KENYA

ENERGY TRANSITION AND INVESTMENT PLAN

SUSTAINABLE ENERGY FOR ALL

ADDITIONAL PARTNER LOGO GOES HERE

Disclaimer

All reasonable precautions have been taken by SEforALL to verify the reliability of the material in this publication. It is to be noted that there could be various energy transition pathways to net-zero emissions and the scenarios explored in this report inform a potential pathway and is not prescriptive in nature. Neither SEforALL nor any of its officials, agents, data, or other third-party content providers provides a warranty of any kind, either expressed or implied, and they accept no responsibility or liability for any consequence of use of the publication or material herein. The information contained herein does not necessarily represent the views of all members of SEforALL. SEforALL statement on energy solutions can be found here. The mention of specific companies or certain projects or products does not imply that they are endorsed or recommended by SEforALL in preference to others of a similar nature that are not mentioned. The designations employed and the presentation of material herein do not imply the expression of any opinion on the part of SEforALL concerning the legal status of any region, country, territory, city, or area or of its authorities, or concerning the delimitation of frontiers or boundaries.

FOREWORD

The global energy landscape is undergoing a profound transformation as countries strive to balance economic development, energy security, and climate action. Achieving a sustainable and resilient energy future requires bold leadership, long-term planning, and coordinated investments across all sectors of the economy.

The Energy Transition and Investment Plan (ETIP) provides a strategic roadmap to support the country's transition toward a modern, secure, affordable, and low-carbon energy system. The Plan outlines pathways to accelerate sustainable economic growth while ensuring universal access to reliable energy services, strengthening energy independence, and supporting national climate commitments.

This ETIP has been developed through an evidence-based and inclusive process involving extensive stakeholder engagement, integrated energy systems modelling, and sectoral analysis across the power, transport, industry, buildings, agriculture, and clean cooking sectors. It identifies priority technologies, policy measures, and investment opportunities required to drive the energy transition while maximizing socio-economic benefits such as job creation, industrial development, innovation, and improved public health.

The Plan demonstrates that the energy transition is not only an environmental imperative, but also a major economic opportunity capable of attracting investments, enhancing competitiveness, and improving resilience against future energy and climate-related shocks. It highlights the great potential for establishing local green manufacturing and development of low-carbon technologies to propel industrialization, economic growth and job creation while protecting the environment. Around 2.1 million additional jobs across the wider economy could be created by 2050. Also the Plan illustrates how the energy transition course will support the whole economy by creating about USD 595 billion of near-term investment opportunities by 2050. As such, the plan will be used to engage with national, regional and global partners for mutual benefits

Successful implementation of this ETIP will require strong collaboration between government institutions, development partners, the private sector, financial institutions, academia, and civil society. Through coordinated action and sustained commitment, the country can position itself as a regional leader in sustainable development and energy transition.

We extend our sincere appreciation to all institutions, technical experts, stakeholders, and partners who contributed to the preparation of this Plan and supported the development of a shared vision for a sustainable energy future.

Name
Title

ACKNOWLEDGEMENT

The development of the Energy Transition and Investment Plan (ETIP) was made possible through the collective efforts, technical expertise, and valuable contributions of numerous institutions and individuals.

We would like to express our sincere gratitude to all government ministries, agencies, utilities, private sector representatives, academic institutions, development partners, civil society organizations, and technical experts who participated in consultations, provided data and insights, and contributed to the analytical work underpinning this Plan.

Special appreciation is extended to the technical teams and modelling experts whose efforts supported the integrated analysis of energy demand, supply, investment requirements, emissions trajectories, and socio-economic impacts across the different sectors covered under the ETIP.

The analytical foundation of this plan was led by SEforALL's Energy Transition Planning team, including Dr. Ioannis Pappis and Mr. Alvin Jose (ex-SeforALL). We extend our gratitude to the broader SEforALL team, including Dr. Anindya Bhattacharya, Mr. Tamojit Chatterjee, Dr. Naomi Tan, Ms. Yogitha Miriyala, Ms. Wei Li and Mr. Divyam Nagpal and, for their invaluable contributions.

