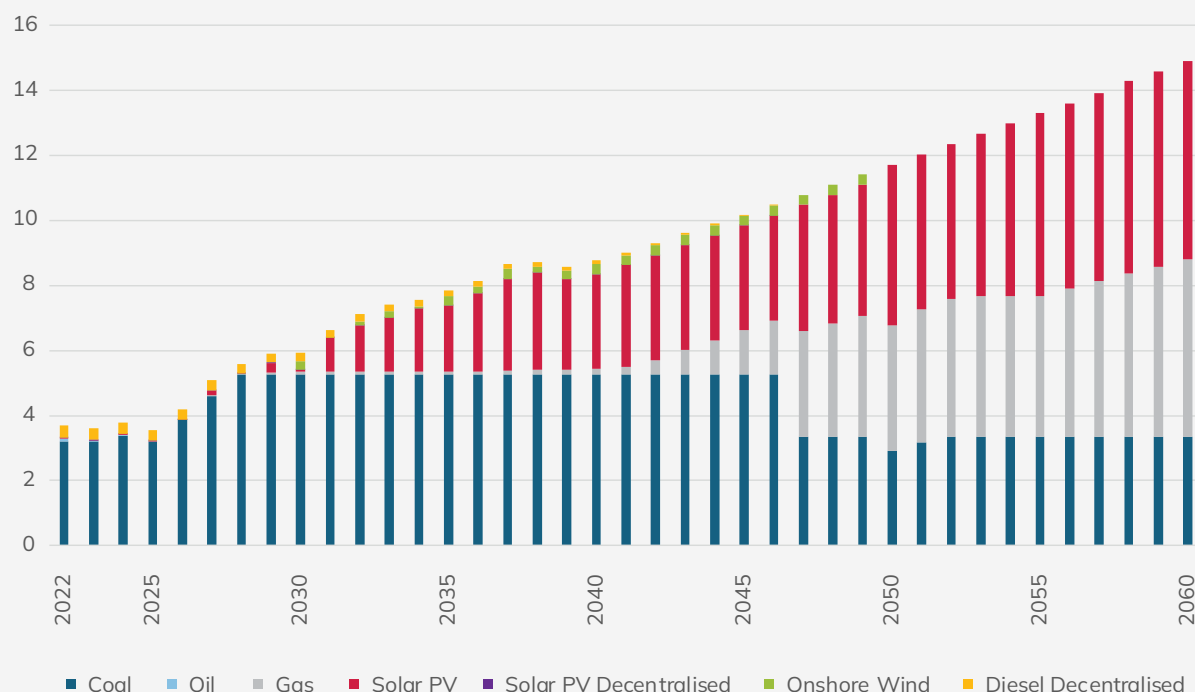
3.2 Power Sector

Electricity generation reaches approximately 11.72 TWh by 2050 under CPS (Figure 10). Solar PV becomes the largest generation source at about 4.96 TWh, followed by coal-bed methane at around 3.85 TWh and coal at approximately 2.92 TWh. The generation mix reflects current policies, committed projects and least-cost expansion while maintaining domestic supply and allowing economically viable regional trade. Coal-bed methane provides dispatchable flexibility but remains conditional on resource confirmation, commercial fuel supply and project delivery. The solar contribution grows steadily as costs fall and additional capacity is built. Firm thermal generation remains important under CPS because the model must meet demand and reserve requirements across the representative time slices.

The generation trajectory reflects the assumed operating lives of Morupule A and B and the commissioning of committed capacity. Solar output can temporarily fall or grow more slowly when minimum coal generation, moderate demand and limited storage constrain the amount of variable generation that the system can absorb. This is an optimization result rather than deterioration in the solar resource and indicates a need for detailed dispatch, curtailment and network analysis. In particular, solar capacity can increase without a proportional increase in annual solar generation when committed thermal plants are subject to minimum operating levels. Limited storage, moderate demand and trade constraints can then reduce the amount of solar output absorbed in individual years. The apparent decline between 2026 and 2029 therefore reflects dispatch and category treatment in the model – not the retirement of solar assets.

FIGURE 10

Power sector generation mix for CPS (TWh)



The renewable share of electricity generation increases from approximately 5.5 percent in 2030 to 36.7 percent in 2040 and 42.3 percent in 2050 under CPS (Table 4). Under CPS Export, the renewable generation share is approximately 41.4 percent in 2030, 38.7 percent in 2040 and 49.8 percent in 2050. The share of renewable installed capacity is higher than the renewable generation share because solar PV operates at a lower annual capacity factor than firm thermal generation. Table 4 should therefore be read as an indicative generation outcome under the system constraints, not as a direct restatement of the installed-capacity policy target.

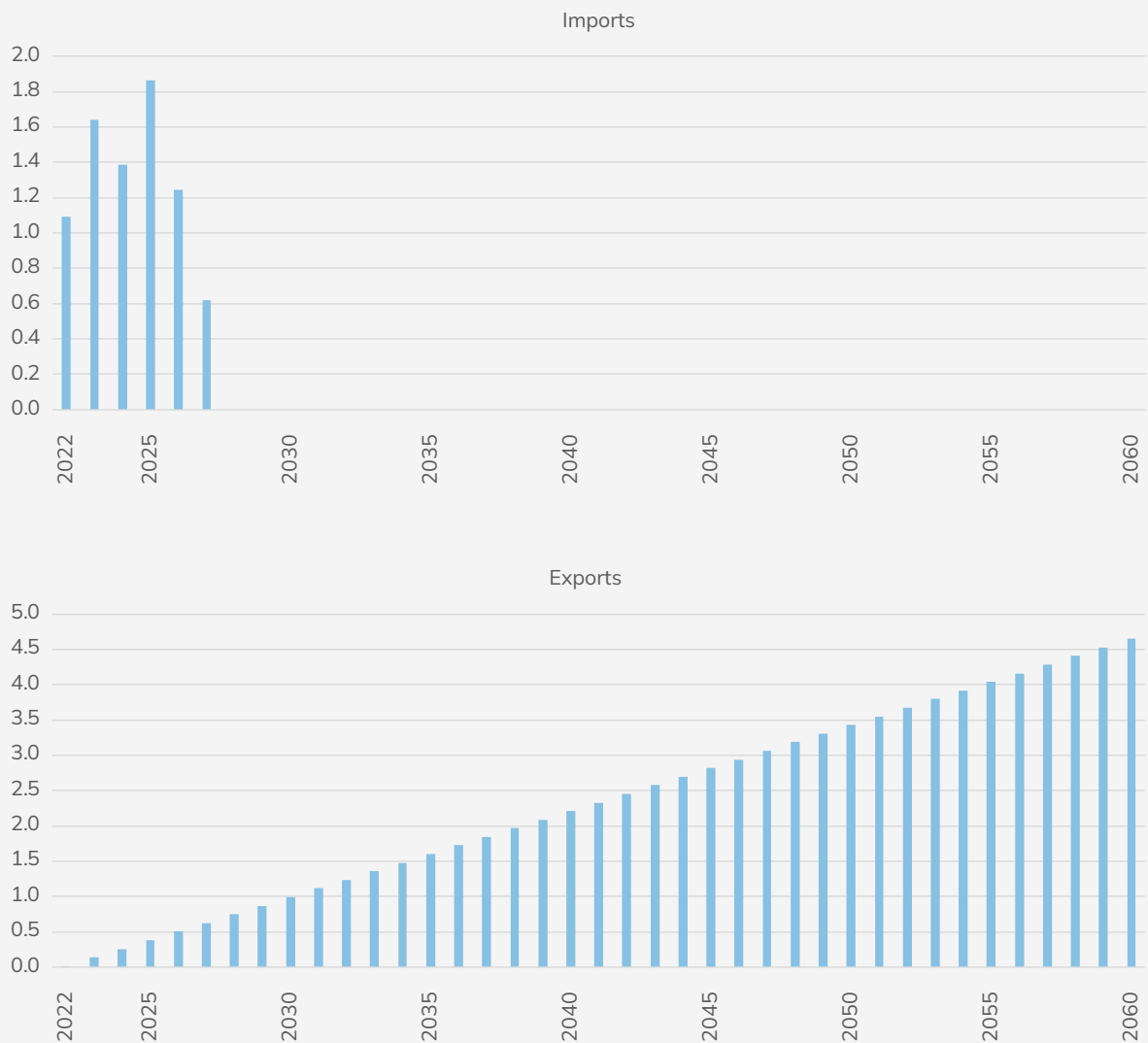
TABLE 4

Renewable generation share for CPS

	2030	2040	2050
CPS	5.5%	36.7%	42.3%
CPS Export	41.4%	38.7%	49.8%

Electricity imports peak at approximately 1.86 TWh in 2025 and become negligible around 2028 as committed domestic generation capacity enters operation (Figure 11). Modelled exports increase to approximately 3.43 TWh by 2050. Exports occur only after domestic demand and reliability requirements are met and remain conditional on regional demand, interconnector capability, market prices and commercial arrangements. No capacity is reserved for export before domestic needs are satisfied. The export trajectory is driven by the model's least-cost decision under the assumed constant real price and available transfer capability. Actual sales may be lower, higher or differently timed once PPAs, market demand, outages, losses and interconnector availability are considered.

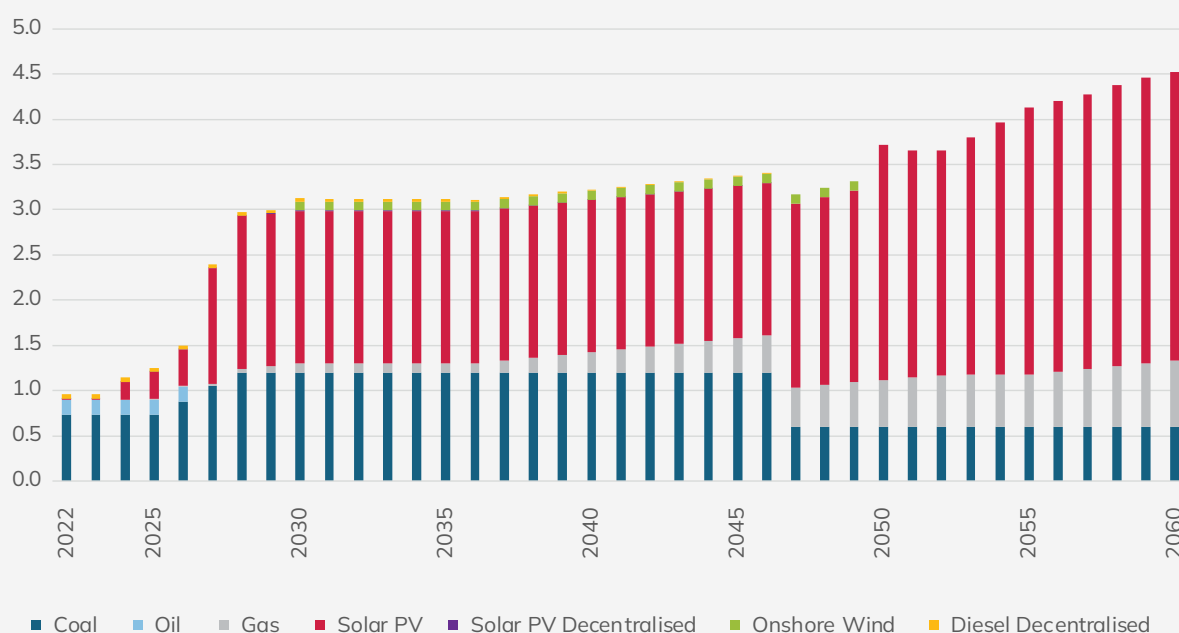
FIGURE 11
Power sector imports and exports for CPS (TWh)



Installed generation capacity reaches approximately 3.72 GW by 2050 under CPS (Figure 12). Solar PV reaches approximately 2.60 GW and provides most new capacity. Coal-bed methane capacity reaches approximately 0.52 GW, while coal capacity is approximately 0.60 GW. The capacity figures represent nameplate capacity. The dependable contribution at system peak will be lower for variable renewable generation and may also be lower for existing thermal units depending on actual availability and outage rates. The portfolio therefore requires subsequent adequacy analysis using plant-specific performance data and chronological demand and renewable profiles.

FIGURE 12

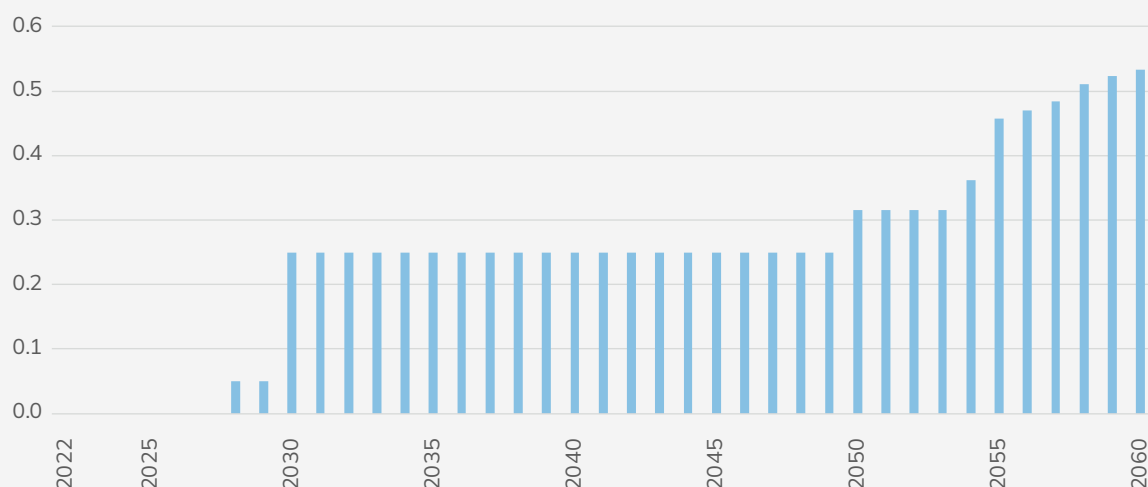
Power sector capacity mix for CPS (GW)



Battery storage is deployed to support renewable integration and short-term balancing (Figure 13). BESS capacity reaches approximately 0.32 GW by 2050 under CPS. Under the four-hour duration assumption, this is equivalent to approximately 1.26 GWh of energy-storage capacity. Charging energy and round-trip losses are represented within the model's power balance. The model uses storage for short-duration shifting and balancing, but the result does not define the final mix of services, technology chemistry or connection locations. These parameters will be determined through detailed system studies and procurement design.

FIGURE 13

Power sector battery storage capacity for CPS (GW)

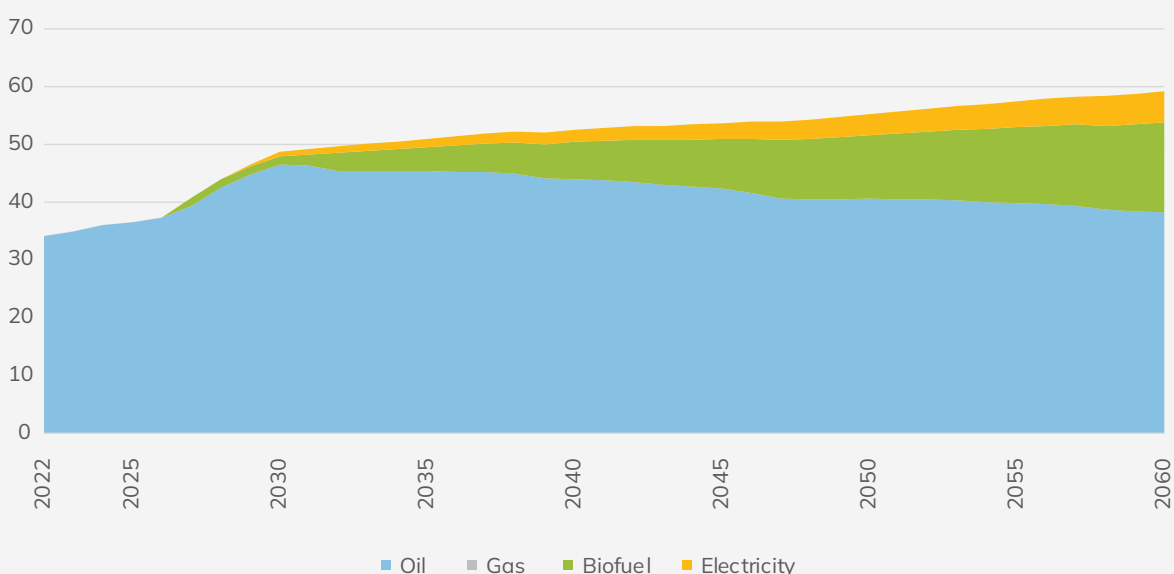


3.3 Transport Sector

Transport final energy demand reaches approximately 55.3 PJ by 2050 under CPS (Figure 14). Oil remains the dominant fuel at about 40.6 PJ, while biofuels reach approximately 11.1 PJ and electricity reaches 3.6 PJ. Continued fleet growth offsets a substantial share of the efficiency improvement from newer vehicles. Electricity and biofuels reduce part of the petroleum requirement, but the pace of vehicle replacement limits the speed of change. The result highlights the continuing importance of fuel-efficiency standards, public transport development and targeted deployment in high-utilization fleets even under the current-policy pathway.

FIGURE 14

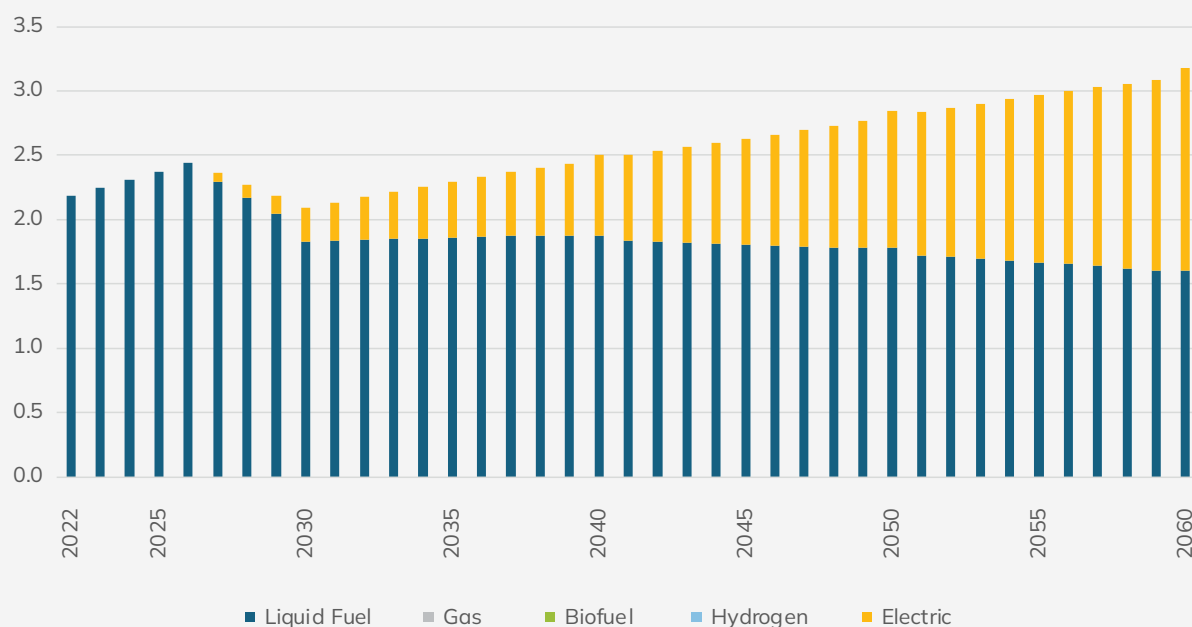
Transport sector fuel demand for CPS (PJ)



Overall, the motorcycle fleet increases from approximately 2,200 units in 2022 to 2,800 units by 2050, driven by population growth, rising mobility demand and continued urban transport needs (Figure 15). Electric motorcycles gain market share under CPS, but liquid-fuel motorcycles remain material through 2060 because current-policy uptake is gradual. Electric two-wheelers are well suited to shorter urban journeys and can use comparatively simple charging arrangements. Their actual uptake will depend on vehicle availability, purchase prices, battery durability, servicing capacity and the development of appropriate safety and charging standards.

FIGURE 15

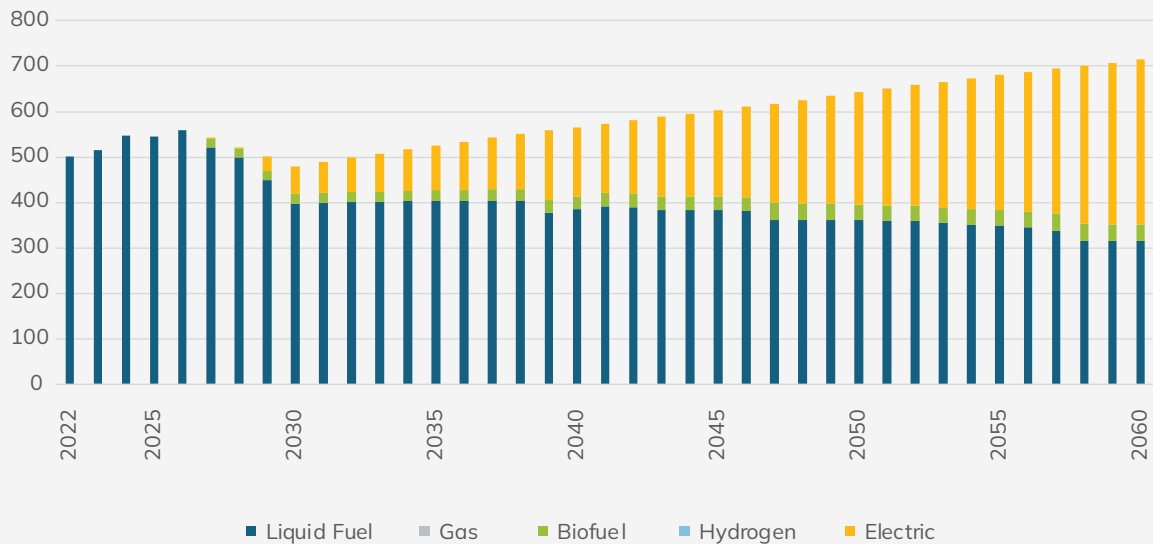
Motorcycle technology mix for CPS (Thousands of vehicles)



The passenger-car fleet reaches approximately 642,000 vehicles by 2050 under CPS (Figure 16). Electric cars account for approximately 247,000 units, liquid-fuel cars for around 361,000 units and the remaining vehicles use biofuels. Fleet turnover is gradual, so infrastructure planning will need to serve both electric and conventional vehicles for a substantial transition period.

FIGURE 16

Passenger car technology mix for CPS (Thousands of vehicles)



The bus fleet reaches approximately 85,000 vehicles by 2050 under CPS (Figure 17). Electric buses account for approximately 21,000 units, while about 59,000 buses remain liquid-fuel vehicles and a smaller share uses biofuels. The result reflects expansion of public transport alongside moderate fleet electrification. The increase in the public transport fleet is accounted for by the NDC target of moving 30 percent of private transport to public transport starting in 2030.