The Ministry of Energy and Petroleum acknowledges and appreciates the contribution and support from various stakeholders, including Government Ministries, Departments and Agencies, Academia, Development Partners, Civil Society and the Private sector Their expertise and insights were crucial in shaping this plan.

Finally, we extend our appreciation to all stakeholders who contributed their time, expertise, and perspectives during the consultation and validation process. The successful implementation of this ETIP will continue to depend on strong partnerships, coordinated action, and a shared commitment toward achieving a sustainable, inclusive, and resilient energy future.

Name
Title

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Context

Internationally, governments, businesses, and investors are rapidly aligning with net-zero emissions pathways, reshaping capital flows and redefining competitiveness in the global energy system.

Kenya stands at a critical juncture. The country has a unique opportunity to strengthen its climate ambition, avoid the economic and financial risks associated with a delayed energy transition, and capture the wide-ranging benefits of a low-carbon development pathway. Kenya is particularly well positioned to leverage emerging green growth opportunities, including participation in carbon markets, development of green hydrogen, expansion of green manufacturing, and localization of low-carbon technologies.

Secure investment. A faster transition strengthens investor confidence and attracts climate-aligned finance and donor support as fossil investments decline.

New growth sectors. A net-zero pathway unlocks opportunities in green hydrogen, carbon markets, and clean technology manufacturing.

Energy independence. Scaling domestic renewables reduces import dependence and enhances long-term energy security.

Aims and Objectives

This report is an update to Kenya's existing Energy Transition and Investment Plan (ETIP), launched in 2024. The update to the ETIP has been undertaken to align it with recent policy updates including NDC 3.0, Mission 300 Energy Compact and strategies such as those initiated as part of Kenya's commitment to the Beyond Oil and Gas initiative. This plan will help Kenya frame an energy transition agenda that will attract investment, while at the same time ensuring a just transition from fossil fuels and fully supporting Kenya's rapid economic growth trajectory.

Key Findings

Energy demand is set to triple, driven by population and economic growth. Kenya's total final energy demand increases significantly (4.3 times) by 2060, driven by strong population growth (2.76% on average per annum) and rising GDP per capita (4% annual growth). This creates substantial pressure on the energy system to expand capacity by 6 times by 2060 in BAU while ensuring affordability and reliability.

Kenya's power sector is already low-carbon but must scale rapidly. With over 80% renewable capacity today, Kenya is well-positioned for a clean transition. However, significant capacity expansion — particularly in gas, geothermal, solar, nuclear and hydrogen — is required to meet growing electricity demand and enable electrification across sectors to achieve NZE 2050.

Decarbonization of the transport sector provides the largest opportunity for Net Zero. The transport sector is currently dominated by oil products and remains the primary driver of fossil fuel consumption. Achieving net-zero requires a rapid transition mainly to electric & hydrogen mobility, , alongside infrastructure deployment and policy support.

Clean cooking transition is critical for both emissions and health. Traditional biomass continues to dominate cooking, particularly in rural areas. Scaling up clean cooking solutions — including LPG and electricity — is essential to reduce emissions, improve health outcomes, and support sustainable development to achieve clean cooking strategy by 2030.

Industrial decarbonization requires shifting away from coal. Industry is highly dependent on coal, particularly in energy-intensive sectors. Transition pathways require electrification, efficiency improvements, and alternative fuels to reduce emissions while maintaining competitiveness.

Achieving net-zero requires an economywide transformation. The NZE scenario shows that deep decarbonization is feasible but requires coordinated action across all economic sectors, including electrification where electricity represents 49% of total fuel consumption in 2050), renewable energy expansion representing 49% of total electricity generation in 2050) , and reduced reliance on fossil fuels by 33% by 2050 and 60% by 2060 cumulatively compared to the BAU during 2024-2060..

Electrification of end use sectors emerges as a key driver of decarbonization. In the NZE scenario, electricity consumption in industry increases by 19%, while electricity consumption in transport increases by more than twenty-fold by 2050 compared to the BAU scenario. This reflects the significant electrification of these sectors, which emerges as a least-cost pathway for achieving net-zero emissions by 2050. Electricity consumption increases by around 3 times compared to BAU by 2050 and that will require expanded capacity in the power sector, especially in renewables.

Investment needs are substantial but essential. Achieving the NZE 2050 pathway requires approximately USD 234 billion (+22%) in additional cumulative system costs compared to the BAU scenario by 2050. These additional costs are driven by around USD 177 billion in capital investments and USD 85 billion in operation and maintenance (O&M) expenditures, partially offset by approximately USD 35 billion in fuel cost savings.. The NZE 2050 pathway could support approximately 1.4 million additional net jobs by 2050, with over 80% driven by investments in the transport sector, highlighting the central role of electrified mobility in job creation.

Policy implementation is the key differentiator between scenarios. The gap between BAU, CPS, and NZE highlights the importance of strong and consistent policy implementation. Without policy action, fossil fuel dependence persists, while ambitious policies enable a rapid and cost-effective transition.

Energy Demand Growth

Kenya's energy demand is projected to increase significantly over the modelling horizon, driven by strong population growth, urbanization, rising GDP per capita, and increasing access to modern energy services across all sectors of the economy [1, 2]. As economic activity and living standards improve, demand for mobility, cooling, lighting, cooking, industrial production, and agricultural services is expected to rise substantially.

Energy demand increases across all sectors, particularly in transport, industry and, buildings. The transport sector has become one of the largest contributors to future energy demand growth due to increasing vehicle ownership and mobility needs (Figure 1). At the same time, industrial energy demand expands in line with economic growth and industrialization (Figure 2) while demand in buildings increases due to growing population, number of households and increasing income levels (Figure 3).