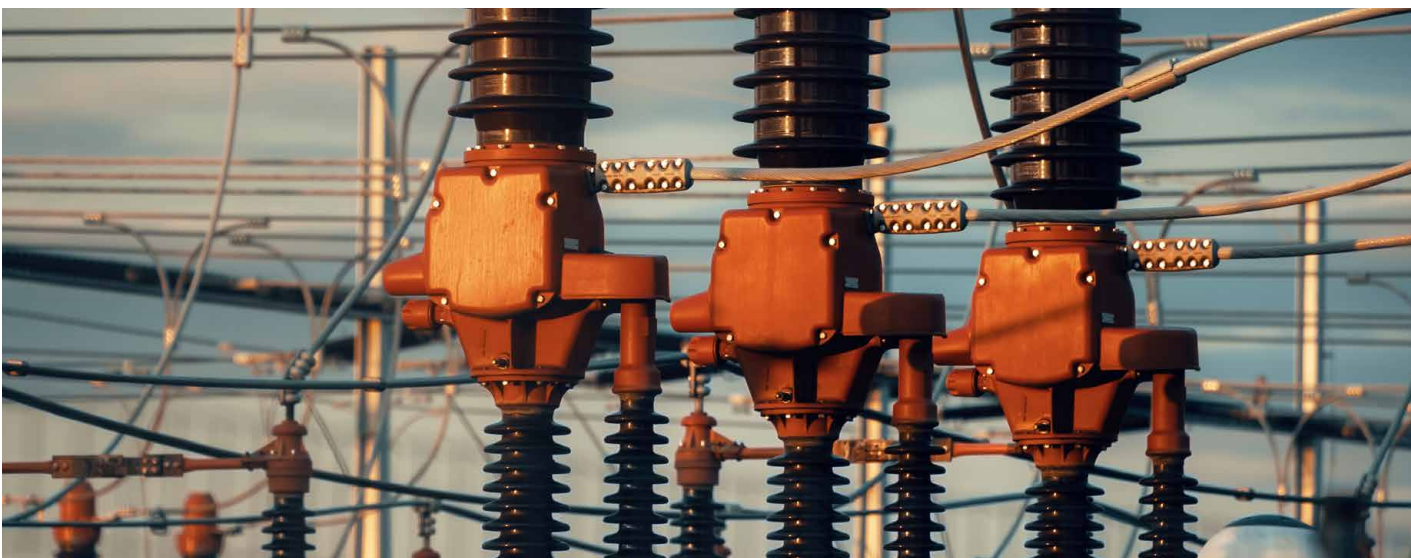
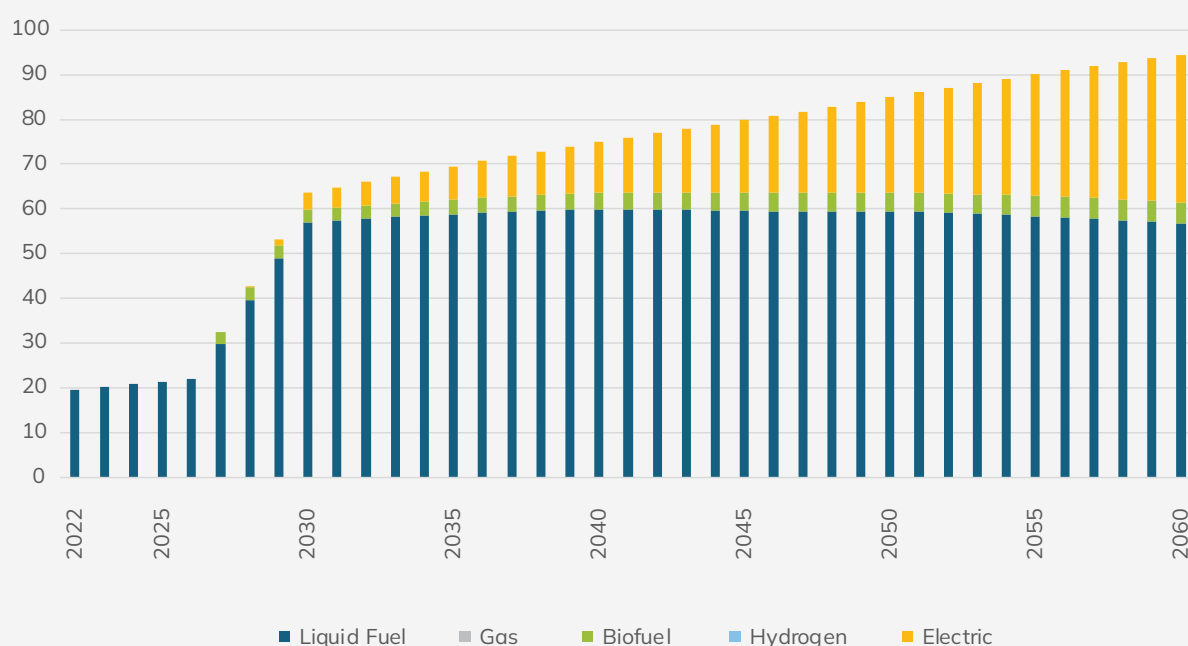


FIGURE 17

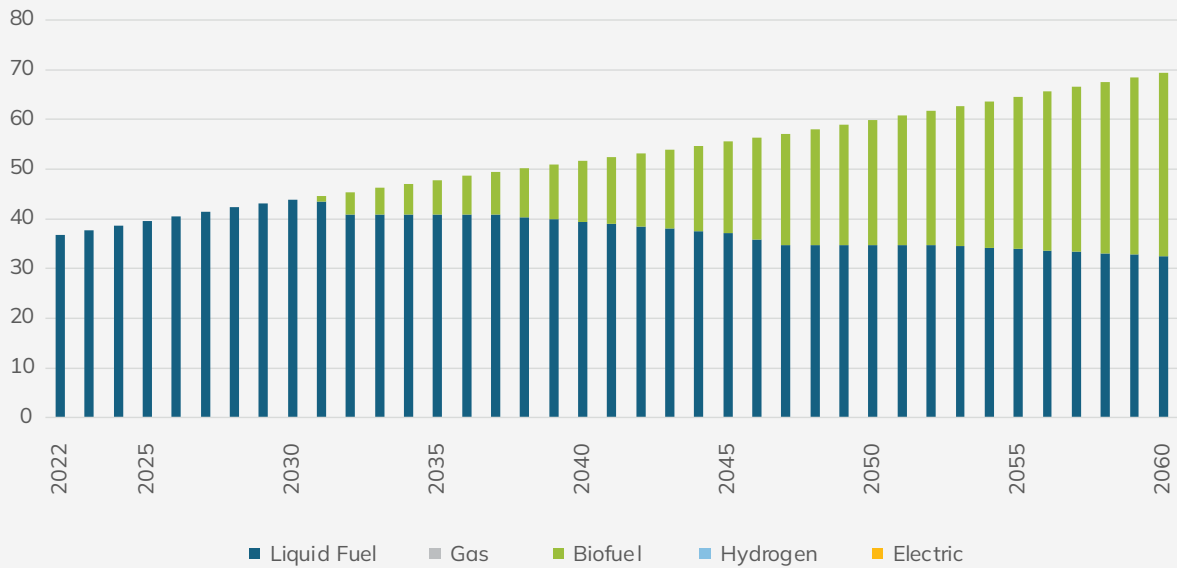
Bus technology mix for CPS (Thousands of vehicles)



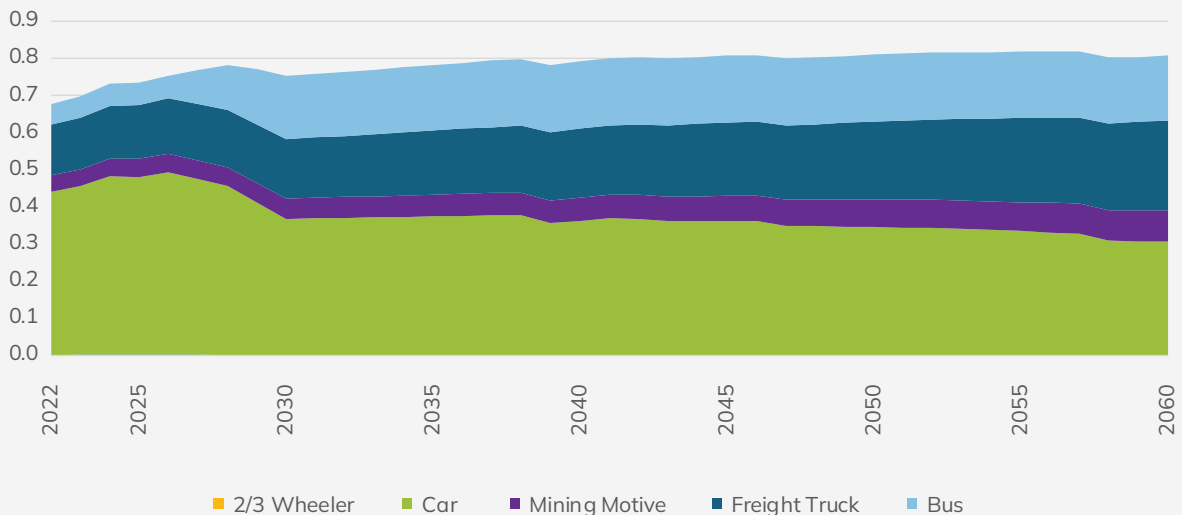
Overall, the freight fleet increases from approximately 37,000 trucks in 2022 to 60,000 trucks by 2050 (Figure 18). Under the CPS, the transition is driven primarily by fuel switching, with around 25,000 biofuel trucks and 35,000 liquid-fuel trucks by 2050. Biofuel uptake in road freight is represented through biodiesel blending in conventional diesel trucks rather than through dedicated pure-biofuel vehicles. Trucks classified under the diesel-biofuel blend category retain the same drivetrain characteristics as conventional ICE trucks. This treatment is consistent with Botswana's National Energy Policy objective of diversifying the national energy mix, improving energy security and promoting greater use of domestic renewable energy resources. The policy framework also identifies biofuels as a potential option for reducing dependence on imported petroleum products and supporting more sustainable transport. Botswana's updated NDC further includes increased uptake of renewable energy technologies and hybrid technologies in the transport sector, although it does not prescribe a specific biodiesel blend or freight-sector mandate.

FIGURE 18

Freight truck technology mix for CPS (Thousands of vehicles)



Under the CPS, transport emissions increase from approximately 0.68 Mt CO₂ in 2022 to 0.81 Mt CO₂ by 2050, representing a rise of around 19 percent over the period (Figure 19). Emissions growth is driven by increasing transport activity and fleet expansion, with efficiency improvements insufficient to offset rising demand. Passenger cars remain the largest source of transport emissions, while road transport continues to dominate overall emissions.

FIGURE 19Transport sector CO₂ emissions for CPS (Mt CO₂)

3.4 Mining Sector

Mining-process demand increases from approximately 4.3 PJ in 2022 to 6.53 PJ by 2050 under CPS (Figure 20). Coal supplies approximately 3.78 PJ, electricity 1.83 PJ and oil about 0.92 PJ. The pathway supports mining-demand growth and reliability without applying an additional mining-electrification constraint beyond current policy. Some diesel use remains for on-site generation, backup power and remote operations. The result reflects the structure of Botswana's mining sector, where electricity is used extensively for crushing, grinding, pumping, ventilation and mineral processing, while coal and petroleum products continue to support thermal processes, mobile equipment and backup generation [11].

Mining demand is expected to become more diversified over the modelling period. Diamond production remains central through large operations such as Jwaneng, Orapa, Letlhakane and Karowe, while the expansion of copper mining in the Kalahari Copper Belt increases electricity and processing requirements. The planned expansion of Khoemacau Copper Mine, for example, is intended to more than double copper output from approximately 60,000 tonnes to 130,000 tonnes per year. Botswana is also pursuing wider development of critical minerals as part of its economic diversification and industrialization agenda.

Coal demand in the sector is closely linked to the wider Morupule energy and mining complex. Morupule Coal Mine supplies the domestic power system and other industrial users, while Morupule power stations remain important sources of grid electricity. The Motheo expansion increased Morupule Coal Mine's production capacity from approximately 2.8 million tonnes to 4.2 million tonnes per year, with a longer-term corporate objective of expanding sales to domestic and export markets. This creates an important linkage between mining growth, domestic coal supply and power sector demand, although the role of coal declines relative to electricity under the REES pathway.

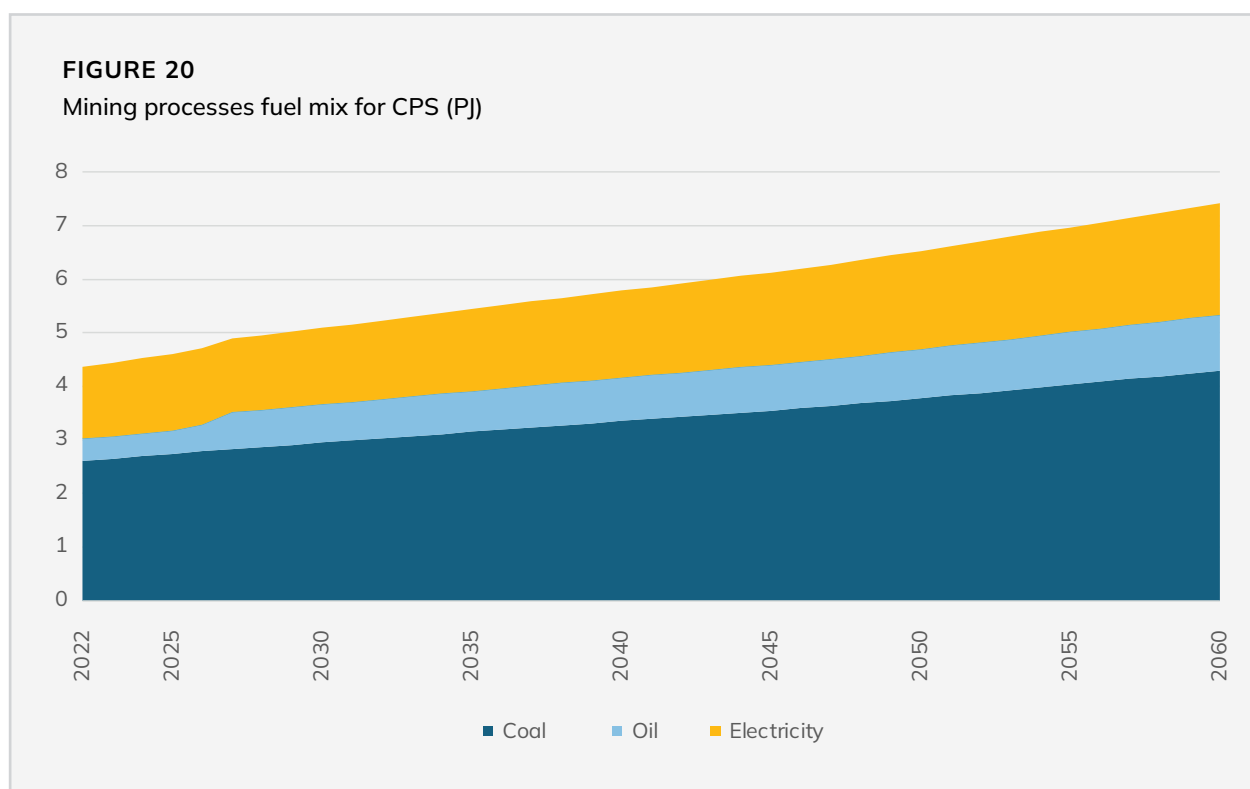
Reliable power supply is a major commercial consideration for mining projects. Large mines may obtain electricity from the national grid, develop dedicated network connections, retain diesel backup generation or invest in on-site renewable systems. The Karowe Mine provides an example of mine-financed power infrastructure: Lucara constructed a 29 km, 132 kV transmission line and associated substations under an agreement with Botswana Power Corporation, allowing the underground expansion to rely primarily on grid electricity while retaining backup diesel generation. Karowe has also piloted a grid-connected rooftop solar PV system [12].

As Botswana introduces open-access and wheeling arrangements, corporate PPAs could provide a further route for mining companies to procure renewable electricity directly from independent generators. Mine-site solar, storage and hybrid systems may also be commercially attractive where they reduce exposure to outages, diesel use and electricity-price volatility. These options are particularly relevant for remote operations and new mining projects where network reinforcement is required.

The commercial case for mining decarbonization is reinforced by commitments made by major operators. Debswana's sustainability framework includes an ambition to become carbon-neutral, minimize its water footprint and achieve a net-positive biodiversity impact by 2030. Its decarbonization strategy is organized around four pillars: reducing energy intensity, transitioning to alternative fuels, decarbonizing electricity supply and developing carbon-recovery initiatives [13]. In May 2025, Debswana and Botswana Power Corporation signed a memorandum of agreement on Renewable Energy Certificates, enabling Debswana operations to demonstrate the use of renewable electricity sourced from solar projects developed under the national Integrated Resource Plan.

These developments indicate that the mining sector offers one of the strongest near-term investment cases for renewable electricity and energy-efficiency measures. Mines are large and creditworthy customers with relatively stable demand, making them suitable anchor off-takers for utility-scale solar, storage, transmission upgrades and corporate PPAs. Compared with dispersed household or transport demand, mining loads can support larger projects through long-term supply agreements and can facilitate earlier mobilization of private capital.

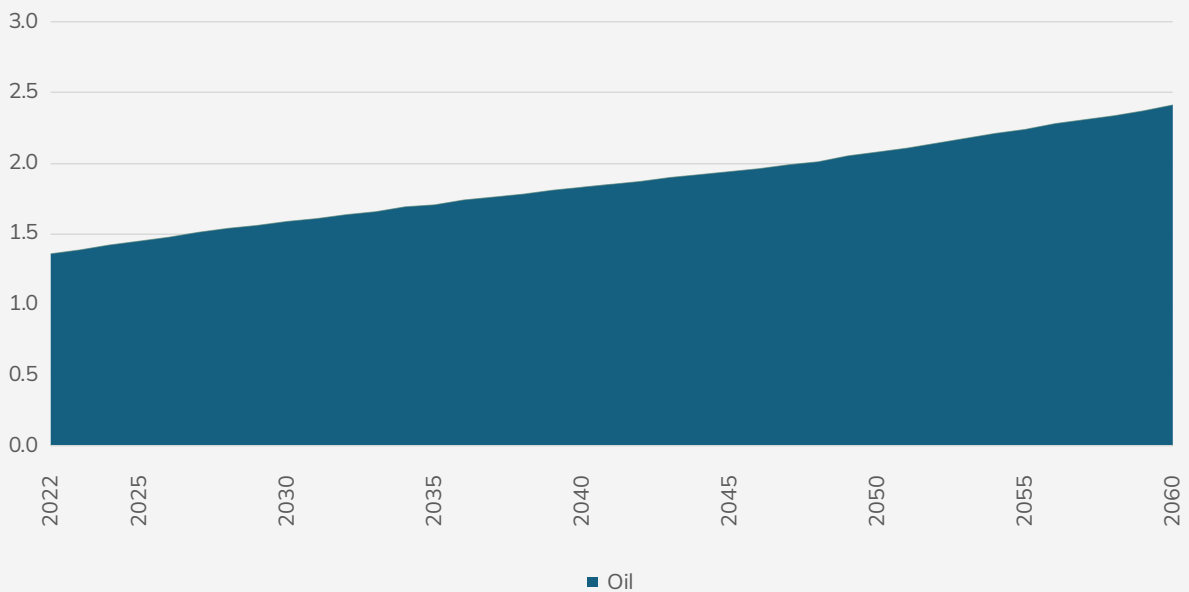
Under CPS, these investments primarily support demand growth, reliability and moderate electrification. Under REES Domestic, the same commercial structures become a central mechanism for achieving the target of supplying 75 percent of mining demand with electricity by 2050. Mining should therefore be presented not only as a source of rising energy demand, but also as a potential anchor for renewable investment, network development and the wider decarbonization of Botswana's productive economy.



Mining-transport demand reaches approximately 2.1 PJ by 2050 and remains fully oil-based under CPS (Figure 21), reflecting the operational requirements of remote and high-load vehicles and the limited current-policy deployment of alternative infrastructure.

FIGURE 21

Mining transport demand fuel mix for CPS (PJ)

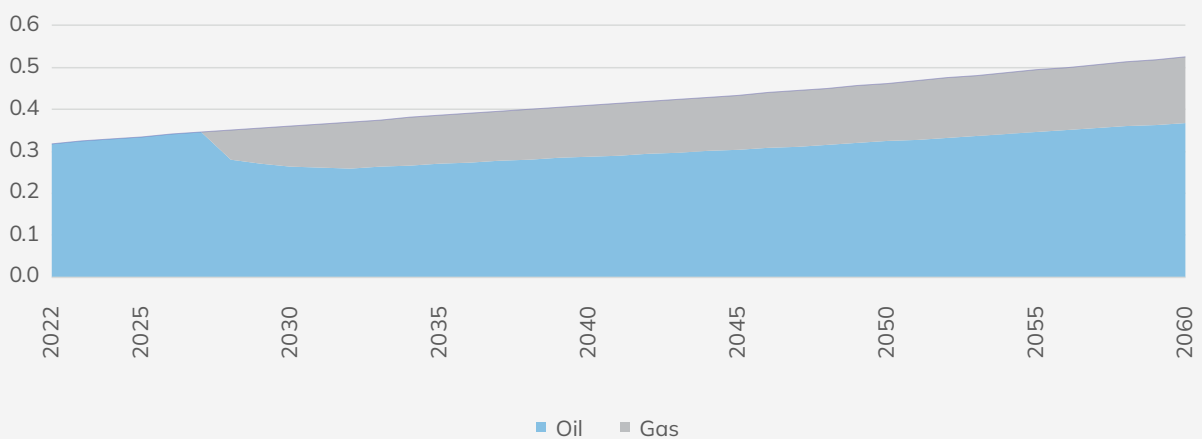


3.5 Industry Sector

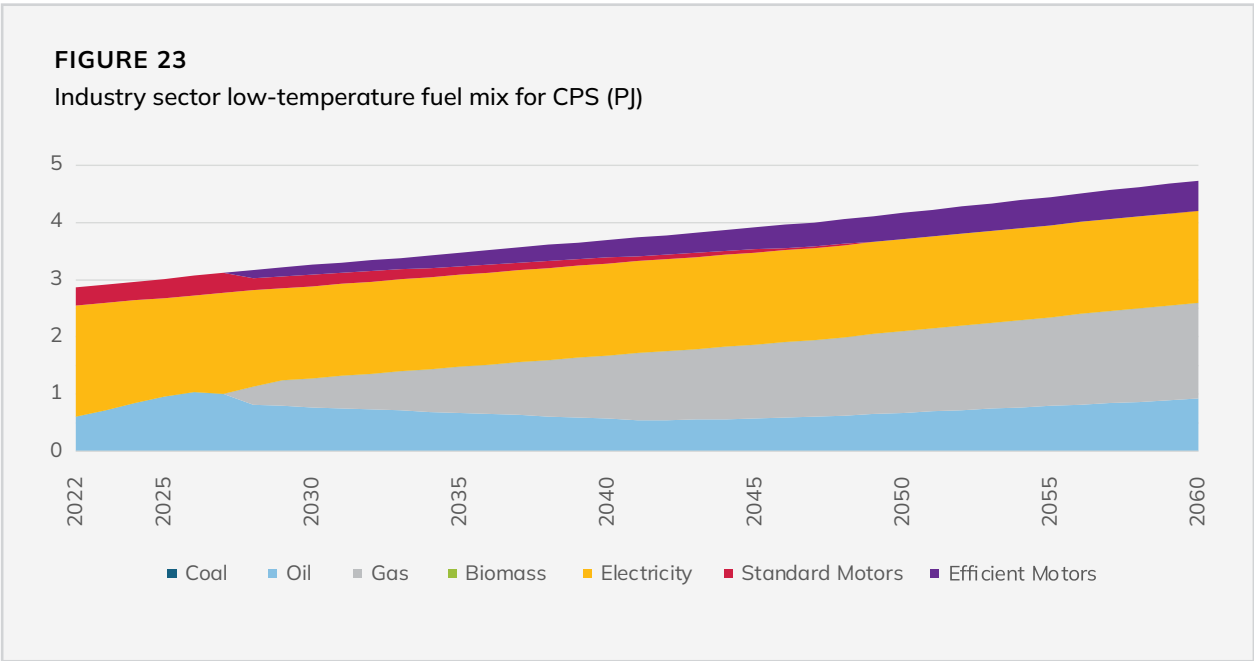
Under the CPS, industrial demand increases from approximately 0.32 PJ in 2022 to 0.46 PJ by 2050 (Figure 22). Oil remains the dominant energy source throughout the period, while gas use increases gradually to around 0.14 PJ as it becomes available for part of the industrial heat demand. Fuel switching occurs primarily based on relative technology and fuel costs rather than through targeted decarbonization policies. Post-extraction processes, such as for soda ash production, are accounted for under overall demand in the mining sector.