Figure 1: Energy demand projection for buildings sector

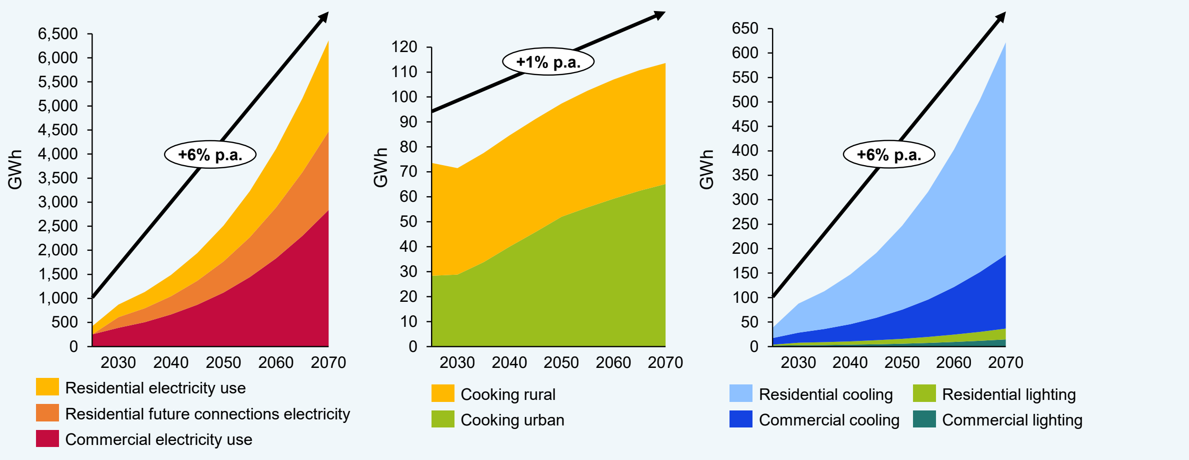


Figure 2: Energy demand projection for the transport sector

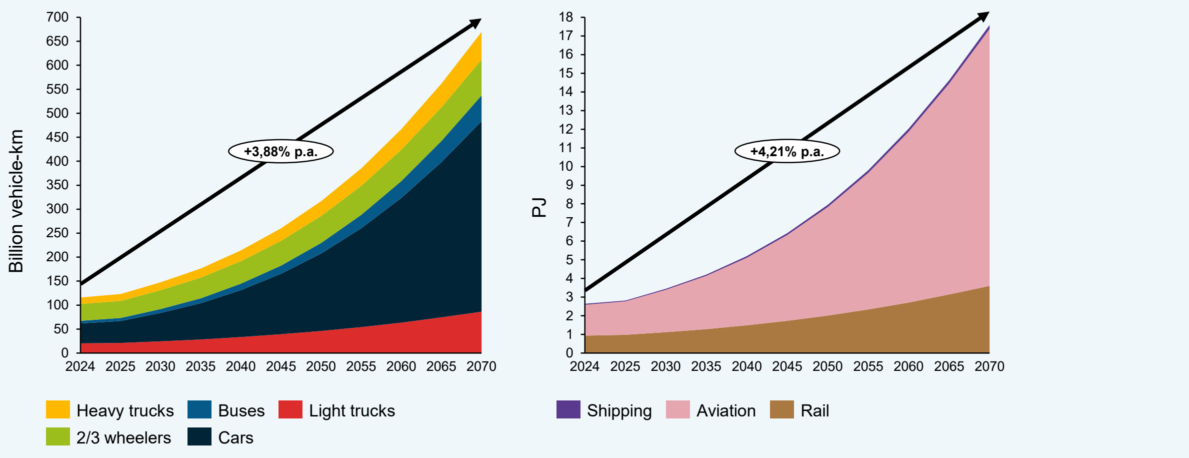
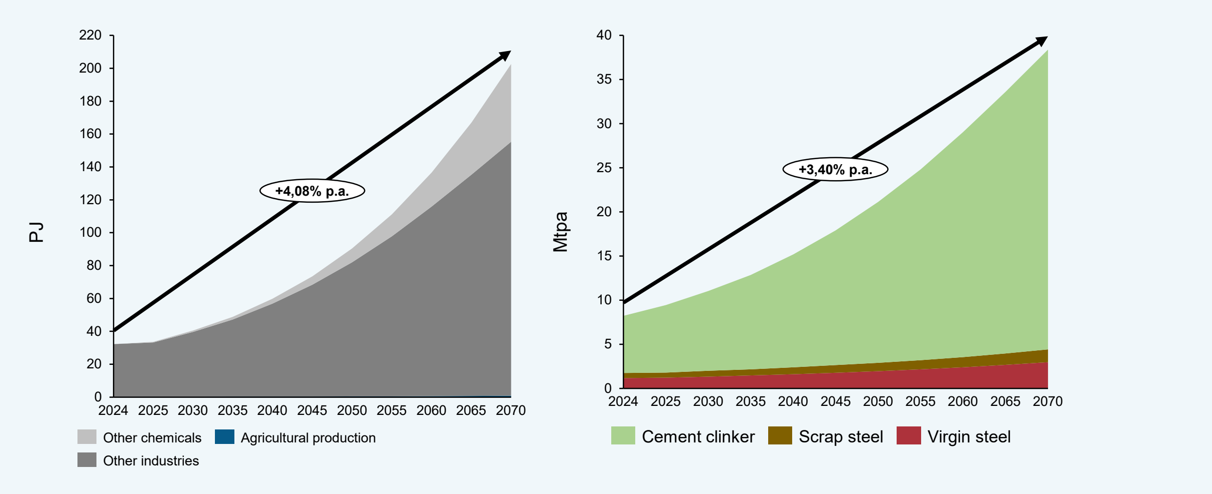


Figure 3: Energy demand projection for the industry and agriculture sectors.