FIGURE 22

Industry sector high-temperature fuel mix for CPS (PJ)

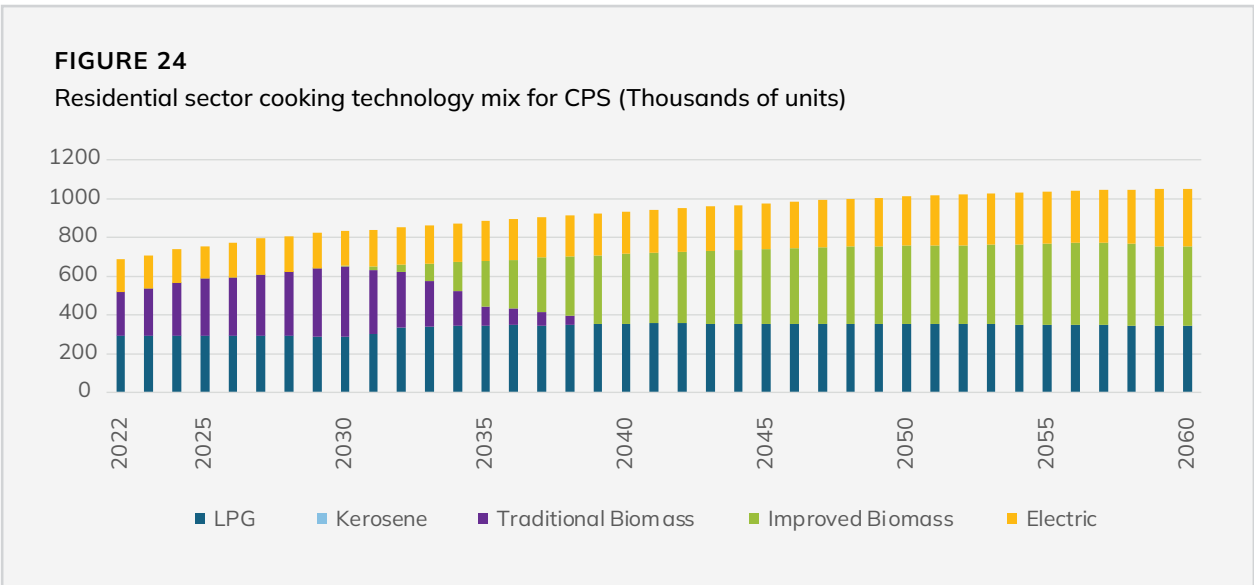


Under the CPS, demand rises from approximately 2.9 PJ in 2022 to 4.2 PJ by 2050, with electricity remaining the largest energy carrier throughout the period (Figure 23). Gradual improvements in motor efficiency contribute to reducing energy intensity, but oil and gas continue to play a role owing to existing infrastructure and limited technology switching.

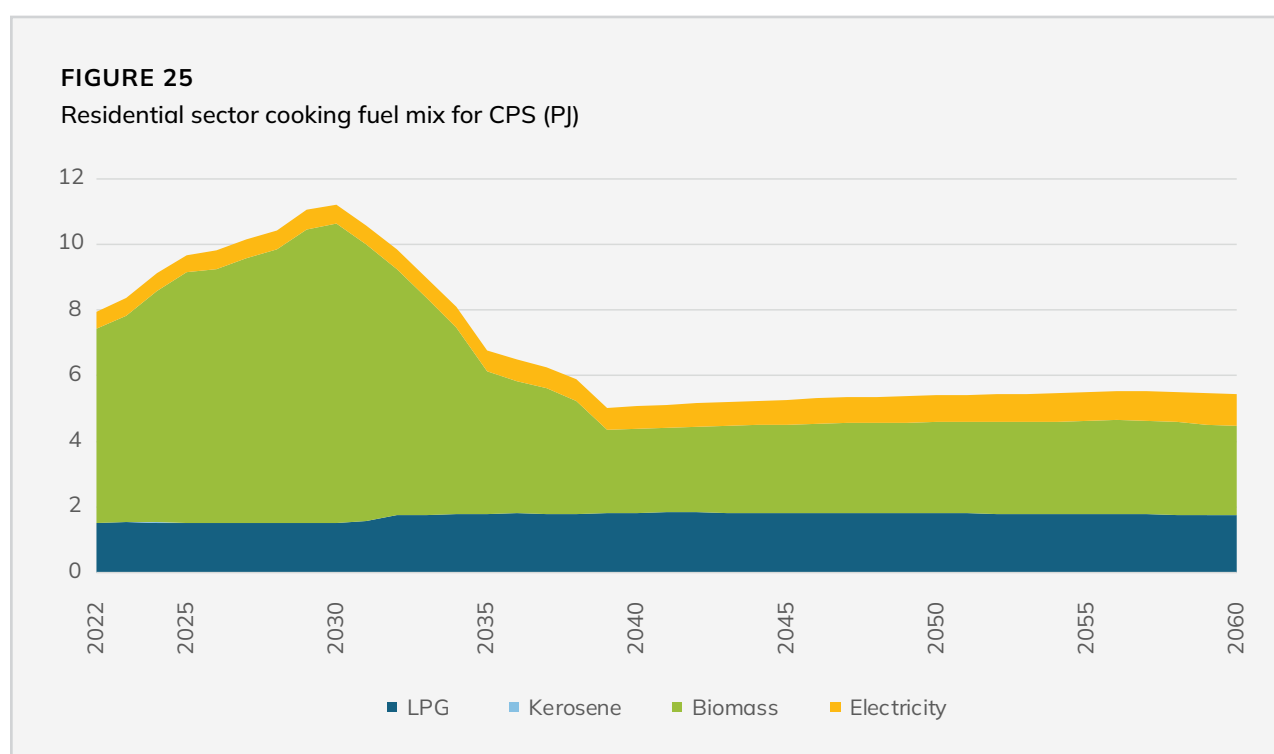


3.6 Clean Cooking

The total number of cookstoves increases from approximately 685,000 units in 2022 to 1 million units by 2050, reflecting household growth and rising demand for cooking services (Figure 24). Under the CPS, electric cookstoves expand to around 254,000 units by 2050, supported by ongoing clean-cooking policies, while traditional biomass use declines significantly after the early 2030s as households transition towards cleaner fuels.



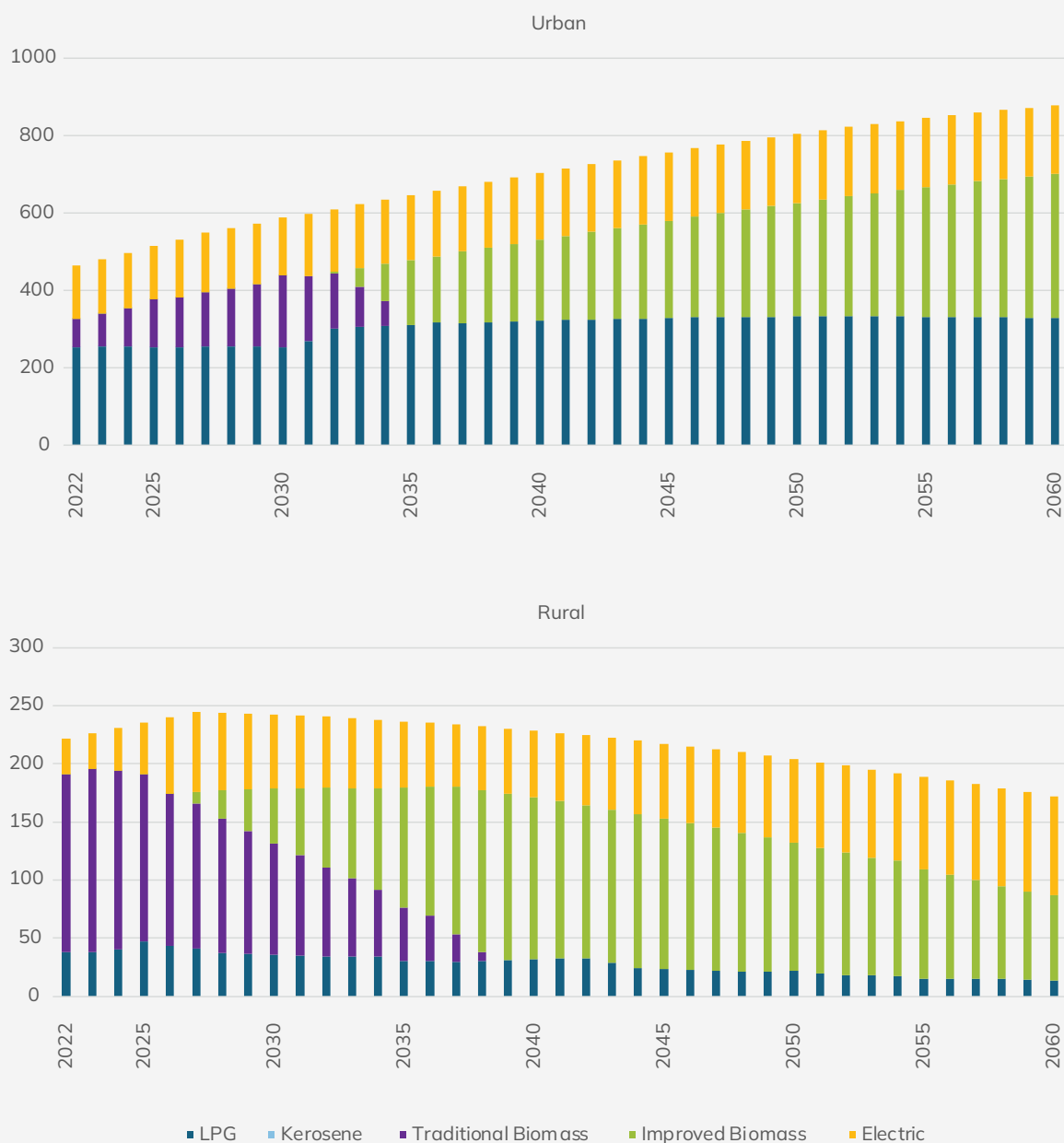
Cooking-fuel demand declines despite growth in the number of households, reflecting improvements in cooking efficiency and a transition towards cleaner cooking technologies (Figure 25). Under CPS, total cooking-fuel demand reaches approximately 5.40 PJ by 2050. Biomass remains the largest source at approximately 2.76 PJ, followed by LPG at 1.82 PJ and electricity at 0.82 PJ.



The distribution of cookstoves shifts significantly between urban and rural areas. Urban cookstoves increase from approximately 460,000 units in 2022 to 800,000 units by 2050, while rural cookstoves decline from around 220,000 to 200,000 units as households increasingly migrate towards urban areas (Figure 26). Under the CPS, urban cooking remains primarily supplied by LPG and improved biomass, supported by better access to modern fuels and energy infrastructure.

FIGURE 26

Residential sector urban and rural cooking technology mix for CPS (Thousands of units)





Chapter 4

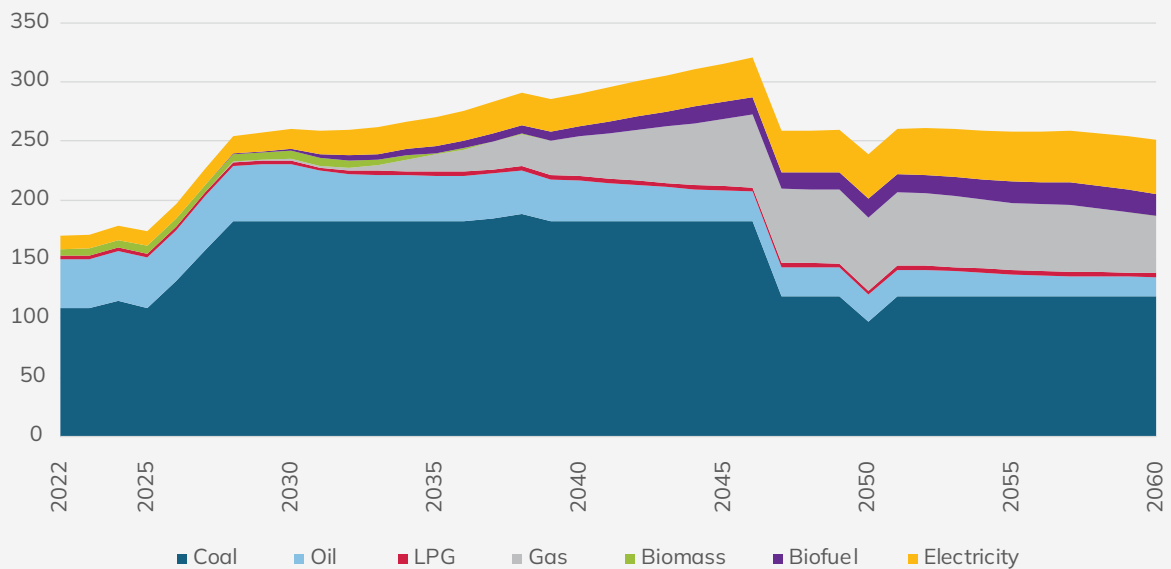
RENEWABLE ENERGY AND ELECTRIFICATION SCENARIO

4.1 Overview

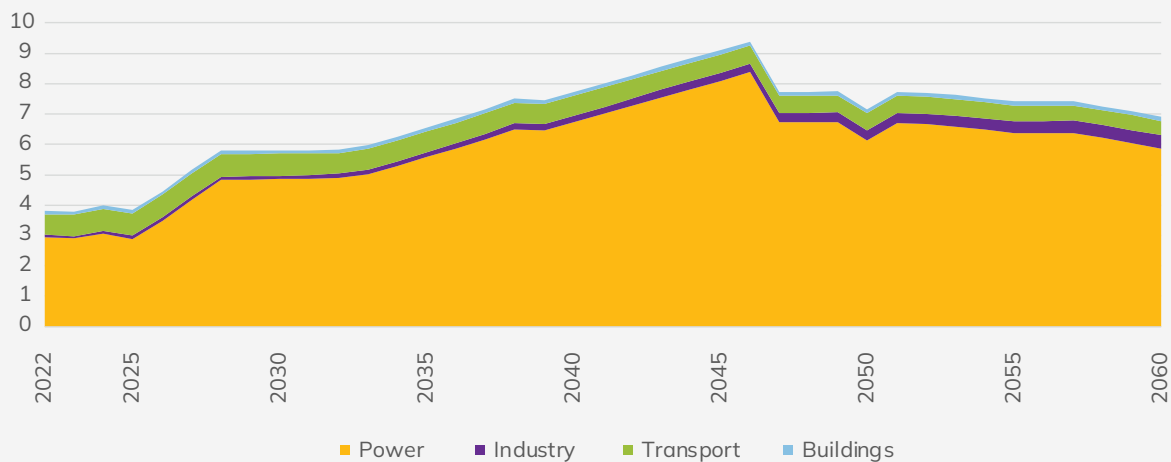
Under REES, total fuel consumption reaches approximately 240 PJ by 2050 (Figure 27). Coal remains the largest primary fuel at approximately 97.4 PJ, followed by coal-bed methane at 61.9 PJ. Electricity use rises to approximately 37.9 PJ as transport, mining, industry and cooking become more electrified, while direct oil consumption falls to approximately 22.3 PJ. Biofuel use reaches approximately 15.6 PJ and LPG approximately 3.6 PJ. The higher total fuel requirement relative to CPS reflects stronger productive-sector activity and a larger electricity system, while direct oil consumption is substantially lower. Biofuel use increases, particularly in transport, while coal and gas remain in applications that are not fully electrified by 2060.

FIGURE 27

Total fuel consumption for REES (PJ)

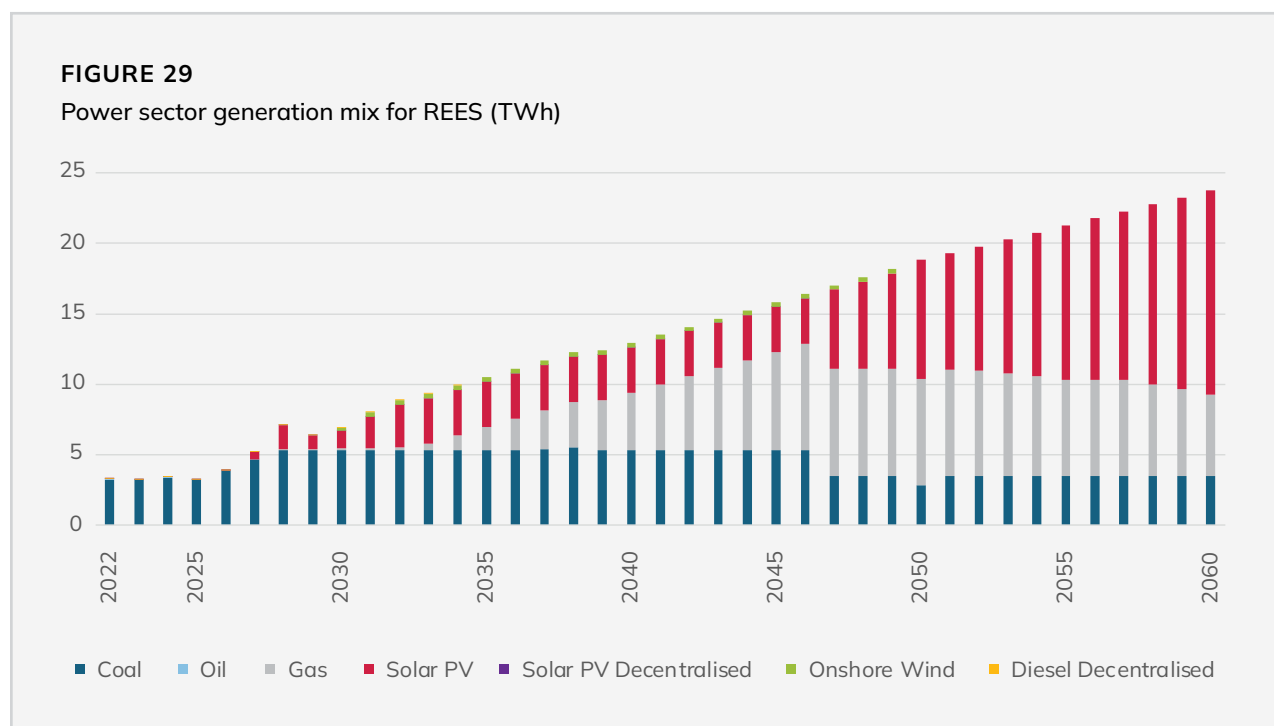


Energy-related CO₂ emissions increase during the expansion of electricity demand and thermal generation and peak at approximately 9.3 Mt CO₂ around 2046 (Figure 28). By 2050, emissions decline to approximately 7.16 Mt CO₂. Power generation remains the largest source at approximately 6.13 Mt CO₂, followed by transport at 0.56 Mt CO₂, industry at 0.34 Mt CO₂ and buildings at 0.13 Mt CO₂. The decline after the mid-2040s reflects the expansion of solar PV and battery storage and the retirement of coal capacity.

FIGURE 28Total energy-related CO₂ emissions for REES (Mt CO₂)

4.2 Power Sector

Electricity generation reaches approximately 18.86 TWh by 2050 under REES (Figure 29). Solar PV becomes the largest generation source at approximately 8.46 TWh, followed by gas (coal-bed methane) which provides about 7.53 TWh of dispatchable generation and coal provides approximately 2.87 TWh. Botswana only sees a limited amount of wind generation, less than 1 TWh, given the low wind potential in most parts of the country. The larger generation requirement reflects increased electrification of transport, mining, industry and households, together with modelled regional electricity trade. Gas provides dispatchable flexibility, while remaining coal generation contributes firm supply during the transition.

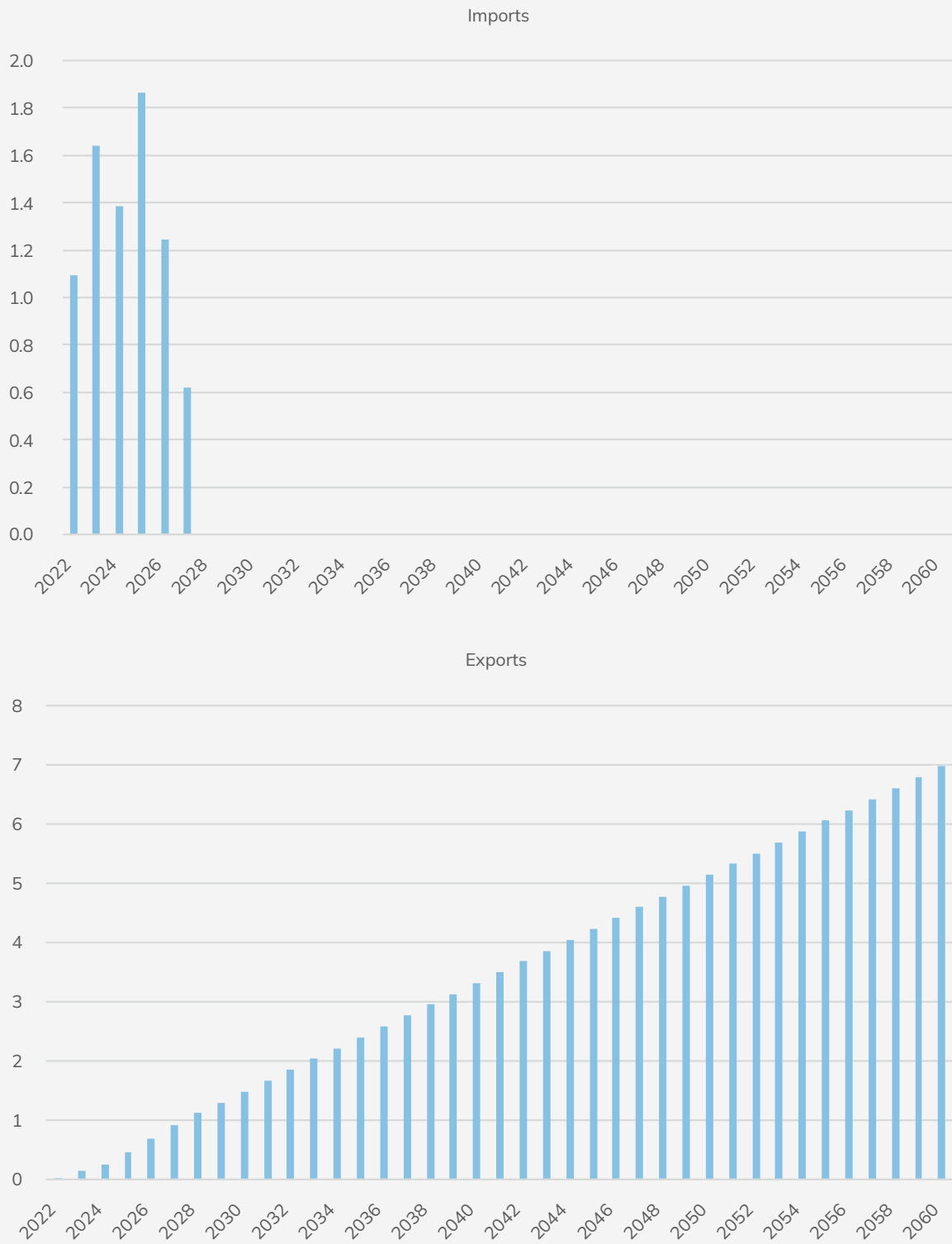


The results indicate that the transition towards a renewables-based power system is driven primarily by solar PV deployment, supported by flexible gas generation, rather than by the introduction of additional low-carbon generation technologies such as nuclear or carbon capture and storage (CCS). These technologies are not selected in either pathway, reflecting their relatively high capital costs, limited deployment potential, and lack of economic competitiveness compared with Botswana's strong solar resource and renewable energy options under the assumed system conditions. The renewable energy capacity share reaches 70 percent by 2050. This reflects the balance between system reliability requirements and the need to meet both domestic demand growth and export requirements.

Electricity imports follow the same near-term trajectory as CPS, peaking at approximately 1.86 TWh in 2025 before becoming negligible around 2028 as additional domestic capacity enters operation (Figure 30). By 2050, modelled electricity exports reach approximately 5.14 TWh. These exports remain conditional on regional electricity demand, interconnector availability, market prices and commercial arrangements. The additional exports are primarily supported by the larger solar fleet and remain subject to regional demand, transmission availability and commercial arrangements.

FIGURE 30

Power sector imports and exports for REES (TWh)



Installed generation capacity reaches approximately 5.89 GW by 2050 under REES (Figure 31). Solar PV reaches approximately 4.28 GW, including decentralized capacity, and accounts for approximately 73 percent of installed generation capacity. Gas capacity reaches approximately 1 GW and coal capacity around 0.62 GW. The higher capacity requirement reflects the lower annual capacity factor of solar PV (solar PV is modelled with a capacity factor of approximately 18 percent, increasing to around 23 percent for the strongest resource profiles) and the need for additional installed capacity to meet electricity demand reliably. Additionally, the REES Export capacity exceeds Domestic with an average peak demand because it also supplies growing electricity demand from transport, mining, industry and households, charges battery storage and supports regional exports.

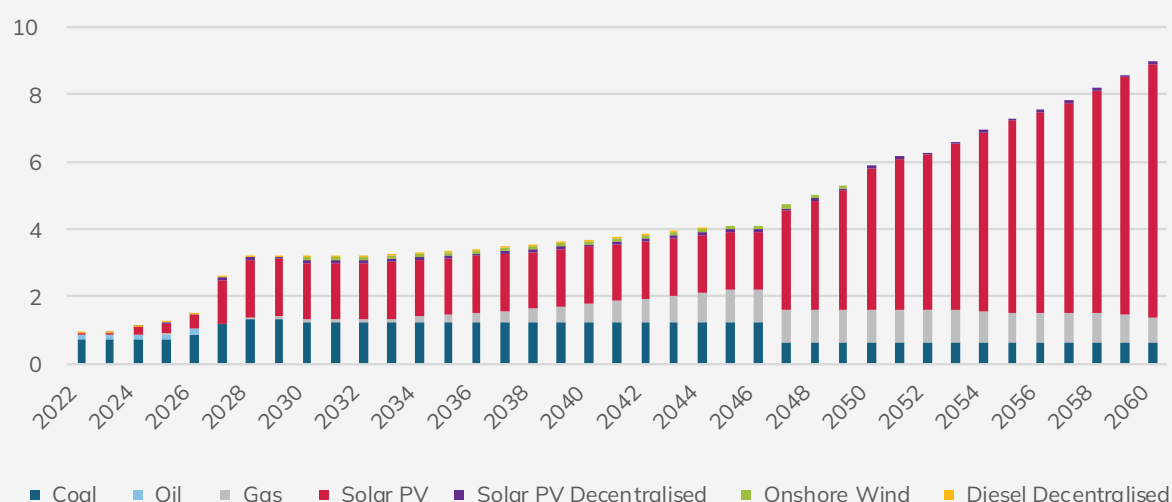
The REES pathway enables faster and sustained renewable energy deployment, while no significant expansion of onshore wind capacity is selected by the least-cost optimization owing to onshore wind's relatively high capital costs and low-capacity factor (Table 2 and Table 10). The model result provides a national capacity-expansion direction and will need to be complemented by detailed dispatch, adequacy and network studies to assess curtailment, reserve requirements, system stability, transmission corridors and the operational coordination of solar, storage and firm capacity.

Solar PV accounts for more than half of installed capacity by 2030 but contributes only a small share of electricity generation. This occurs because recently commissioned coal plants are subject to a minimum capacity factor of 50 percent, requiring substantial coal generation irrespective of the availability of solar electricity. At the same time, solar capacity is installed to meet the renewable capacity target. With limited demand, exports and storage available to absorb both sources, much of the potential solar output is curtailed. The result highlights a potential conflict between committed baseload coal generation and the achievement of renewable energy targets.

Curtailment volumes are not available from the present model outputs and are therefore not quantified. The scale of solar deployment should consequently be regarded as a long-term capacity-expansion result that requires subsequent hourly dispatch and grid studies to assess curtailment, transmission constraints, export availability and storage operation. Using an indicative utility-scale PV land requirement of 7.3 to 8.9 acres per MW, the 4.3 GW solar fleet could require approximately 127 km² to 155 km², depending on plant design and site conditions.

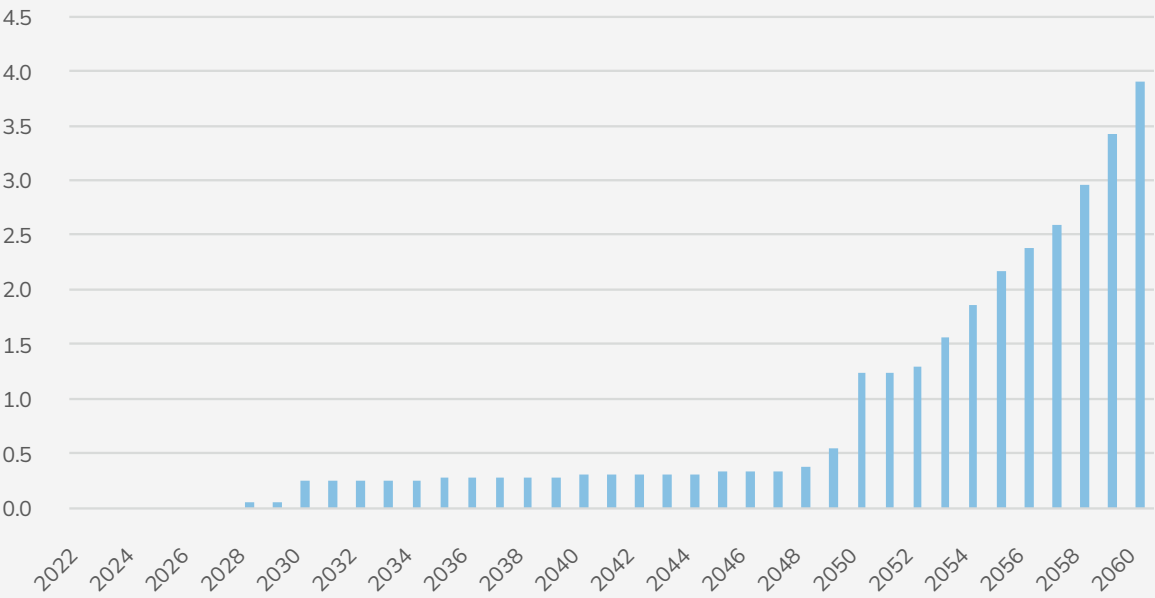
FIGURE 31

Power sector capacity mix for REES (GW)



Battery storage reaches approximately 1.24 GW by 2050 under REES (Figure 32). Under the four-hour duration assumption, this corresponds to approximately 4.96 GWh of energy-storage capacity. The figure shows a marked acceleration after 2050, reaching approximately 3.9 GW, or 15.6 GWh, by 2060 as solar generation and the need for energy shifting, balancing and system flexibility increase. The accelerated storage deployment after 2053 reflects the increasing need for balancing and solar energy shifting as variable renewable generation becomes dominant. Existing BESS capacity is retired and replaced according to assumed technical lifetimes, with storage becoming increasingly cost-effective at higher renewable penetration levels. Limited alternative flexibility options within the model contribute to the greater reliance on BESS for system balancing and firming.

FIGURE 32
Power sector battery storage capacity for REES (GW)

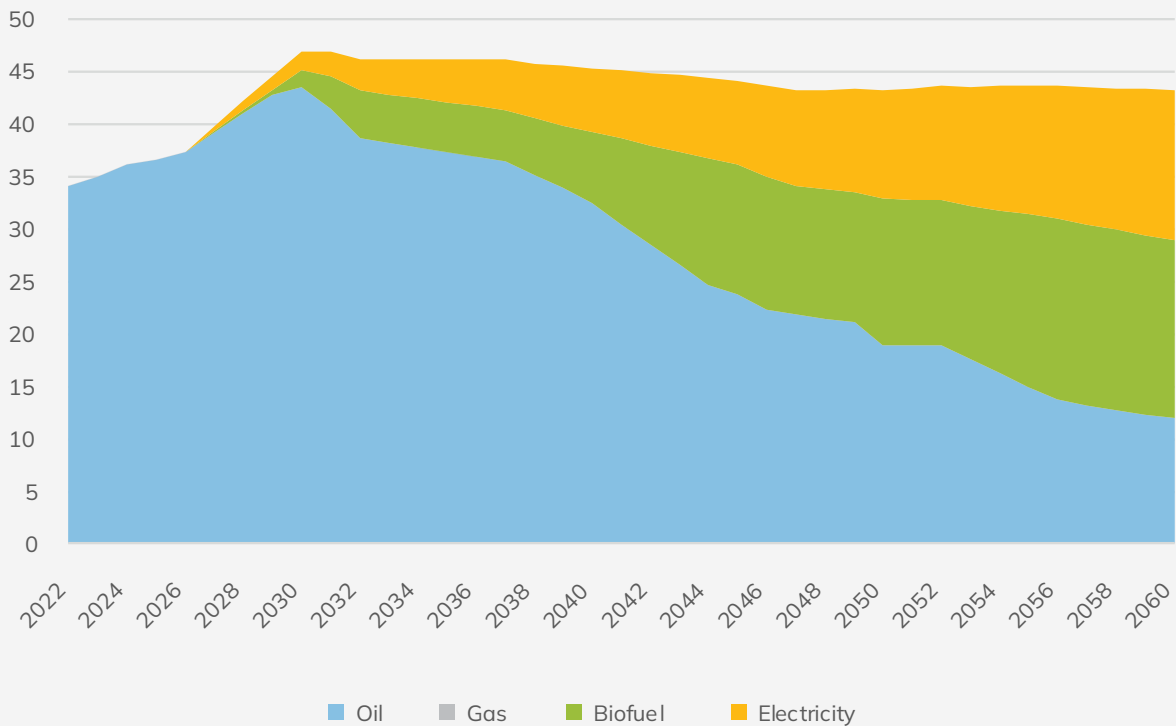


4.3 Transport Sector

REES transport final energy demand reaches approximately 43.1 PJ by 2050 (Figure 33). Oil consumption declines to approximately 18.9 PJ, while biofuels provide approximately 13.9 PJ and electricity approximately 10.3 PJ. The lower final energy requirement relative to CPS reflects the higher efficiency of electric vehicles compared with conventional internal-combustion vehicles.

FIGURE 33

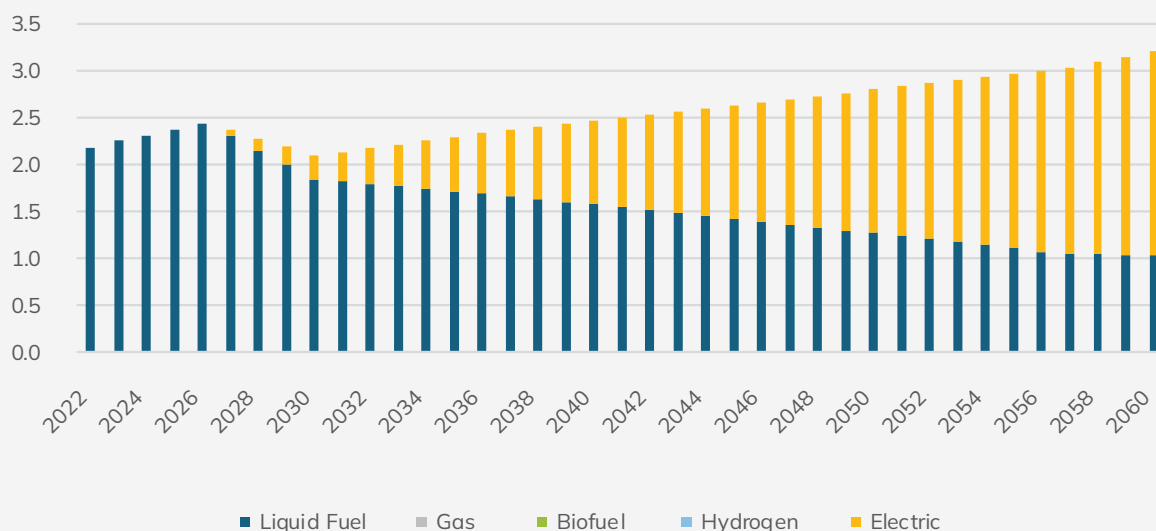
Transport sector fuel demand for REES (PJ)



Overall, the motorcycle fleet increases from approximately 2,200 units in 2022 to 2,800 units by 2050, driven by population growth, rising mobility demand and continued urban transport needs (Figure 34). The REES pathway achieves a faster transition, with electric motorcycles reaching approximately 1,500 units by 2050, or nearly 55 percent of the fleet, reducing liquid-fuel motorcycle numbers to around 1,300 units. The faster uptake of electric two-wheelers is supported by declining EV costs after 2030 and stronger decarbonization assumptions.

FIGURE 34

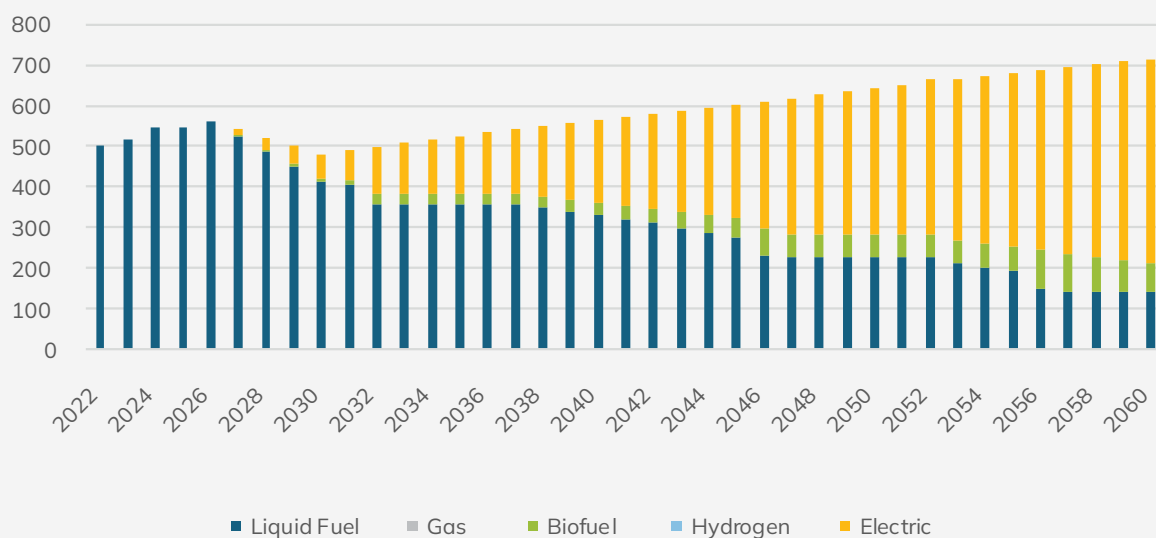
Motorcycle technology mix for REES (Thousands of vehicles)



The passenger car fleet increases from approximately 500,000 vehicles in 2022 to 642,000 vehicles by 2050 (Figure 35). The REES pathway results in a faster transition towards electrification, with EVs reaching approximately 360,000 units by 2050, or 56 percent of the fleet, reducing the number of liquid-fuel cars to around 228,000 units. The accelerated uptake of EVs is enabled by declining technology costs and EV cost competitiveness achieved after 2030.

FIGURE 35

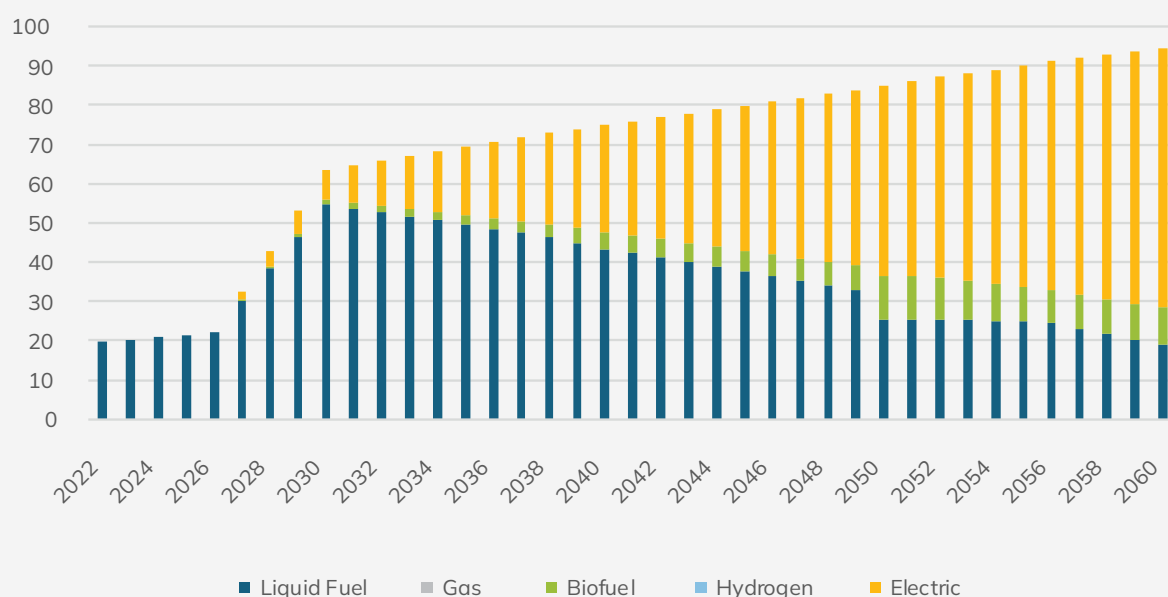
Passenger car technology mix for REES (Thousands of vehicles)



The bus fleet increases from approximately 20,000 vehicles in 2022 to 85,000 vehicles by 2050 (Figure 36). The REES pathway achieves a faster transition, with electric buses reaching approximately 48,000 units by 2050, or 56 percent of the fleet, reducing liquid-fuel bus numbers to 25,000 units. The accelerated adoption of electric buses is supported by strong policy incentives for public transport electrification and the ability of centralized fleets to adopt new technologies more rapidly than dispersed vehicle ownership.

FIGURE 36

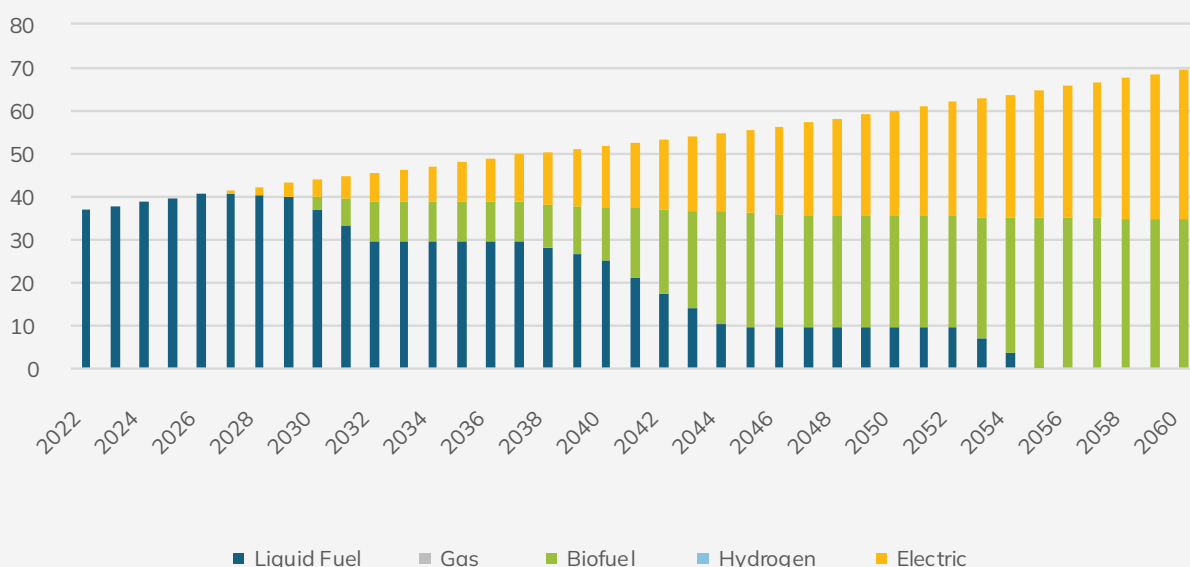
Bus technology mix for REES (Thousands of vehicles)



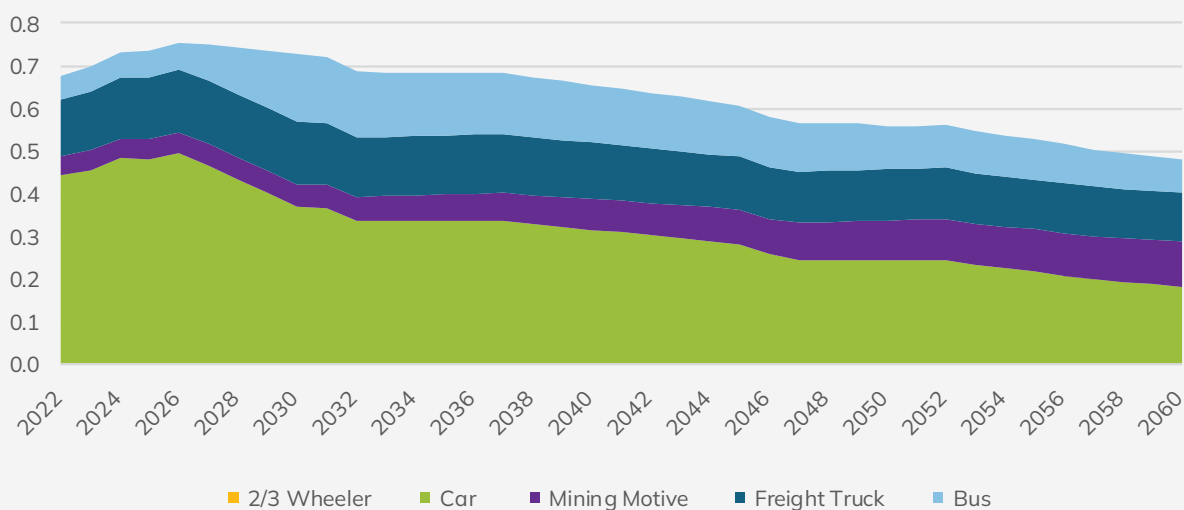
The freight fleet reaches approximately 59,900 trucks by 2050 (Figure 37). Biofuel trucks account for approximately 25,700 vehicles, electric trucks approximately 24,500 and remaining liquid-fuel trucks approximately 9,700. The REES pathway therefore substantially reduces conventional liquid-fuel freight while combining electrification with continued biofuel use. The transition remains gradual because of the long replacement cycles and demanding operating requirements of heavy-duty freight vehicles.

FIGURE 37

Freight truck technology mix for REES (Thousands of vehicles)

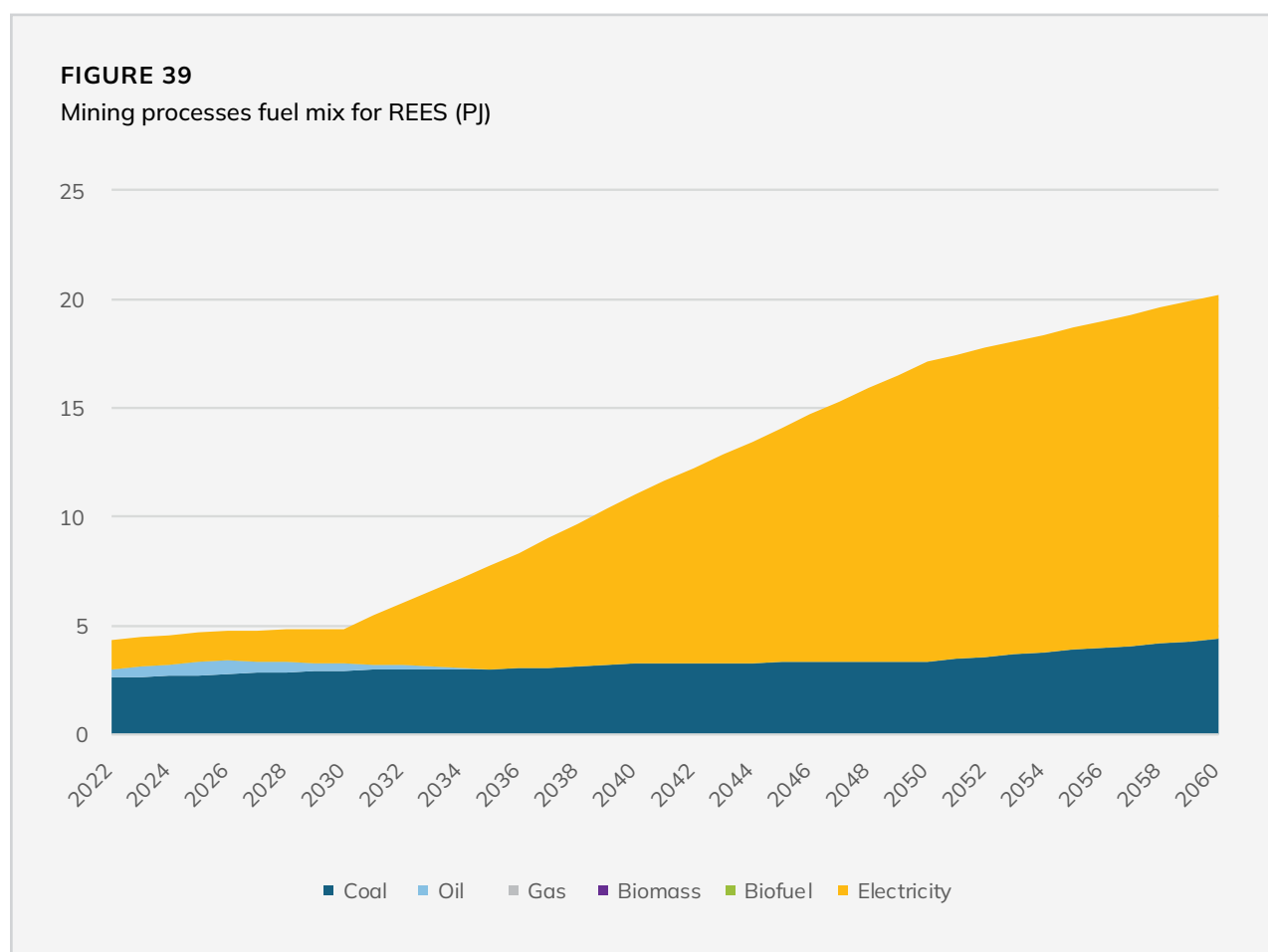


Transport-related CO₂ emissions decline to approximately 0.56 Mt CO₂ by 2050 under REES (Figure 38). The reduction is driven by accelerated adoption of electric vehicles and biofuels, with passenger-car and bus electrification providing important reductions in direct oil consumption and associated emissions. Freight emissions decrease more slowly, reflecting the longer replacement cycles and technological challenges associated with heavy-duty vehicles.