Under both the BAU and NZE scenarios, fuel consumption increases over time. However, the structure of energy consumption differs significantly between the two pathways. Under the NZE scenario, energy demand growth is increasingly met through electrification of transport, cooking, and industrial technologies, while under BAU the energy system remains largely dependent on oil-based technologies and traditional fuels (Figure 4).

Under BAU, fuel demand increases from around 1,028 PJ in 2024 to approximately 2,663 PJ by 2060, corresponding to an average annual growth rate of around 3%. In contrast, under the NZE scenario, fuel demand increases to approximately 1,041 PJ by 2060, decreasing overall by around 1.5 times compared to the BAU. This lower fuel demand is primarily driven by large-scale electrification of transport, buildings, and industry, particularly after 2045 when electric vehicle penetration and efficient appliances accelerate significantly.

Clean cooking policy by 2030 also plays a key role by phasing out inefficient traditional biomass stoves and supporting the transition towards modern cooking solutions. Overall, the NZE pathway shifts Kenya's energy system from a solid & liquid fuel-intensive structure towards a more electrified and efficient system, reducing dependence on fossil fuels and improving long-term energy security.

Figure 4: Fuel consumption by sector under BAU and NZE (PJ)

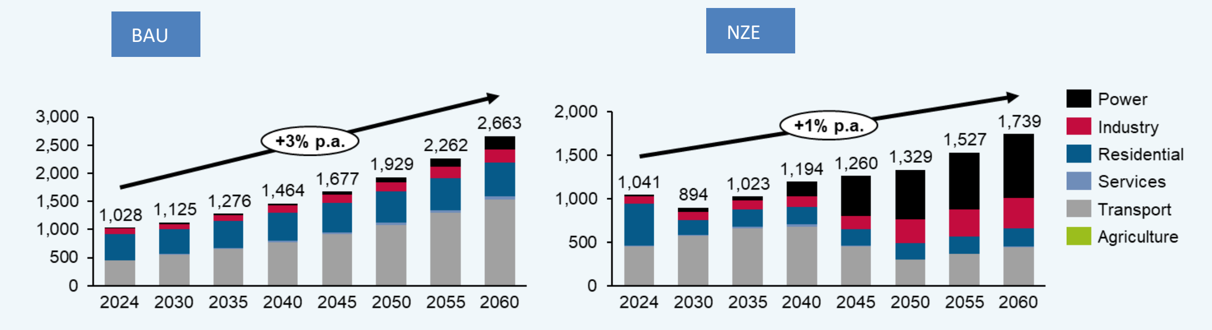
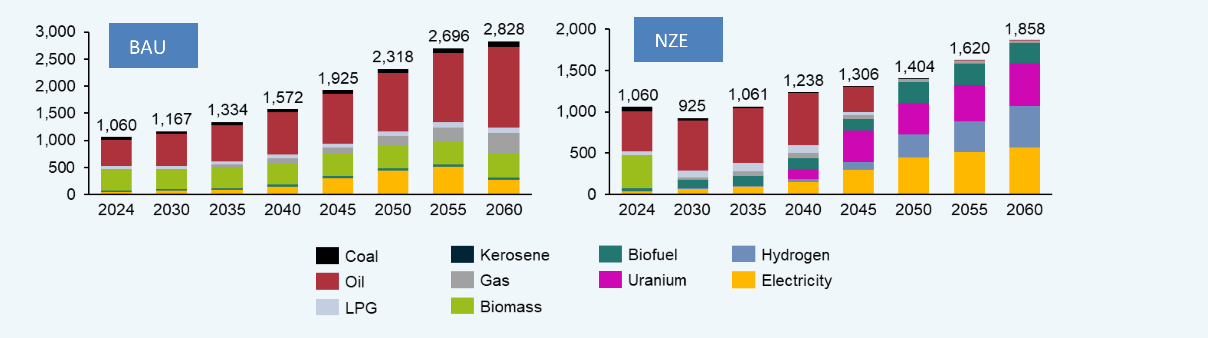