FIGURE 38Transport sector CO₂ emissions for REES (Mt CO₂)

4.4 Mining Sector

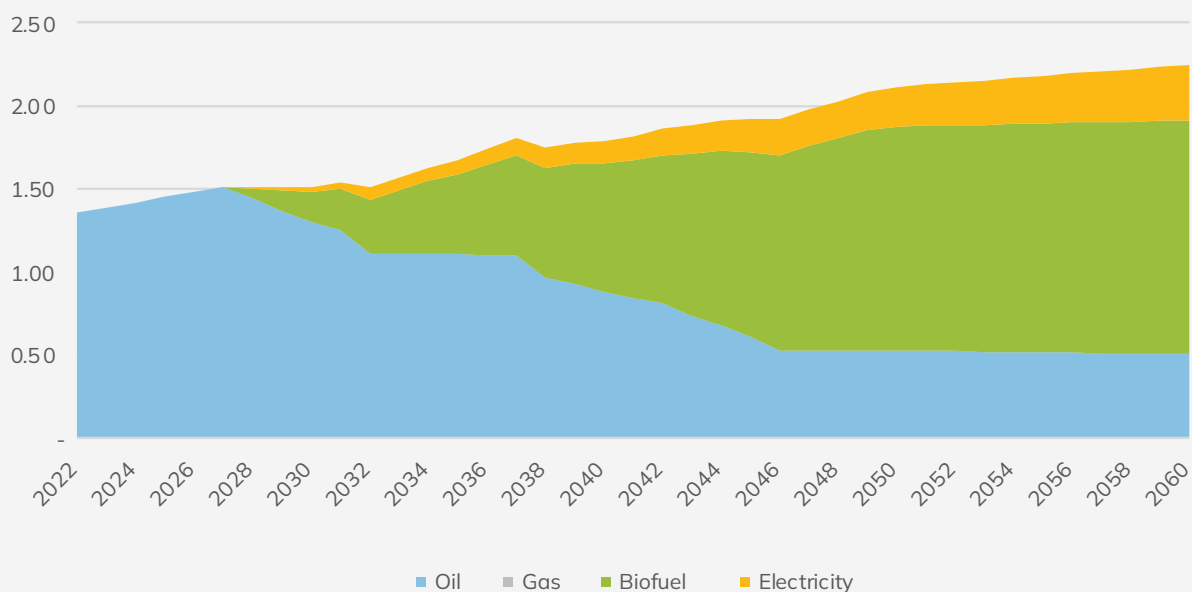
Mining-process energy demand reaches over 17 PJ by 2050 under REES (Figure 39). Electricity becomes the dominant energy carrier at approximately 14 PJ, while coal supplies around 3.4 PJ. The result reflects both stronger mining activity and substantial electrification of suitable mining processes.



Mining-transport energy demand reaches approximately 2.11 PJ by 2050 (Figure 40). Biofuel becomes the largest energy source at approximately 1.34 PJ, while oil falls to approximately 0.53 PJ and electricity reaches approximately 0.24 PJ. The result indicates a significant reduction in conventional oil dependence, although direct electrification of heavy mining transport remains limited. Continued technology development will therefore be required for battery-electric haulage, trolley-assist systems and other low-carbon options. This reflects the operational challenges of transitioning remote, high-load mining equipment, where alternative fuel options and supporting infrastructure remain limited.

FIGURE 40

Mining transport demand fuel mix for REES (PJ)

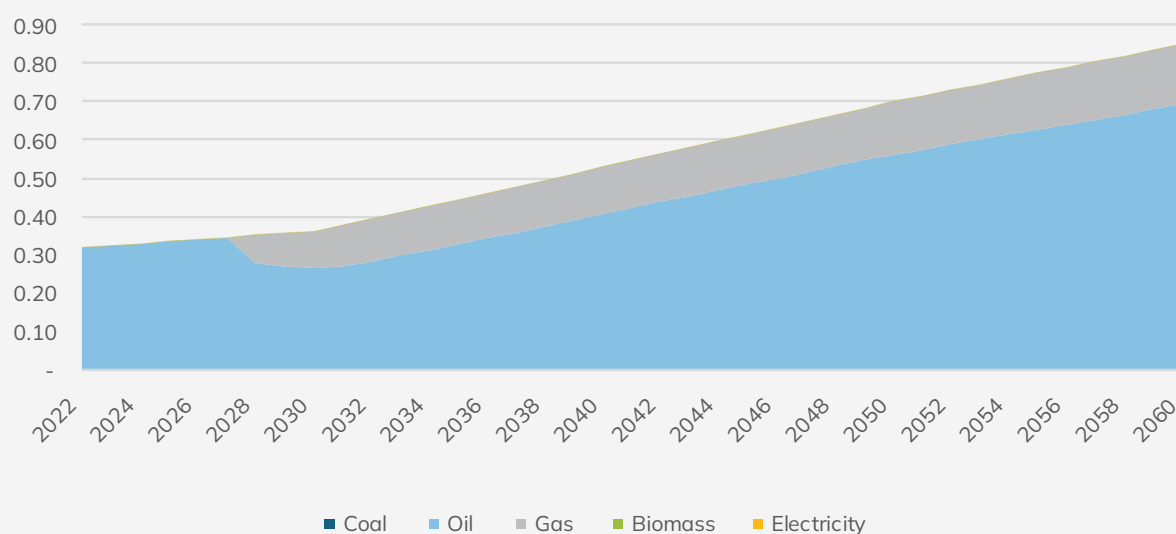


4.5 Industry Sector

High-temperature industrial energy demand reaches approximately 0.70 PJ by 2050 under REES (Figure 41). Oil remains the dominant energy source at approximately 0.56 PJ, while gas reaches approximately 0.14 PJ. High-temperature industrial processes therefore remain difficult to electrify within the modelled period.

FIGURE 41

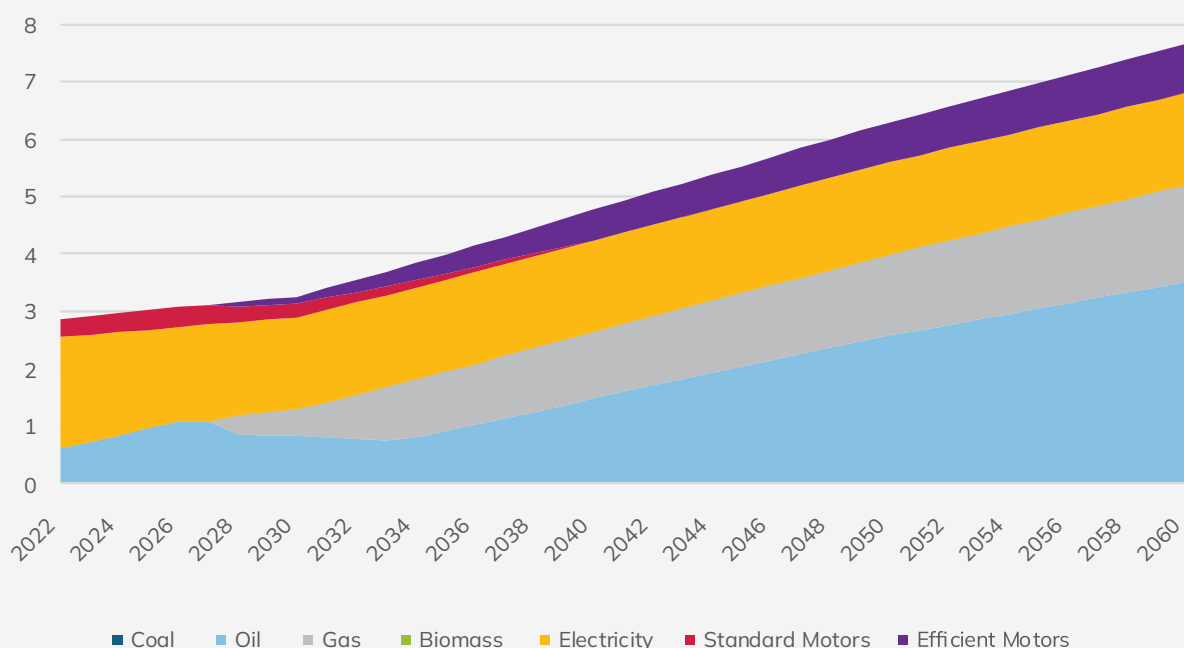
Industry sector high-temperature fuel mix for REES (PJ)



Low-temperature industrial energy demand reaches approximately 6.3 PJ by 2050 (Figure 42). The components plotted in Figure 42 comprise approximately 2.58 PJ of oil, 1.61 PJ of electricity, 1.42 PJ of gas and 0.70 PJ associated with efficient motors. Low-temperature heat demand gradually shifts towards gas and electricity, supported by improved efficiency and greater adoption of efficient motors. However, oil and gas are not fully phased out, as existing industrial infrastructure and technology constraints limit the pace of fuel switching.

FIGURE 42

Industry sector low-temperature fuel mix for REES (PJ)

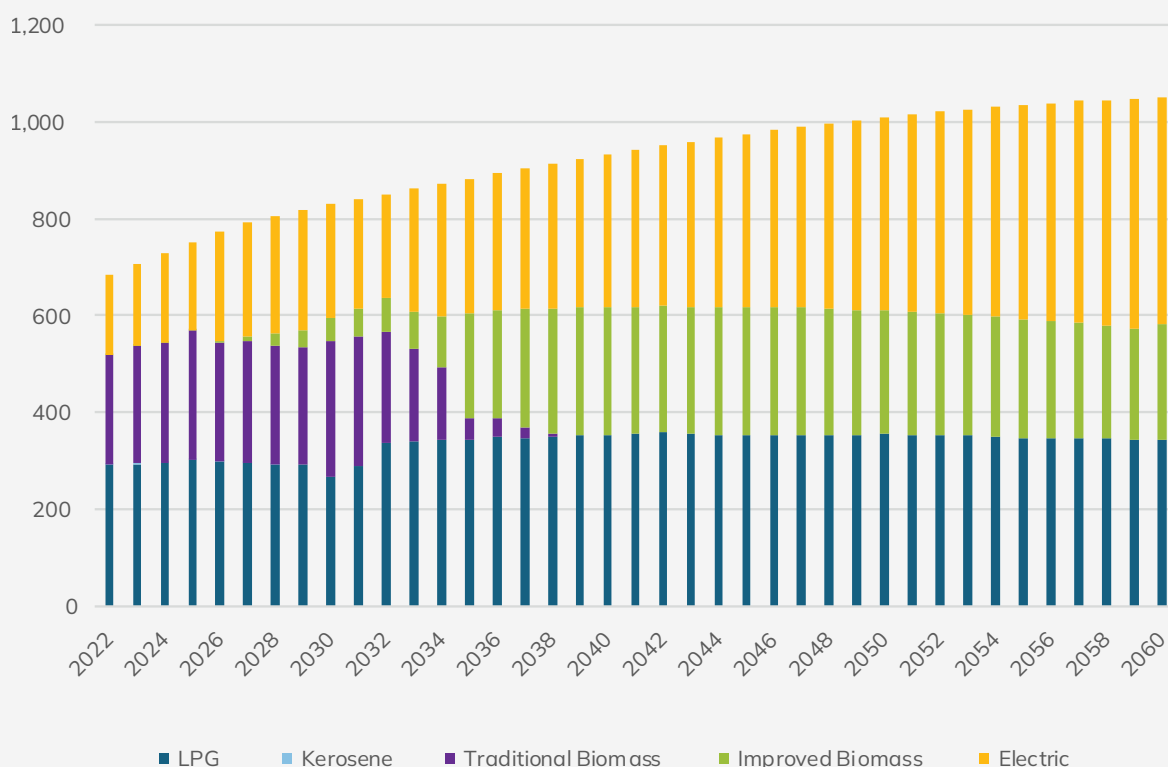


4.6 Clean Cooking

The total number of cookstoves increases from approximately 685,000 units in 2022 to 1 million units by 2050, reflecting household growth and rising demand for cooking services (Figure 43). The REES pathway achieves a faster transition towards electric cooking, with electric cookstoves reaching approximately 400,000 units by 2050. This shift is driven by stronger adoption of electric cooking technologies and reduced reliance on traditional biomass and LPG. Across both pathways, traditional biomass use decreases as households move towards improved biomass, LPG and electricity-based cooking solutions. However, LPG remains an available transition fuel, particularly where electricity access or reliability constraints limit immediate electrification.

FIGURE 43

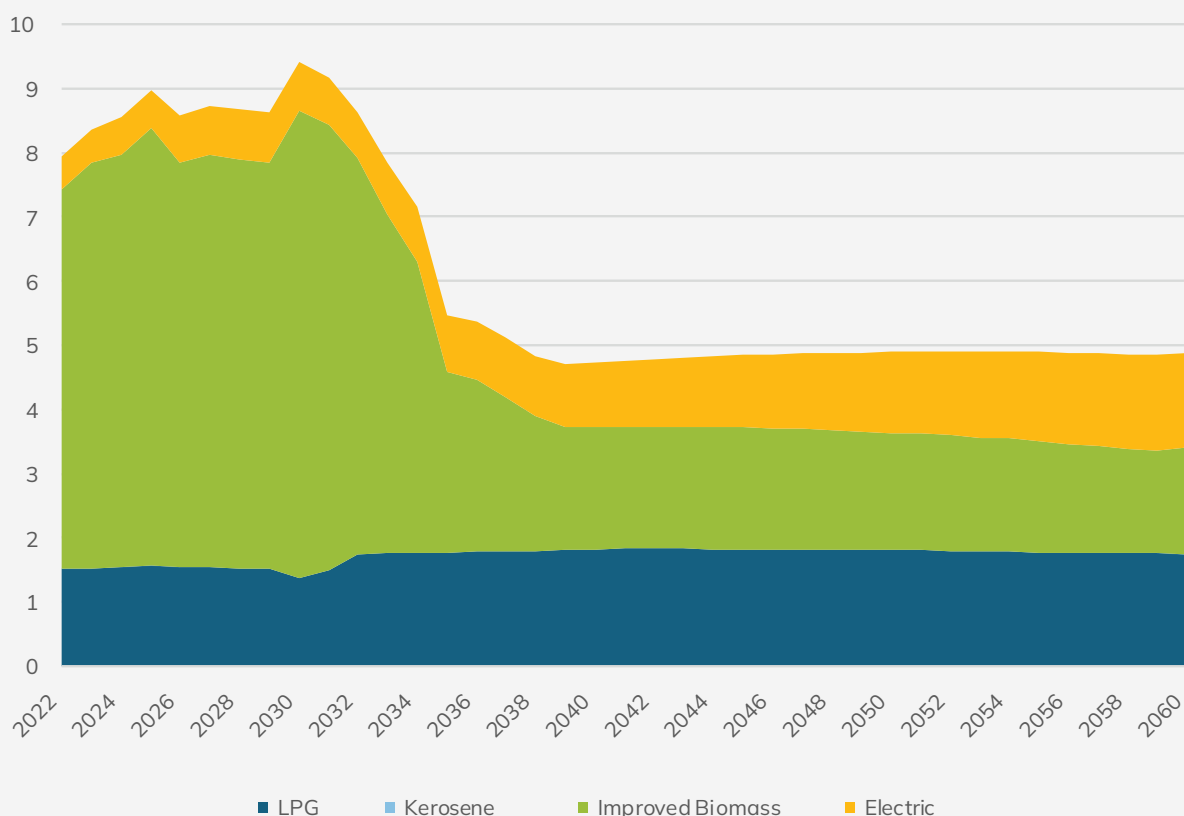
Residential sector cooking technology mix for REES (Thousands of units)



Cooking-fuel demand declines in both pathways despite growth in the number of households, reflecting improvements in cooking efficiency and a transition towards cleaner cooking technologies. The REES pathway achieves a further reduction in cooking energy demand, reaching approximately 4.9 PJ by 2050, driven by faster adoption of efficient and electric cooking technologies (Figure 44). Electricity consumption increases to around 1.3 PJ, reflecting greater uptake of electric cookstoves and improved access to electricity. Across both pathways, improved cookstoves reduce traditional biomass consumption, although biomass is not fully eliminated owing to affordability constraints, rural energy access limitations and continued reliance on locally available fuels. LPG adoption remains constrained by cost considerations, limiting its role as a long-term cooking solution.

FIGURE 44

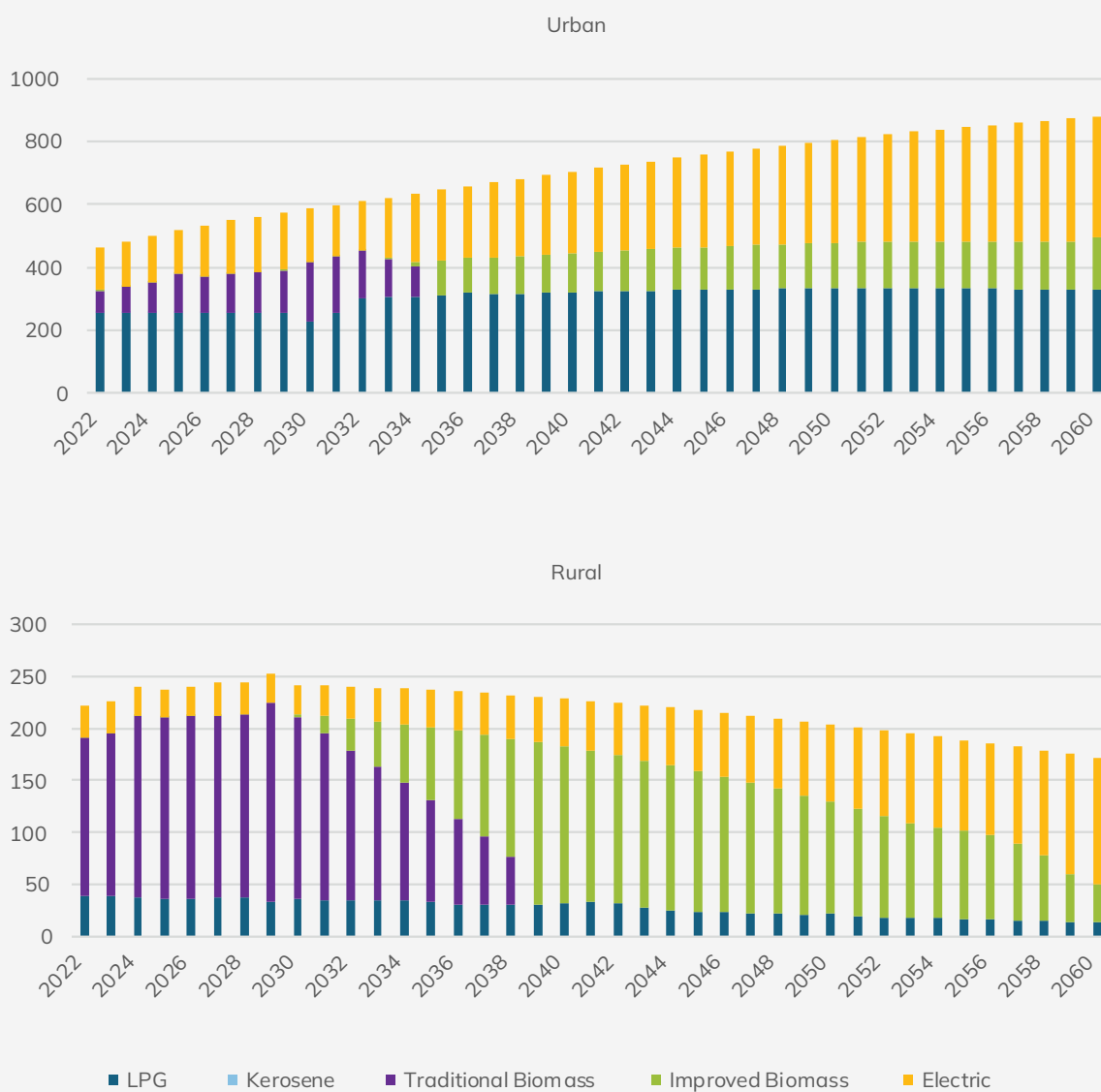
Residential sector cooking fuel mix for REES (PJ)



The distribution of cookstoves shifts significantly between urban and rural areas. Urban cookstoves increase from approximately 460,000 units in 2022 to 805,000 units by 2050, while rural cookstoves decline from around 220,000 to 204,000 units as households increasingly migrate towards urban areas (Figure 45). The REES pathway accelerates electrification, with urban electric cookstoves reaching approximately 330,000 units by 2050 and rural electric cookstoves increasing to around 72,000 units. While electricity access is mostly widespread across Botswana (80 percent in 2024) [14], rural households continue to retain a role for biomass owing to differences in cooking practices, fuel affordability, appliance costs and the relative availability of alternative fuels. Urbanization follows IIASA projections [10], resulting in a gradual shift of households towards urban areas where LPG supply chains and electricity access are more established. Improved biomass continues to serve as an important transitional solution in rural areas.

FIGURE 45

Residential sector urban and rural cooking technology mix for REES (Thousands of units)





Chapter 5

INVESTMENT OUTLOOK FOR RENEWABLE ENERGY AND ELECTRIFICATION PATHWAY 2050

5.1 Current Policy Scenario

5.1.1 Capital requirements

Under the Current Policy Scenario (CPS), cumulative capital investment reaches approximately USD 40 billion between 2022 and 2050, split between two streams of capital that differ fundamentally in how they would need to be financed (Table 5). Supply-side investments such as power generation, transmission and distribution, and battery storage reach approximately USD 7 billion, or around one-fifth of the total. This is new infrastructure that does not exist today and that the power sector and its financiers would need to actively plan, procure and finance: generation plant, network reinforcement and storage assets that would need project development and capital raising.

TABLE 5

Cumulative investment for CPS, split into supply (power, industry and mining, T&D network, batteries) and end-user (transport, clean cooking) investments

Sector	Project archetypes	2022–2050 (USD, billions)
Supply-side Investment needs		
Power	Solar PV, coal-bed methane and committed generation	3.5
T&D network	Transmission and distribution	3.8
Total		7.3
End-user investment needs		
Industry and mining	Mining and industry power infrastructure, high- and low-temperature heating processes	1.8
Transport	Electric two-wheelers, cars, buses, trucks	30.5
Clean cooking	Clean cookstoves	0.07
Total		32.4

End-use investment requires approximately USD 32.4 billion, of which transport accounts for the majority share at USD 30.5 billion, industry and mining account for USD 1.8 billion, and clean cooking and other related investments in the buildings sector account for only USD 70 million. This capital is of a different character. It corresponds overwhelmingly to vehicles, cookstoves and household equipment that Batswana consumers, businesses and fleet operators would purchase in any case, as part of the ordinary turnover of an ageing vehicle fleet and household capital stock.

This distinction, between capital that must be mobilised for the transition and capital that already flows through the economy regardless of pathway, is carried through the remainder of this chapter.

5.1.2 Operating costs

Cumulative operating expenditure under CPS reaches over USD 37 billion between 2022 and 2050 (Table 6), of a similar order of magnitude to cumulative capital expenditure. Power-sector operating costs reach approximately USD 2.3 billion. End-user operating expenditure reaches approximately USD 35 billion, majorly comprising transport, USD 1 billion for mining and industry and USD 65 million for clean cooking. Fuel expenditure is reported separately under cumulative fuel-and-trade costs (Figure 46).

The scale of cumulative OPEX relative to CAPEX underlines the importance of ongoing fuel and operating costs over the modelling period. Under CPS assumptions, coal and diesel-based generation continue operating in line with current policy, sustaining fuel-related operating costs; fuel prices and technology O&M costs are held consistent across all scenarios so that differences in outcomes reflect technology choice rather than cost assumptions. The Export sensitivity raises operating costs only marginally, as the additional generation it requires is small relative to the overall system.

TABLE 6

Cumulative operating cost for CPS, split into supply (power, industry & mining) and end-user (transport, clean cooking) investments

Cumulative Total Operating Cost (USD, billions)		
Sector	2022–2050	2050–2060
Power	2.3	0.9
End-User Operating Costs		
Industry & Mining	1.2	0.4
Transport	34	15
Clean cooking	0.1	0.03
Total End-User Operating Costs	35	15.43

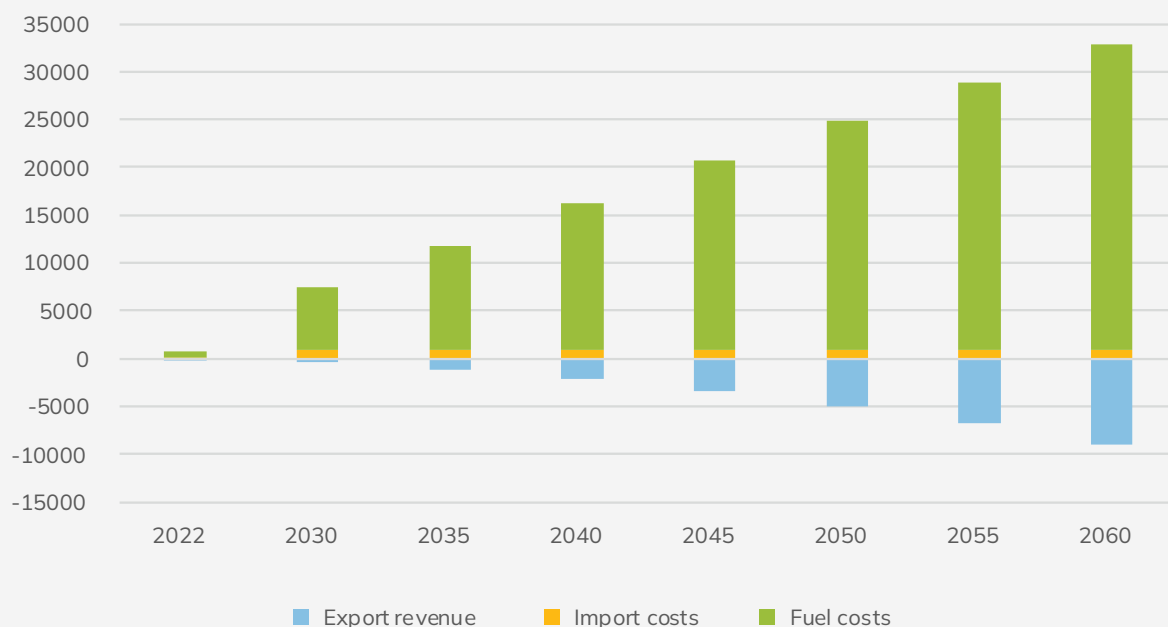
5.1.3 Revenue trade

Cumulative net fuel and trade cost under CPS reaches approximately USD 20 billion between 2022 and 2050 (Figure 46), comprising fuel expenditure of approximately USD 24 billion and electricity-import expenditure of USD 0.9 billion, offset by approximately USD 5 billion of modelled electricity-export revenue. Export revenues remain conditional on regional demand, interconnector capability, market prices and commercial arrangements, and are treated accordingly as an upside rather than a committed income stream.

Regional power trade is enabled under CPS but no additional export capacity is imposed exogenously; export volumes are determined by relative economic competitiveness under the assumed regional market conditions.

FIGURE 46

Cumulative revenue flow for CPS (USD millions)



5.2 Renewable Energy and Electrification Scenario

5.2.1 Capital requirements

Under REES, cumulative capital investment reaches over USD 43 billion between 2022 and 2050, approximately USD 5 billion or 13.3 percent above CPS (Table 7). Supply-side investment reaches nearly USD 11 billion, comprising USD 5 billion for power generation, USD 5.3 billion for transmission and distribution, USD 0.5 billion for battery storage and USD 890 million for industry and mining.

End-user investment reaches approximately USD 37 billion. Transport remains the largest investment category at over USD 32 billion, while clean-cooking and other building-related investment reaches USD 112 million (Table 7).

Compared to CPS, investments in mining under REES are significantly higher reflecting the electrification of mining equipment and vehicles and the shift to lower-temperature, cleaner processing routes. Unlike grid infrastructure, it is investment that mining companies undertake directly against their own project economics, financed predominantly through corporate and project finance rather than public or concessional sources.

TABLE 7

Cumulative investment for REES, split into supply (power, industry and mining, T&D network, batteries) and end-user (transport, clean cooking) investments

Investment		Cumulative Total Investment (USD billions)	
Sector	Project archetypes	2022–2050	2050–2060
Power	Solar PV, natural gas	5	3
T&D network	T&D	5	2
Batteries	Four-hour battery storage	1	1
Total		11	6
Mining	Mining equipment and vehicles, expansion of mining operations and processes	5	3
Industry	Clean mining, high- and low-temperature heating processes	0.1	0.03
Transport	Electric two-wheelers, cars, buses, trucks	32	15
Clean cooking	Clean cookstoves	0.1	0.05
Total		37.2	18.1

5.2.2 Operating costs

Under REES, cumulative operating expenditure reaches approximately USD 39 billion between 2022 and 2050, approximately USD 1.6 billion or 5 percent above CPS (Table 8). Power-sector operating expenditure reaches approximately USD 2.5 billion.

End-user operating expenditure reaches approximately USD 37 billion, comprising approximately USD 35 billion for transport, USD 1 billion each for mining and industry and USD 67 million for clean cooking. Fuel expenditure is reported separately under cumulative fuel and trade costs (Figure 47).

TABLE 8

Cumulative operating cost for REES, split into supply (power, industry and mining) and end-user (transport, clean cooking) investments

Operating cost	Cumulative Total Operating Cost (USD billions)	
Sector	2022–2050	2050–2060
Power	2.5	1.4
End-Use Sectors operating costs		
Mining	1	0.6
Industry	1	0.2
Transport	35	16
Clean cooking	0.1	0.03
Total of end-use sector operating costs	37	17

5.2.3 Revenue trade

Under REES, cumulative net fuel-and-trade costs reach approximately USD 14.2 billion between 2022 and 2050 (Figure 47). This comprises fuel expenditure of approximately USD 20.7 billion and electricity-import expenditure of USD 0.9 billion, offset by approximately USD 7.4 billion in modelled electricity-export revenue. Relative to CPS, REES reduces cumulative net fuel-and-trade costs by approximately USD 5.7 billion (Figures 46 and 47).

Under the REES export sensitivity, cumulative net fuel-and-trade cost reaches approximately USD 4 billion by 2050 (Figure 57). Fuel expenditure reaches USD 21 billion and electricity-import expenditure remains at USD 0.9 billion, while cumulative electricity-export revenue reaches nearly USD 18 billion.

Fuel costs remain the largest offset to gross revenues, although increased renewable deployment reduces exposure to fossil fuel costs over time. The expansion of solar, wind and storage capacity supports greater regional trade in low-carbon electricity, while coal phase-down limits thermal generation available for export. Lower import dependence results from increased domestic renewable generation, with future export revenues dependent on regional demand for clean electricity.

FIGURE 47

Cumulative revenue flow for REES (USD millions)



5.2.4 Incremental cost of the transition

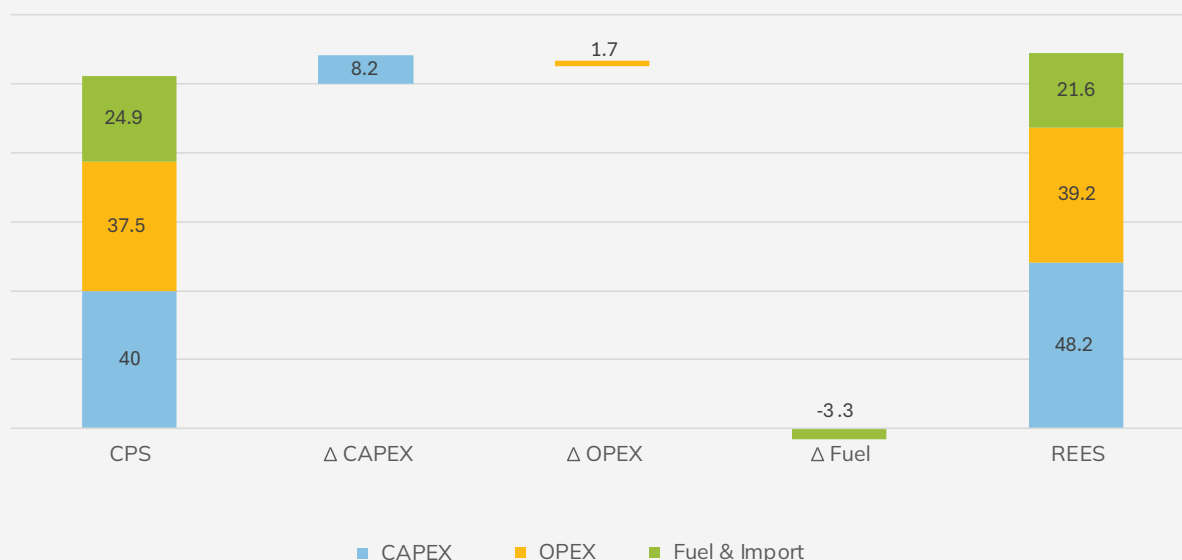
Comparing CPS and REES over the period from 2022 to 2050, the gross cumulative cost presented in Figure 48 increases from approximately USD 102 billion under CPS to USD 108 billion under REES. The REES pathway therefore has a gross incremental cost of approximately USD 6 billion, equivalent to around 6.4 percent higher than CPS or USD 100 million more annually. (Figure 48).

The increases in capital expenditure are partly offset by approximately USD 3 billion of fuel savings (Figure 48). Figure 48 presents fuel and import expenditure on a gross basis and does not deduct modelled electricity-export revenue. When export revenue is considered separately through Figures 46 and 47, REES reduces cumulative net fuel and trade costs by approximately USD 5.7 billion relative to CPS.

Although the REES scenario requires a modest increase in overall cumulative system costs, it strengthens Botswana's long-term energy security by reducing exposure to imported fuels and international fuel-price volatility. Furthermore, the expansion of low-carbon generation and electricity exports positions Botswana as a major electricity supplier within the Southern African Power Pool, creating additional economic opportunities while supporting the development of a more resilient, low-carbon electricity system.

FIGURE 48

Total cumulative costs (2022–2050) for CPS and REES (USD billions)



5.2.5 Financing strategy and sources of capital

The financing of the Renewable Energy and Electrification Scenario needs to draw on three main sources of capital. Cumulative supply-side investment reaches approximately USD 11 billion to 2050 (Table 8). Power generation accounts for approximately USD 4.979 billion and battery storage a further USD 0.527 billion, while transmission and distribution require approximately USD 5.331 billion.

Private capital needs to fund the large-scale solar and battery storage. This would need to be raised through independent power producers under long-term power purchase agreements, building on the agreements already signed for solar. These projects can attract finance at competitive rates, given Botswana's investment-grade standing and strong solar resource.

Public funds or public-private partnership models would need to be used mainly for the transmission and distribution network. The government would need to focus these funds on the network and on rural access. Network investment also needs to follow committed projects on generation. Concessional and blended finance from development partners needs to bridge the gap. This means first-of-a-kind assets such as grid-scale storage and export-corridor transmission, guarantees and payment security facilities that lower the cost of private borrowing, and a project-preparation facility that turns the pipeline into bankable projects.

Two further sources need to complete the framework. Domestic funds, in particular the country's pension funds, need to be channelled into local-currency energy infrastructure, which also removes the currency risk that would otherwise fall on the country.

End-user capital requirements reach approximately USD 37 billion, of which approximately USD 32 billion relates to transport and USD 5 billion for an expanded mining sector (Table 8). Mining-sector capital, the largest single increment at USD 3.120 billion, is expected to be financed predominantly by mining companies themselves, through corporate balance sheets and project finance against their own equipment and processing investments; government's role here is chiefly to ensure that power tariffs, connection processes and equipment-import arrangements do not unnecessarily slow electrification that the sector already has a commercial incentive to pursue.

Further for transport and clean cooking, rather than mobilising new capital these sectors would require narrowing the price gap between clean and conventional options at the point of purchase. Consumer and fleet finance products that spread the EV price premium over the vehicle's life, targeted duty or tax treatment on electric vehicles and clean cookstoves, results-based incentives tied to verified uptake, and, for lower-income households, subsidised or concessional financing for cookstove replacement. Consumer finance, fleet finance, concessional lending, results-based mechanisms and targeted public support will therefore be important alongside infrastructure finance.





Chapter 6

POLICY IMPLICATIONS AND THE PATH FORWARD

6.1 Policy Context

The REES Domestic scenario describes Botswana's domestic energy transition pathway beyond current policy commitments. By 2050, the scenario targets at least 70 percent low-carbon installed generation capacity, 70 percent electrification of passenger and bus travel, 80 percent of household final energy supplied by electricity and other clean fuels, 75 percent electrification of mining demand and 50 percent electrification of industrial demand (Table 1).

Under REES Domestic, electricity generation reaches approximately 18.86 TWh and installed generation capacity approximately 5.89 GW by 2050 (Figures 29 and 31). Solar PV becomes the largest generation source and reaches approximately 4.28 GW of installed capacity, while battery storage reaches approximately 1.24 GW (Figures 31 and 32). Transport final energy demand declines to approximately 43.1 PJ (Figure 33), mining-process electricity use reaches approximately 13.76 PJ (Figure 39), and electric cookstoves reach approximately 400,000 units by 2050 (Figure 43).

The transition requires cumulative capital expenditure of over USD 43 billion between 2022 and 2050 (Table 8 and Figure 48). Transport represents the largest capital requirement, followed by transmission and distribution, power generation and battery storage. Successful implementation will therefore depend on predictable regulation, long-term infrastructure planning, competitive procurement, private investment, targeted public financing and strengthened institutional capacity.

6.2 Economy-wide Implementation Framework

The REES Domestic pathway provides a national transition framework that connects electricity planning, transport, mining, industrial policy, clean-cooking programmes, the NDC and Vision 2036. Implementation is structured around milestones in 2030, 2040, 2050 and 2060, with responsibilities distributed across various ministries and agencies, including the Ministry of Minerals and Energy (MME), BERA, BPC, the Ministry of Local Government and the Ministry of Environment.

A comprehensive monitoring system should track renewable energy capacity, electricity generation, grid investments, vehicle technology, clean-cooking adoption, industrial and mining electrification, fuel imports, and investments, as well as emissions. Since REES emissions peak around 2046 at 9.3 Mt CO₂ before decreasing, reporting should distinguish sector emissions from electricity-related emissions to ensure that electrification aligns with power sector decarbonization.

Regional practices support a regularly updated planning framework. South Africa's Integrated Resource Plan links demand, generation, storage and retirement schedules. Similar cycles in Botswana would allow for adjustments as demand, technology costs and system conditions change.

6.2.1 Power sector

The power sector is central to the REES Domestic pathway. By 2050, electricity generation reaches approximately 18.86 TWh and installed generation capacity approximately 5.89 GW (Figures 29 and 31). Solar PV accounts for approximately 4.28 GW of capacity and 8.46 TWh of annual generation, supported by approximately 1.24 GW of battery storage and dispatchable generation required to maintain system reliability (Figures 29, 31 and 32). Utility-scale renewable generation, storage and expanded transmission and distribution can be procured through competitive bidding supported by standardized PPAs, transparent grid-connection rules and published commissioning schedules.

South Africa's REIPPP demonstrates how competitive bidding processes and long-term PPAs effectively attract private investments. Meanwhile, Namibia employs a feed-in scheme complemented by competitive bidding procedures. For Botswana, a pivotal approach involves implementing a tiered procurement framework tailored to its market size, utility infrastructure and project pipeline. Distributed generation can be facilitated through mechanisms such as net billing or net metering regulations, standardized connection procedures, requirements for smart meters, and transparent export compensation policies, as exemplified by Zambia and Zimbabwe.

Open access and wheeling would also enable mines and large industrial consumers to procure renewable energy directly, with applicable network-use charges, loss factors, balancing obligations and settlement arrangements. This approach could broaden private-sector participation while retaining appropriate safeguards for the utility and public finances.

A comprehensive grid development plan must outline renewable zones, priority substations, mining and industrial corridors, EV load centres and areas needing reinforcement for electric cooking. It is essential to adopt a proactive approach to grid development, as transmission assets typically require longer lead times than solar projects. Utility performance measures might include reliability, technical losses, connection durations, renewable energy curtailment and customer service excellence.

Battery storage would require dedicated regulations on licensing, tariffs, safety and decommissioning, starting with long-term contracts for reserves and advancing to competitive ancillary services.

The REES pathway suggests that additional unrestrained coal investments beyond existing commitments are inconsistent with long-term decarbonization objectives. This necessitates regular evaluations of existing plants, stricter environmental standards, reduced utilization, funding for rehabilitation initiatives, and worker transition strategies. Strategic capacity planning should not depend exclusively on high annual generation figures.

6.2.2 Transport sector

Transport is the largest investment under the REES Domestic scenario and plays a key role in reducing oil demand. Its implementation requires a comprehensive framework that includes vehicle standards, public procurement policies, charging infrastructure, fiscal measures and the promotion of low-carbon fuels. Special focus should be placed on high-usage sectors such as buses, government fleets, taxis, delivery vehicles and motorcycles.

The model predicts the deployment of 1,500 electric motorcycles, 360,000 electric passenger vehicles, 48,000 electric buses and 24,000 electric freight trucks by 2050. Transport-related emissions could drop to approximately 0.56 Mt CO₂ by 2050, although the sector remains the most challenging to decarbonize.

A national e-mobility strategy could set targets for government procurement, urban buses, commercial fleets and the development of charging infrastructure. South Africa's Electric Vehicles White Paper offers a regional approach that links vehicle adoption, industry and the transition from internal combustion engines [16]. Botswana's strategy should focus on adoption, charging, servicing and aligning regional standards.

Vehicle taxation policies could be aligned with emissions and efficiency metrics, including time-bound measures such as reduced import duties, registration benefits and concessional loans. These measures should be reviewed periodically as related costs decline. Broad, permanent purchase subsidies would have significant fiscal implications, as transport accounts for the majority of REES capital expenditure.

A comprehensive national charging plan should encompass urban areas, highways, bus depots, taxi ranks, mines and logistics hubs. EV-ready standards could initially be implemented in new public buildings, commercial properties and parking facilities. Managed charging for large fleets would help reduce the load on the grid and promote solar energy use during daylight hours.

Bus electrification should be incorporated into comprehensive public transportation upgrades, including route planning, depot investment, service agreements and fleet renewal efforts. Freight policies would initially focus on efficiency, biofuel use and demonstration projects for battery-electric or trolley-assisted trucks, with regional standards aligned through collaboration with regional (SADC) countries.

Expanding biofuels requires establishing quality and sustainability standards, along with emission limits and protections for land and water use, especially for freight and legacy fleets where direct electrification remains technically or economically limited.

6.2.3 Mining and industry sectors

Mining and industrial electrification can promote decarbonization and diversify the economy. Under REES Domestic, electricity becomes the dominant energy source for mining, and low-temperature industrial processes increasingly rely on electricity. Residual fossil fuel use continues in high-temperature processes with limited technological options.

Mine-level energy transition plans would support monitoring renewable procurement, stationary equipment, pumping, ventilation, processing, vehicle replacement and emissions. For new licences and major expansions, these plans could be integrated into project approval and reporting. Existing operations could be gradually incorporated into the framework based on mine size and asset lifespan.

Open access and corporate PPAs would enable mines and industries to directly contract for renewable electricity and co-invest in transmission, storage and local generation. Sector milestones would enhance renewable procurement and reduce diesel consumption in stationary applications where electric options are available.

The ongoing reliance on oil for mining transportation underscores the need for targeted technology pilots, such as battery-electric haul trucks, trolley-assist in pit crushing and conveying, renewable fuels and hydrogen applications. Technology choices should consider mine design, haul distances and infrastructure factors.

Industrial policies would establish standards for motors, low-temperature heat and high-temperature processes by setting minimum performance criteria for motors, pumps, compressors, boilers and transformers. Major users could implement energy-management systems and conduct audits, supported by performance-based incentives for energy savings.

South Africa's energy-efficiency framework includes performance disclosures and verified measures; Zimbabwe's lighting standards specify minimum performance criteria; and Botswana is encouraged to continue its participation in the SADC MEPS verification and enforcement harmonization programmes. Industrial finance options may include loans, guarantees, grants and energy service contracts, with hydrogen reserved for applications that are difficult to electrify.

6.2.4 Buildings, households and clean cooking

The household transition will incorporate electric cooking, LPG, improved biomass and decentralized electricity supply, depending on location and affordability. REES Domestic aims to reach about 400,000 electric cookstoves by 2050, including 330,000 in urban areas and 72,000 in rural areas. Overall demand for cooking fuels is expected to decrease owing to the adoption of more efficient electric and improved stoves, but biomass use is not entirely phased out.

An integrated clean-cooking programme would include access to electricity, appliance financing, household wiring, network reinforcement, consumer information and after-sales support. Urban initiatives emphasize electric cooking, while in rural areas, a mix of electricity, LPG and certified improved biomass systems are used until a reliable and affordable supply is available.

Targeted financing options include on-bill repayment, concessional credit or results-based support, primarily helping low-income households cover connection and appliance costs, rather than providing broader electricity subsidies.

Building energy codes could establish phased standards for lighting, cooling, water heating, insulation and EV readiness. Larger buildings might gradually disclose their energy performance. South Africa's energy certificates serve as a regional model, although Botswana would need to adapt the coverage and enforcement.

It is recommended to set minimum standards and labelling requirements for lighting, cookstoves and water heaters as supplements to the existing minimum energy performance standards (MEPS) for domestic refrigerators and air conditioners, with strict enforcement to prevent the spread of inefficient products that could impact household expenses and electricity planning.

6.2.5 Finance, skills and delivery

Implementation would integrate public investment, private finance and concessional capital. Public resources are targeted towards transmission, rural access, public transportation, project preparation, government buildings and capacity-building. Private financing supports renewable energy, distributed energy systems, electric vehicle charging infrastructure, commercial fleets, mining PPAs and industrial efficiency initiatives.

Zambia's renewable energy financing initiatives, including GET FiT and support mechanisms for small and medium independent power producers (IPPs), exemplify the role of technical assistance and viability-gap funding in helping projects reach financial closure. Namibia's National Energy Fund serves as an example of using dedicated energy funding to support renewable energy projects, improve network support and promote affordability measures. The main lesson for Botswana is the importance of establishing a stable platform for project preparation and financing, rather than simply copying a single fund model.

A national project-preparation facility could assist with conducting feasibility studies, environmental assessments, transaction advice and tender preparation. Government guarantees could be used selectively after addressing regulatory and contractual risks, where the risk of a clear market failure remains.

Skills development programmes should encompass training in solar and battery installation, grid engineering, electric vehicle maintenance, charging systems, industrial energy management and electric cooking. Procurement initiatives may include training and apprenticeship opportunities. Local-content measures ought to focus on regions with domestic potential, such as structures, cables, switchgear, assembly, construction, operations, maintenance and recycling.

6.3 Implementation Priorities

Period	Priority Actions
Until 2030	Adopt the REES implementation framework; launch rolling RE and BESS procurement; issue open-access, wheeling and net-billing rules; complete the grid plan; establish EV and charging standards; begin e-bus procurement; require transition plans from major mines; introduce building codes and continue with the SADC harmonized appliance minimum energy efficiency standards.
2030–2040	Scale renewable generation and networks; expand storage; accelerate EV and clean-cooking uptake; electrify suitable mining and industrial equipment; restrict new unabated coal to committed projects; establish industrial efficiency incentives and heavy-transport pilots.
2040–2050	Achieve 85 percent low-carbon electricity generation capacity; reach the sectoral electrification targets for transport, households, mining and industry; reduce coal utilization; expand demand response and storage; strengthen regional electricity trade.
2050–2060	Replace retiring RE and battery assets; address residual fossil fuel use in freight, mining transport and high-temperature industry; move towards universal modern cooking and review the requirement for remaining coal and gas capacity.