Figure 5: Fuel consumption by fuel type under BAU and NZE (PJ)



The NZE scenario fundamentally reshapes Kenya's final energy consumption through a combination of clean cooking adoption, electrification, and the introduction of new low-carbon energy carriers. While final energy demand continues to increase as a result of population growth, economic development, and expanding access to modern energy services, the fuel mix changes significantly compared to the BAU scenario. The achievement of universal access to clean cooking by 2030 leads to a substantial reduction in traditional biomass consumption, which is progressively replaced by LPG and electricity (Figure 5). Because modern cooking technologies are significantly more efficient than traditional biomass stoves, this transition reduces overall final energy consumption despite increasing energy service demand.

Electrification emerges as a key decarbonization strategy in the NZE pathway, particularly in transport, industry, and buildings. As a result, electricity becomes one of the fastest-growing energy carriers in the energy system, increasing from 161 PJ in the BAU scenario to 447 PJ in the NZE scenario by 2050—almost three times higher than in the BAU pathway. This growth reflects the large-scale deployment of electric vehicles, electrified industrial processes, and modern electric cooking technologies. At the same time, the role of oil products declines significantly compared to the BAU scenario as low-carbon alternatives become increasingly competitive. Hydrogen and nuclear energy also emerge as new contributors to the energy mix, supporting the decarbonization of hard-to-abate sectors and enhancing long-term energy system flexibility. Overall, the NZE pathway delivers the required energy services through a cleaner and more efficient fuel mix, reducing reliance on traditional biomass and fossil fuels while accelerating the transition towards modern energy carriers.

Power Sector Capacity Mix

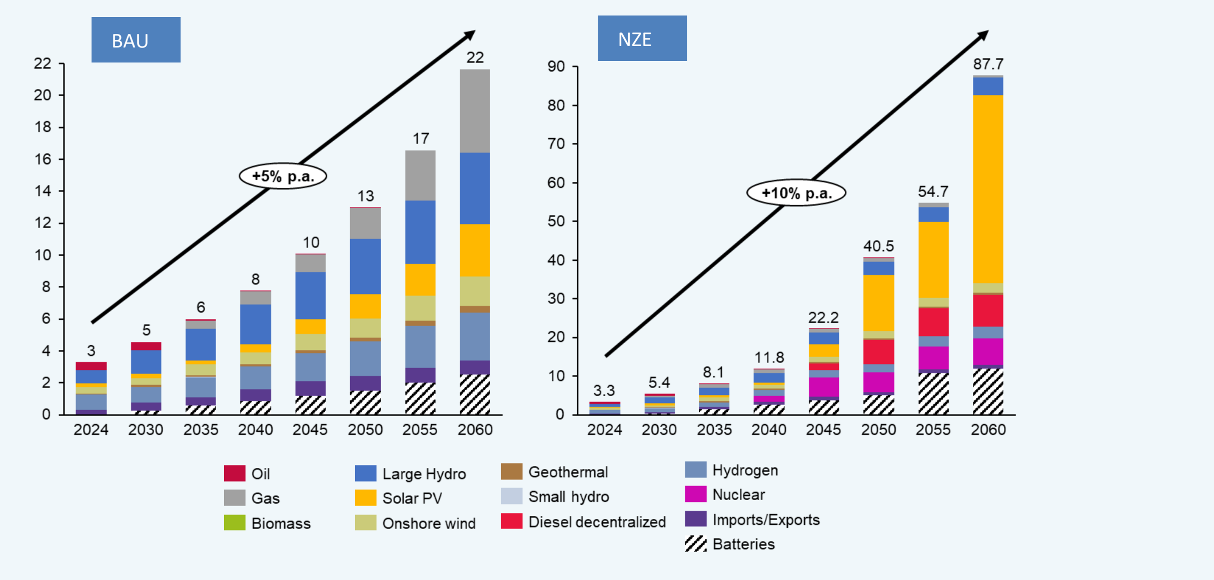
Kenya’s installed power generation capacity expands significantly under both the BAU and NZE scenarios to meet rapidly increasing electricity demand driven by population growth, industrialization, urbanization, and electrification across end-use sectors (Figure 6). Total installed capacity increases from around 3 GW in 2024 to approximately 22 GW by 2060 under BAU, corresponding to an average annual growth rate of around 5%. Under the NZE scenario, capacity expansion accelerates substantially after 2040, reaching approximately 88 GW by 2060 with annual growth of around 10%. Electricity imports-exports increase from 0.3 GW in 2024 to 0.5 GW by 2030 in both scenarios while electric battery storage reaches to 2.5 GW in BAU by 2060 compared to 12 GW in NZE.