6.4 The Path Forward

Botswana's Renewable Energy and Electrification Scenario (REES) framework charts a bold path towards an inclusive, efficient and climate aligned power system. It begins with scaling renewable generation and networks, expanding solar and wind capacity while modernizing the grid to connect communities and industries. This foundation enables the next leap: expanding energy storage and demand response systems that stabilize supply and unlock flexibility across the economy.

The framework prioritizes electrification of key sectors – transport, mining, industry and households – ensuring clean mobility and the productive use of electricity. Additionally, Botswana will restrict new unabated coal to committed projects.

Efficiency incentives and heavy-transport pilots will drive innovation, proving the viability of electric freight. By 2040, these coordinated actions aim to deliver 85 percent low carbon electricity generation, deep sectoral electrification and strengthened regional electricity trade through the SAPP.

Until 2030 (Short term)

Botswana establishes the base of its energy transition by scaling solar and wind to reach low-carbon capacity. Pilot projects in energy storage, electric buses and clean cooking begin. Grid modernization ensures renewable power can reach households and industries.

Lead	Activity	Action	Indicator
MME	Adopt the REES	Institutionalize the REES as a guiding national plan	Adopt the REES
MME	Revise the IRP	Align the REES with the IRP, as a high renewable scenario for the IRP	Revise the IRP
MME/ BOBS	Develop efficiency standards for electrical appliances	Adopt SADC-harmonized appliance and equipment minimum energy efficiency standards (MEPS)	Develop efficiency standards for electrical appliances
BERA	Open-access regulations and battery storage regulations	Establish regulations for wheeling, net-billing and third-party access to the grid	Open-access regulations and battery storage regulations
BERA	Battery storage regulations	Provide regulations for integrating storage systems into the grid	Battery storage regulations
MME (Dept. of Mines)	Mining transition plans	Require transition plans from major mining companies	Mining transition plans
BPC	Rolling RE and BESS procurement	Launch competitive bidding for solar, wind and battery storage to gradually expand generation capacity	Rolling RE and BESS procurement
BPC	Grid-plan completion	Finalize and implement the national transmission and distribution modernization plan	Grid-plan completion
MTI/ BOBS	EV standards and e-bus procurement	Establish electric vehicle and charging infrastructure standards Start procurement of electric buses for urban transport	EV standards and e-bus procurement

2030–2040 (Medium term)

The country accelerates its energy transition, achieving 85 percent low-carbon electricity generation. Sectoral electrification advances: EV adoption grows, mining and industry shift to electric systems, and households adopt clean cooking at scale. Large-scale battery storage and demand-response programmes stabilize the grid, while regional electricity trade expands through the SAPP.

Lead	Activity	Action	Indicator
BERA and IPPs	Scale renewable generation	Commissioning of solar, wind, CSP (MW)	Percentage of low-carbon capacity
BPC and IPPs	Expand storage	Deploy BESS (MW)	Percentage of peak demand met by storage
MTI/MME	EV and clean-cooking uptake	Incentivize EV adoption, scale modern cooking solutions	Percentage of EV penetration Percentage of clean-cooking access
MME and industry	Mining and industrial electrification	Electrify mining equipment and industrial processes	Percentage of electrification of mining equipment
MME	Coal restrictions	Limit new unabated coal to those already committed	Percentage of coal share
MME	Industrial efficiency incentives	Tax breaks and subsidies for efficient processes	Percentage of reduction in industrial energy intensity
MTI	Heavy-transport pilots	Electric freight pilots	Percentage of freight electrified by 2040

2040–2050 (Medium term)

Coal is phased out and Botswana consolidates its clean energy gains. Universal electrification is achieved across households, transport, mining and industry. Storage capacity expands, ensuring flexibility and resilience. Efficiency incentives and industrial retrofits lock in long-term sustainability, edging the nation closer to decarbonization.

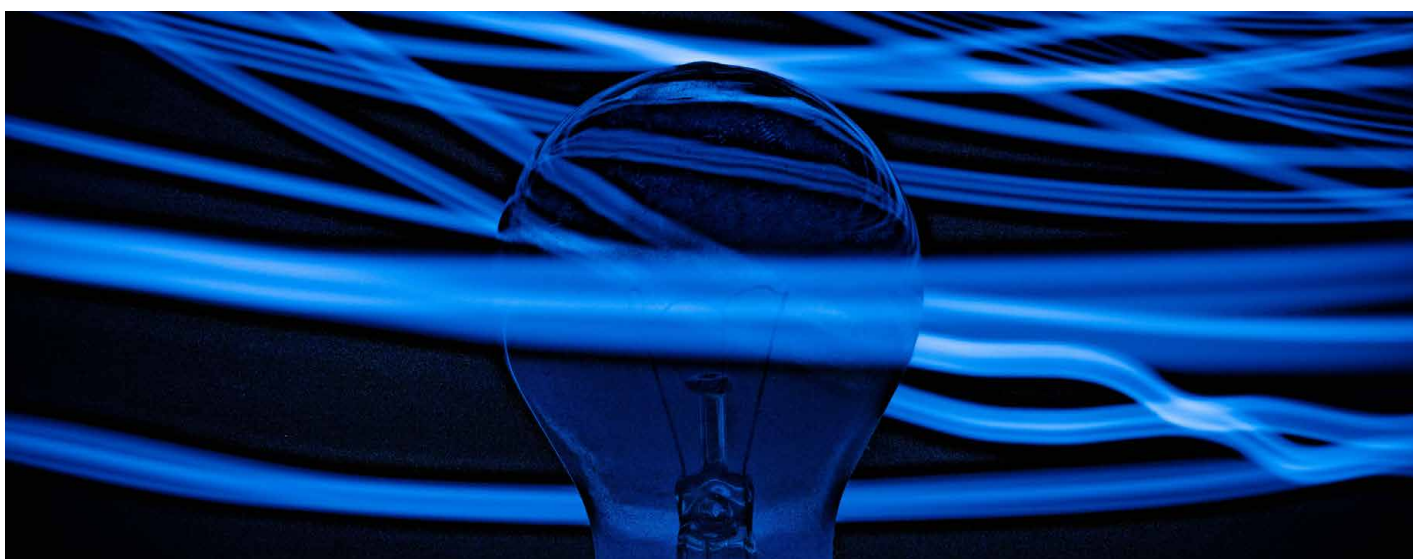
Lead	Activity	Action	Indicator
MME/BPC	Low-carbon electricity generation capacity	Reduce coal utilization	Percentage of coal generation
MME, MIT, mining and industry	Sectoral electrification targets	Reach the sectoral electrification targets for transport, households, mining and industry	Percentage of electrification target reached for sectors
BPC	Demand response and storage	Scale BESS and introduce demand-response programme	BESS capacity installed and percentage of demand reduction achieved
BPC	Strengthening regional electricity trade	Expand interconnection and increase SAPP electricity trade	Percentage of electricity trade in SAPP



2050–2060 (Decarbonized)

Botswana completes its transformation into a decarbonized economy powered entirely by renewables. Transport fleets, mining operations and industries are highly electrified, and the nation emerges as a clean energy export hub. With universal demand response and modernized infrastructure, Botswana secures its energy future while strengthening Southern Africa's collective resilience.

Lead	Activity	Action	Indicator
MME (PIU) and IPPs	Replace retiring assets	Renew solar, wind and battery assets	Percentage replacement of retiring RE assets
MME, mining and industry	Residual fossil fuel phase-out	Address fossil use in freight, mining transport, high-temperature industry	Fossil share percentage
MME and NGOs	Universal modern cooking	Achieve nationwide clean-cooking access	Percentage of modern cooking access
MME	Coal and gas review	Assess need for residual coal/gas capacity	Percentage of decarbonization



BIBLIOGRAPHY

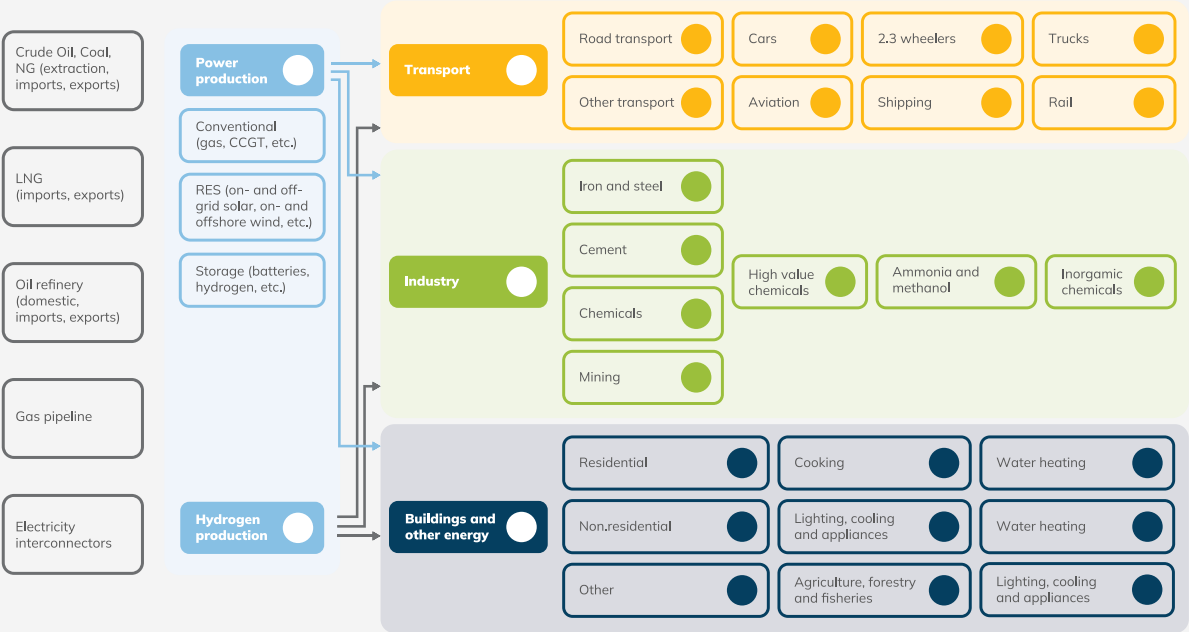
- [1] M. Howells et al., “OSeMOSYS: The Open Source Energy Modeling System: An introduction to its ethos, structure and development”, *Energy Policy*, vol. 39, no. 10, pp. 5850–5870, October 2011. Available at: <https://doi.org/10.1016/j.enpol.2011.06.033>.
- [2] F. Plazas-Niño, N. Tan, M. Howells, V. Foster and J. Quirós-Tortós, “Uncovering the applications, developments, and future research directions of the open-source energy modelling system (OSeMOSYS): A systematic literature review”, *Energy for Sustainable Development*, vol. 85, 101629, April 2025. Available at: <https://doi.org/10.1016/j.esd.2024.101629>.
- [3] Statistics Botswana, “Data Portal”. Accessed 24 July 2026. Available at: <https://www.statsbots.org/bw/data-portal-0>.
- [4] Government of the Republic of Botswana, “National Energy Policy”, 2021.
- [5] Government of the Republic of Botswana, “Integrated Resource Plan for Electricity for Botswana”, 2020.
- [6] Government of the Republic of Botswana, “Botswana’s 2nd Updated Nationally Determined Contribution under the Paris Agreement”, 2024.
- [7] Government of the Republic of Botswana, “National Energy Compact for Botswana”, 2025.
- [8] Botswana Vision 2036 Presidential Task Team, “Vision 2036”, 2016.
- [9] Government of the Republic of Botswana, Ministry of Finance, “Botswana’s Economic Transformation Programme (BETP): Forging a Resilient Future”.
- [10] IIASA, “Shared Socioeconomic Pathways Scenario Database (SSP)”. Accessed 23 July 2026. Available at: <https://iiasa.ac.at/models-tools-data/ssp>.
- [11] DailyNews, “Mining Wealth Hinges on Innovation”. Accessed 29 July 2026. Available at: <https://dailynews.gov.bw/news-detail/90442>.
- [12] Lucara Diamond, “News Releases”. Accessed 29 July 2026. Available at: <https://lucaradiamond.com/newsroom/news-releases/2022-guidance-achieved-across-all-metrics-shaft-s-122856/>.
- [13] Debswana, “Our Environment”. Accessed 29 July 2026. Available at: <https://www.debswana.com/our-environment/>.
- [14] The World Bank, “World Bank Open Data”. Accessed 24 July 2026. Available at: <https://data.worldbank.org/>.
- [15] World Integrated Trade Solution, “Botswana Electrical energy imports by country in 2023”. Accessed 30 July 2026. Available at: <https://wits.worldbank.org/trade/comtrade/en/country/BWA/year/2023/tradeflow/Imports/partner/ALL/product/271600>.
- [16] Government of South Africa, “Electric Vehicles White Paper”, 2023.



Appendix A

MODEL DEVELOPMENT

FIGURE 49
SEM reference energy system for Botswana



Appendix B

DATA ASSUMPTIONS

Table 10 and Table 11 present the technical assumptions used in the modelling.

TABLE 10
Capacity factors for power plants

Power plant	Average maximum	Average minimum
Biomass	0.86	0.4
Coal with CCS		0.5
Coal IGCC		0.5
Coal supercritical		0.5
Coal subcritical		0.5
Coal ultra-supercritical		0.5
Geothermal	1	0.8
Hydropower	0.37	
Natural gas combined cycle		0.1
Nuclear		0.8
Small hydropower	0.24	
Utility-scale solar PV	0.18	
Offshore wind	0	
Onshore wind	0.29	

TABLE 11

List of current/planned power plants

Current power plants	Installed capacity (MW)	Fuel input	Year of installation	Retirement date
Morupule A	132	Coal	1989	December 2029
Morupule B	600	Coal	2014	
Orapa diesel	90	Diesel	2010	
Matshelagabedi diesel	72.54	Diesel	2011	
Bobonong, Kasane, Maun, Charleshill, Serowe, Lobatse Molepolole, Ghanzi, Tsabong, Kang, Tutume	188	Solar PV	2024–2026	
Phakalane solar plant	1.3	Solar PV	2012	
Mmadinare solar PV	100	Solar PV	2025	
New coal power plant phase 1 – Mmamabula	300	Coal	2026/2027	
New coal power plant phase 2 – Mmamabula	300	Coal	2027/2028	
Jwaneng solar PV	100	Solar PV	2026	
Solar PV IPP – 335 MW pipeline	335	Solar PV	2030	
Coal-bed methane (CBM)	100	CBM	2025	
Letlhakane	100	Wind	2030	
Different locations (Maun, Selbi, Jwaneng)	140	Battery	2028	
Maun	2 x 250	Solar PV	2027	
Letlhakane	2 x 200	Solar PV	2027	
Isang	2 x 200	Solar PV	2028	
Morupule	615	Coal	2028	Scrapped
Rooftop solar total capacity	24 (maximum 75)	Solar PV	2022	Multiple locations

Appendix C

EXPORT SCENARIOS

Each scenario is assessed under both Domestic and Export configurations. This section presents the power-sector results for the Export cases (Figures 50 to 57), which are referenced throughout the main text. The Export variants retain the underlying CPS and REES assumptions while allowing additional generation, storage and network investment where regional electricity exports are economically attractive.

By 2050, electricity generation reaches approximately 16.93 TWh under CPS Export and 22.33 TWh under REES Export (Figure 51). Electricity imports are negligible in both cases by 2050 (Figure 52), while modelled exports reach approximately 8.48 TWh in both scenarios (Figure 53). Installed generation capacity reaches approximately 5.75 GW under CPS Export and 7.57 GW under REES Export (Figure 54), while BESS capacity reaches approximately 3.35 GW and 4.67 GW respectively (Figure 55). Energy-related emissions reach approximately 6.45 Mt CO₂ under CPS Export and 7.58 Mt CO₂ under REES Export in 2050 (Figure 56).

The additional export-oriented infrastructure increases cumulative investment requirements. By 2050, cumulative CAPEX reaches approximately USD 41.171 billion under CPS Export and USD 46.300 billion under REES Export, while cumulative OPEX reaches approximately USD 37.524 billion and USD 39.261 billion respectively (Tables 12 and 13). Cumulative net fuel-and-trade costs reach approximately USD 6.473 billion under CPS Export and USD 3.602 billion under REES Export (Figure 57).



FIGURE 50

Power sector fuel consumption for the CPS-BAU and REES Export scenarios (PJ)

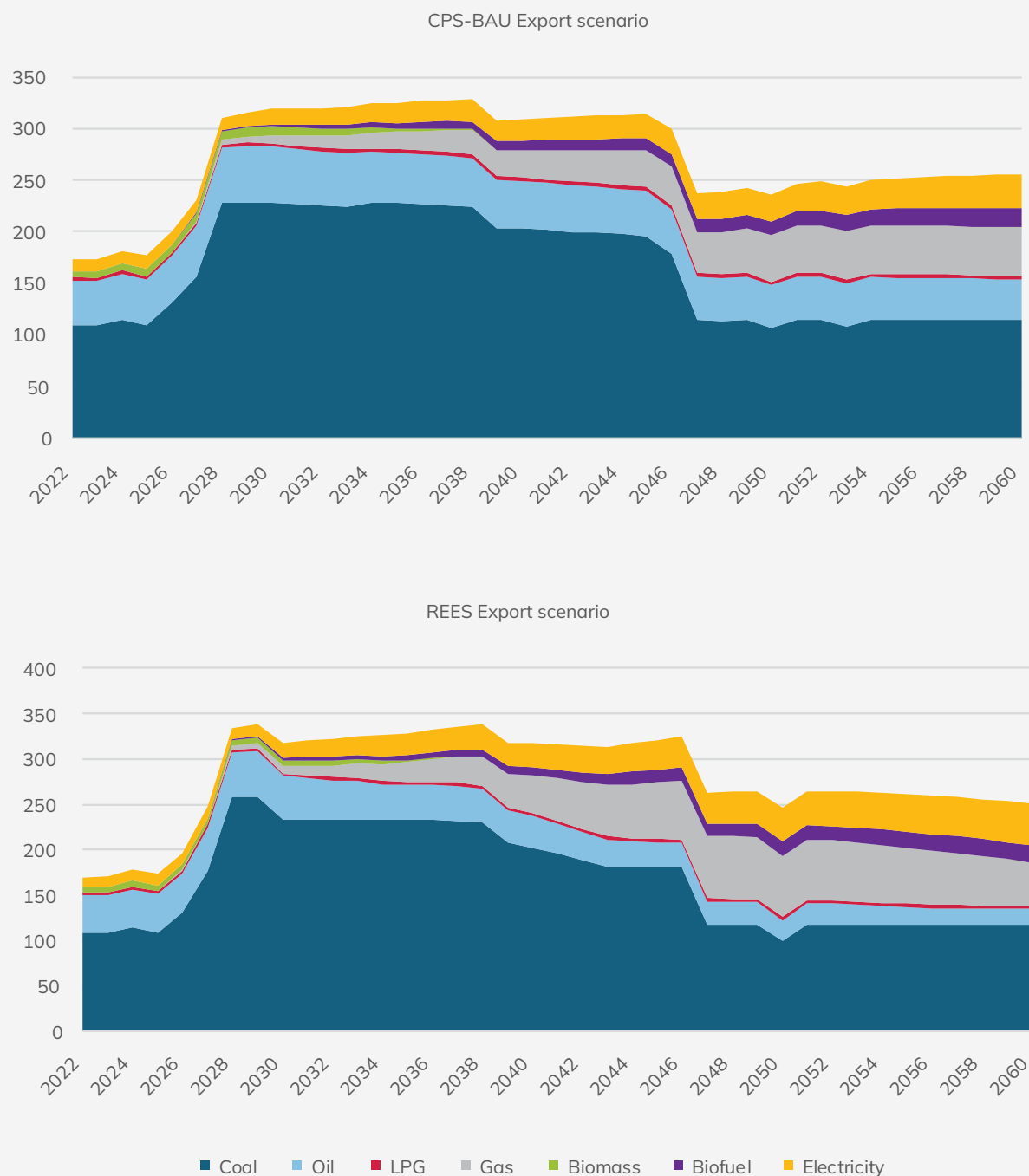


FIGURE 51

Power sector generation mix for the CPS-BAU and REES Export scenarios (TWh)

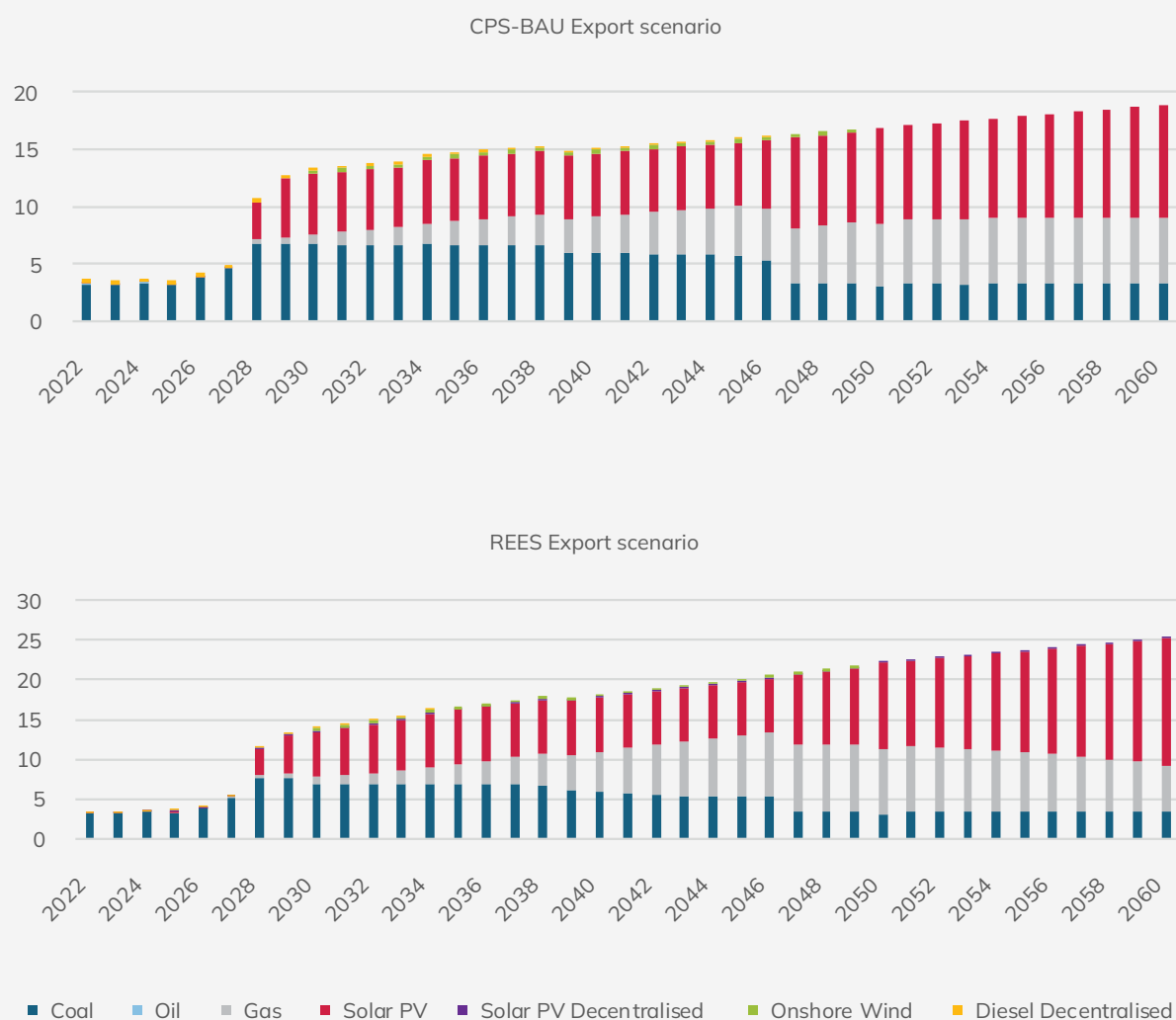


FIGURE 52

Power sector imports for the CPS-BAU and REES Export scenarios (TWh)