Under BAU, the power system continues expanding through a combination of natural gas, geothermal, solar PV, hydro, and imports. Natural gas plays an increasingly important role in meeting growing electricity demand and supporting system flexibility, while renewable technologies continue expanding due to Kenya's strong renewable resource potential. However, fossil fuel-based generation remains an important part of the electricity mix throughout the modelling horizon.

In contrast, the NZE pathway requires a much faster deployment of low-carbon generation technologies to support large-scale electrification across transport, buildings, and industry. Solar PV becomes one of the dominant generation technologies after 2045, complemented by significant expansion of storage facilities. Moreover, geothermal, hydrogen, and nuclear generation also become dominant in later years of the model horizon. The NZE scenario also requires substantial investments in storage systems, transmission and distribution networks, and system flexibility to support the integration of variable renewable energy technologies.

Overall, the NZE pathway transforms Kenya's power system towards a highly electrified and low-carbon electricity mix, significantly reducing dependence on fossil fuel generation by 90% in 2060 compared to the BAU while improving long-term energy security and supporting economy-wide decarbonization objectives.

Figure 6: Power installed capacity under BAU and NZE (GW)

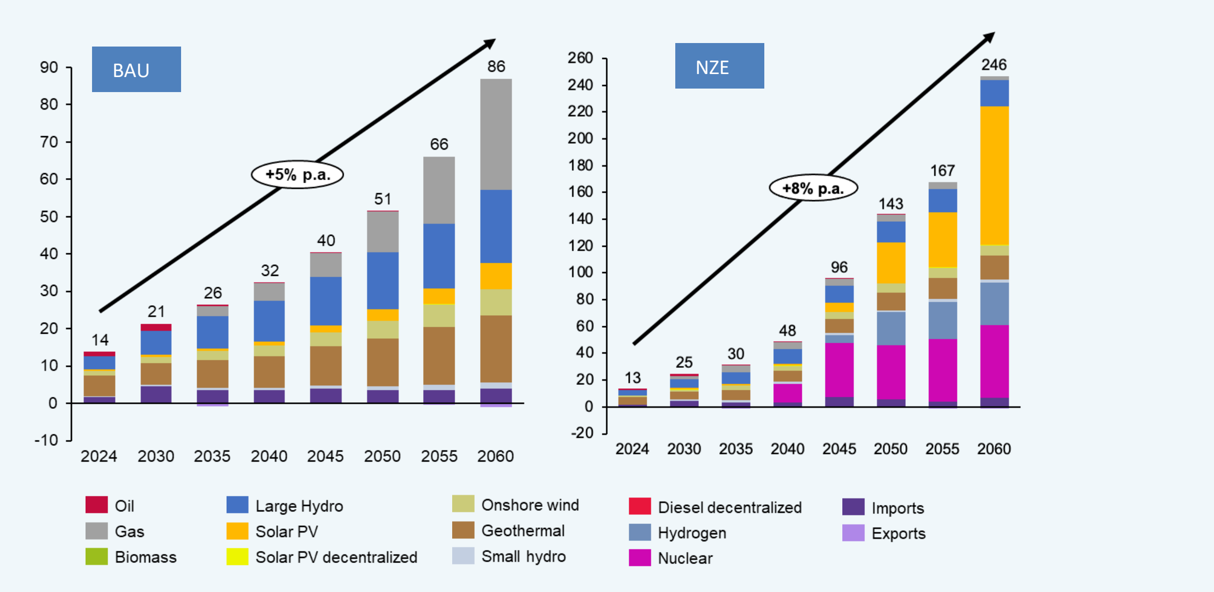