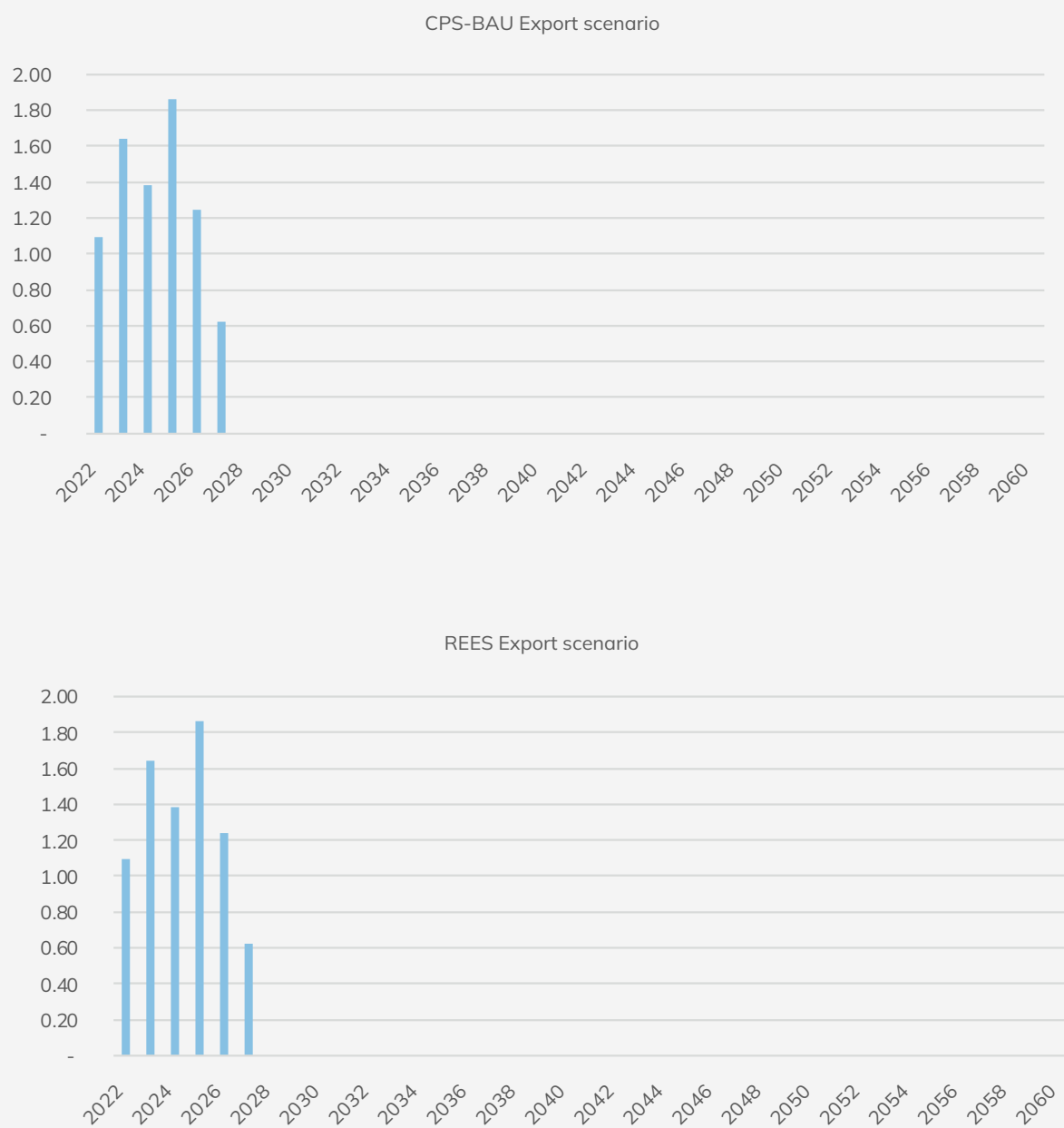


FIGURE 53

Power sector exports for the CPS-BAU and REES Export scenarios (TWh)

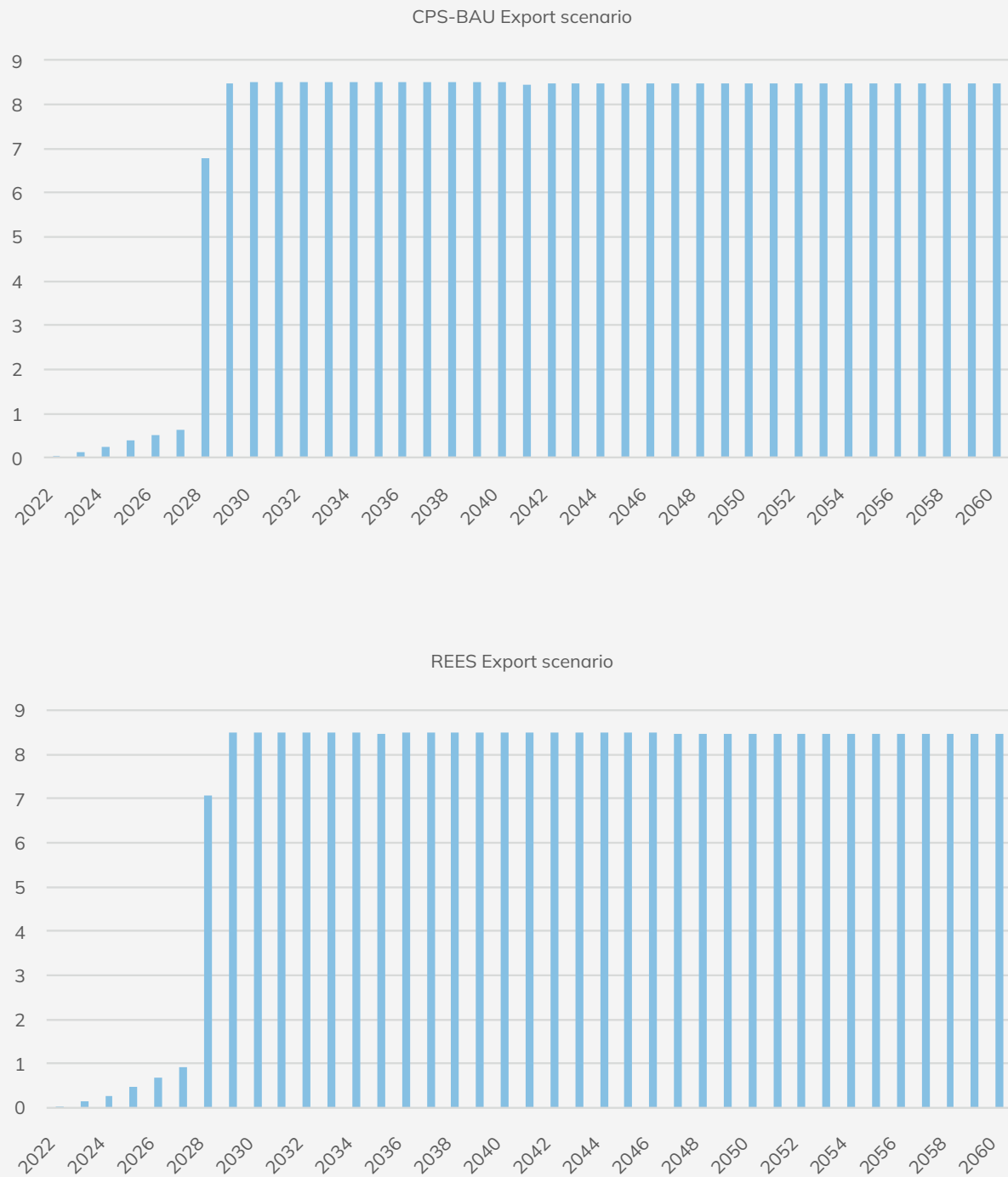


FIGURE 54

Power sector capacity mix for the CPS-BAU and REES Export scenarios (GW)

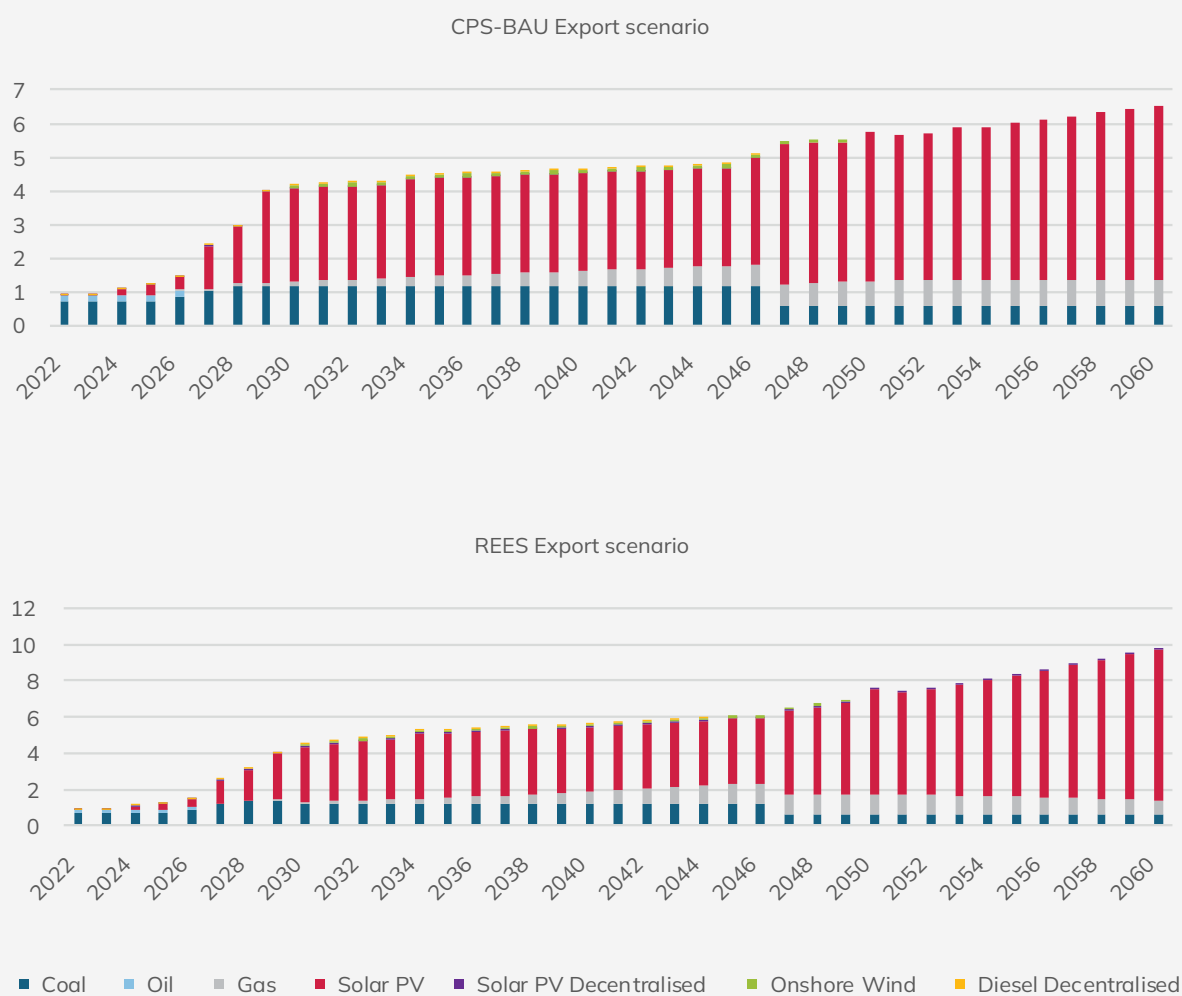


FIGURE 55

Power sector battery storage capacity for the CPS-BAU and REES Export scenarios (GW)

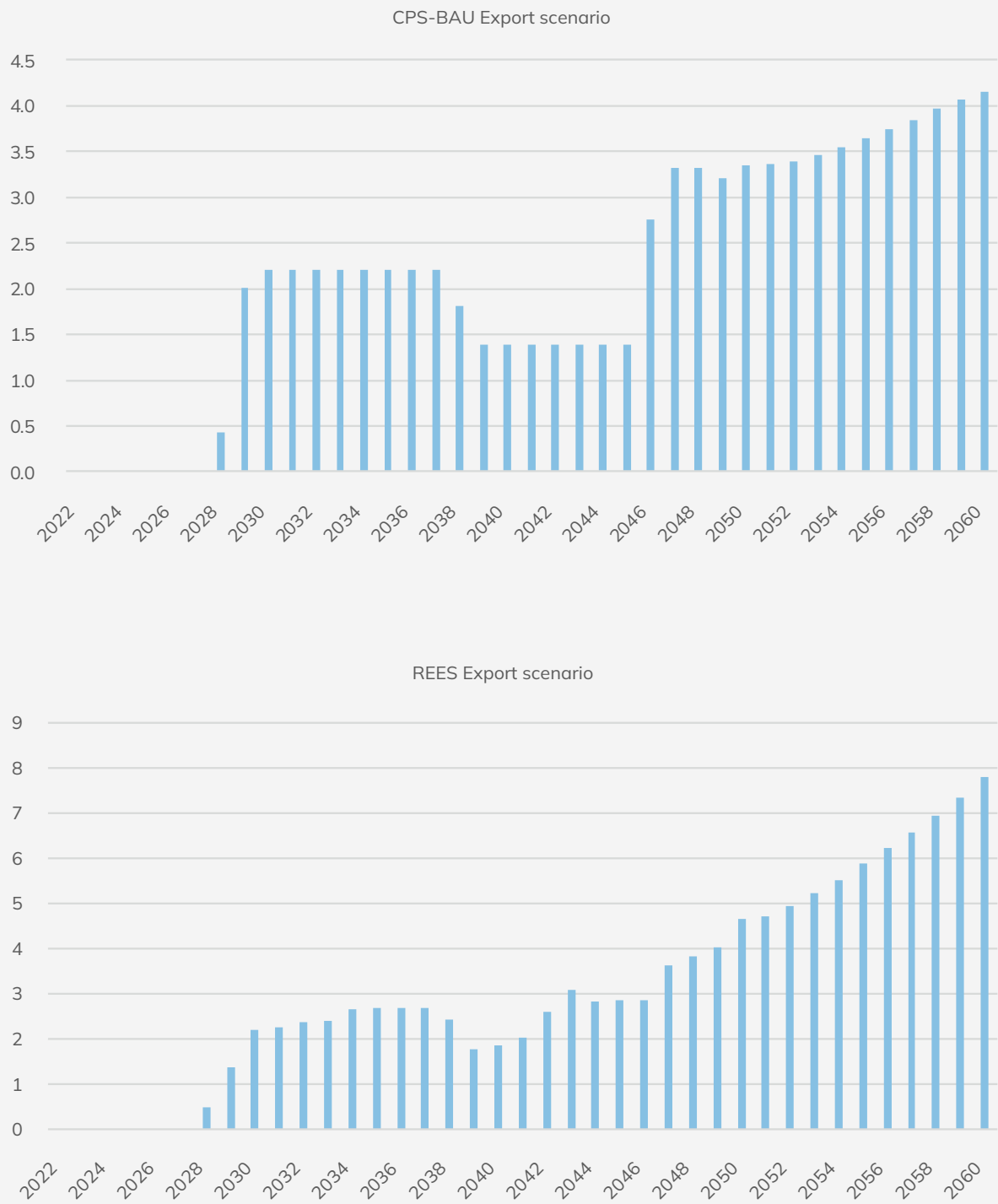


FIGURE 56

Total CO₂ emissions for the CPS-BAU and REES Export scenarios (Mt CO₂)

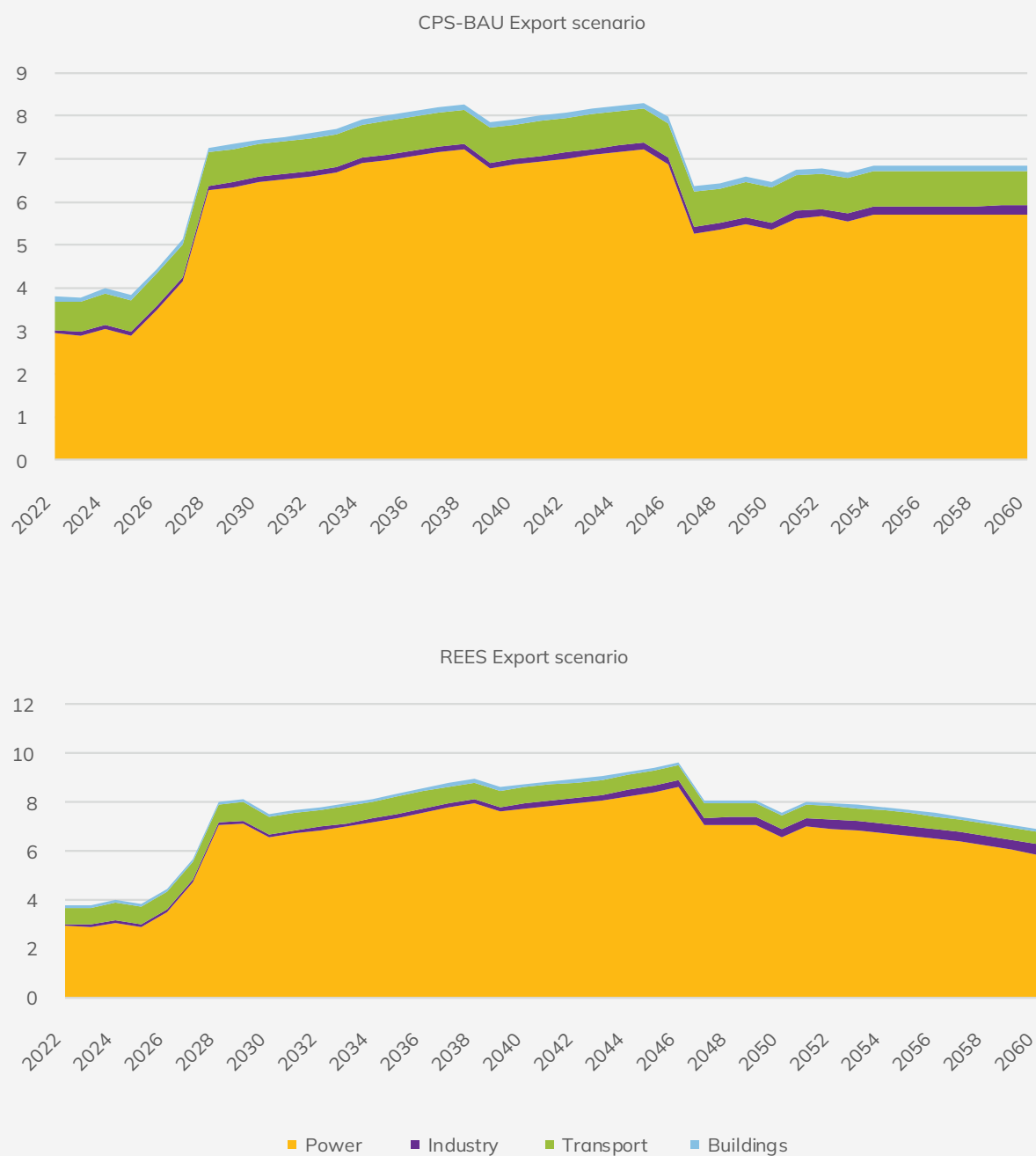


TABLE 12

Cumulative investment for CPS and REES, split into system-level (power, industry and mining, T&D network, batteries) and end-user (transport, clean cooking) investments (USD millions)

Investment		CPS Export	REES Export
Sector	Project archetypes	2022–2050	2022–2050
Power	Solar PV, natural gas	4,860	5,979
Industry and mining	Clean mining, high- and low-temperature heating processes	69	89
T&D network	T&D	3,785	5,290
Batteries	Four-hour battery storage	1,835	2,531
Total		10,549	13,889
Transport	Electric two-wheelers, cars, buses, trucks	30,516	32,299
Clean cooking	Clean cookstoves	69	112
Total		30,622	32,411

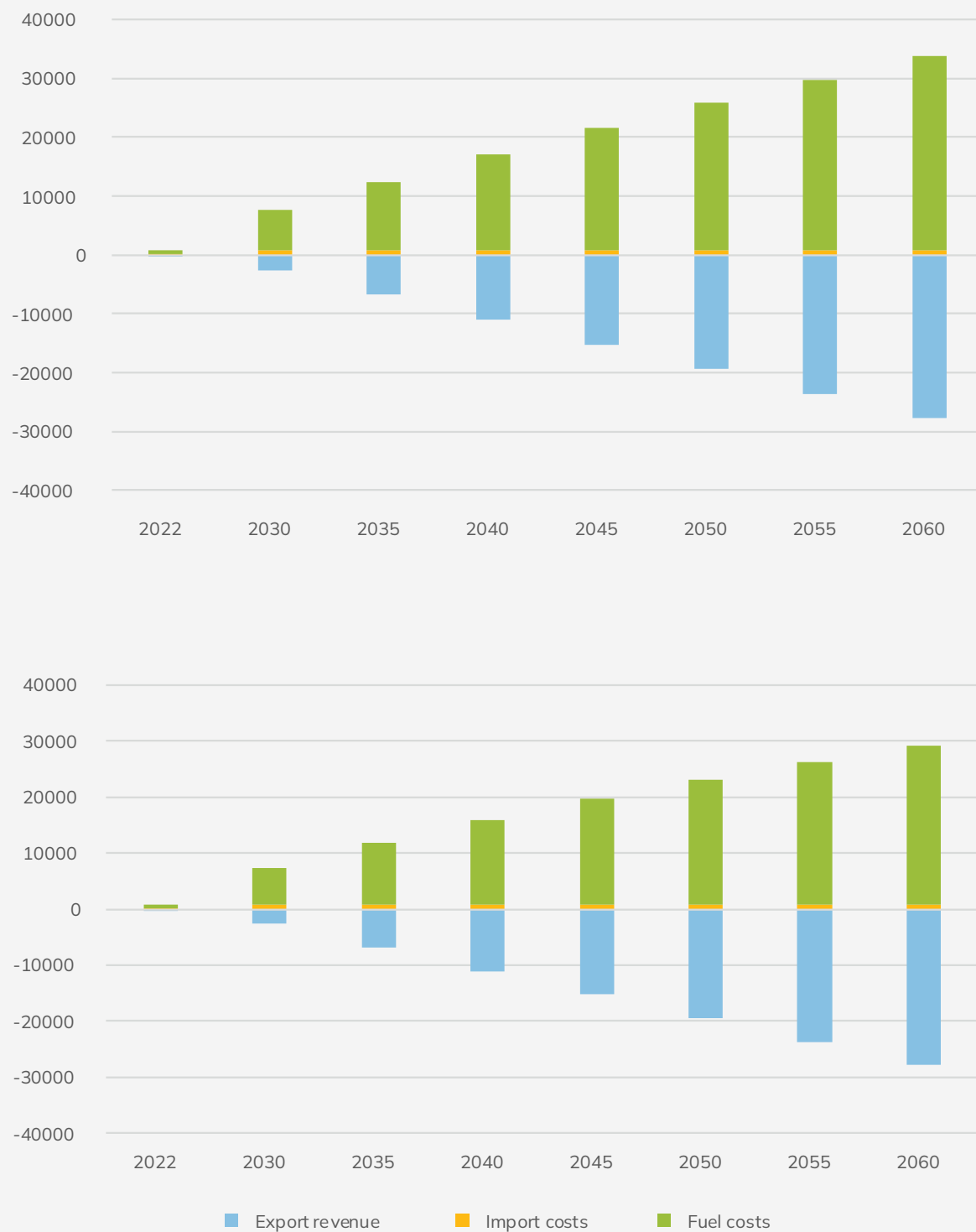
TABLE 13

Cumulative operating cost for REES, split into supply (power, industry and mining) and end-user (transport, clean cooking) investments (USD millions)

Operating cost		CPS Export	REES Export
Sector	Project archetypes	2022–2050	2022–2050
Power	Solar PV, natural gas	2,824	3,408
Industry and mining	Clean mining, high- and low-temperature heating processes	695	734
Total		3,519	4,142
Transport	Electric two-wheelers, cars, buses, trucks	33,941	35,052
Clean cooking	Clean cookstoves	65	67
Total		34,005	35,119

FIGURE 57

Revenue flow for the CPS-BAU and REES Export scenarios (USD millions)



An aerial photograph of a vast, flat landscape featuring a complex network of winding rivers and channels, characteristic of a delta or wetland region. The terrain is a mix of light and dark green, suggesting different vegetation or water levels. The sky is a pale, hazy blue. The image is used as a background for the document.

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BOTSWANA

NATIONAL RENEWABLE ENERGY POWER SECTOR PLAN

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