Power Sector Generation Mix

Electricity generation increases significantly under both the BAU and NZE scenarios to meet growing demand across all sectors of the economy (Figure 7). Under BAU, total electricity generation increases at an average annual growth rate of around 5%, driven mainly by increasing electricity demand from buildings, industry, and transport. The generation mix continues to rely on a combination of natural gas, geothermal, solar PV, hydro, and electricity imports, with natural gas becoming an increasingly important source of generation in the long term to support system flexibility and rising demand.

Under the NZE scenario, electricity generation expands more rapidly, with annual growth reaching around 8% as large-scale electrification accelerates across transport, buildings, and industry. The NZE pathway significantly transforms the power generation mix towards low-carbon technologies, with solar PV becoming one of the dominant generation sources after 2045, representing 43% in 2060, supported by major expansion of geothermal generation, batteries, hydrogen technologies, and nuclear generation in later years. The role of fossil fuel-based generation is substantially reduced compared to BAU, although limited natural gas generation remains in the system to support flexibility and reliability.

Figure 7: Power generation mix under BAU and NZE (TWh)



Transport Sector Fuel Mix

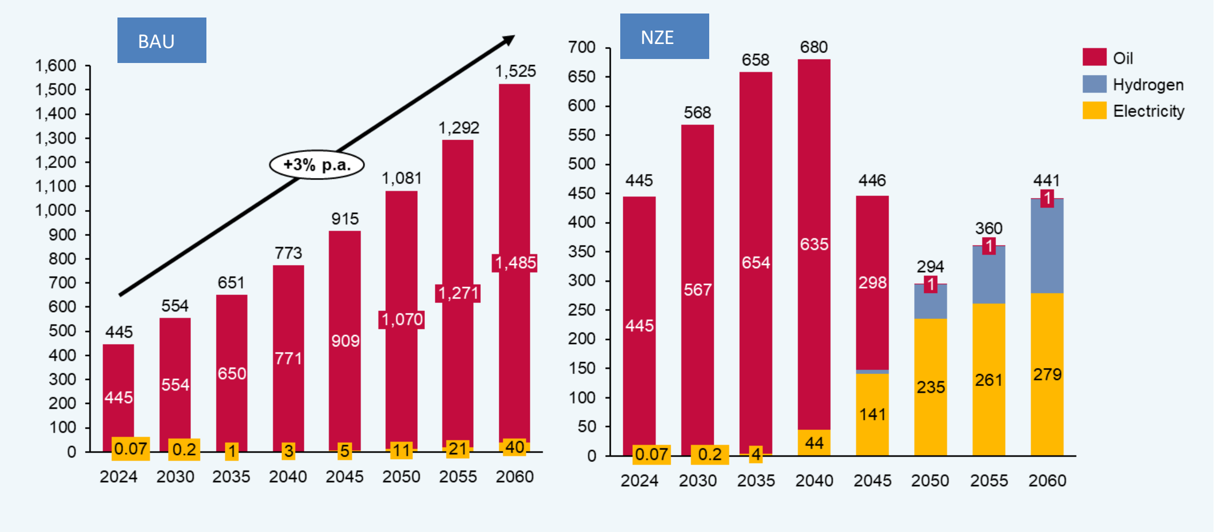
The transport sector remains one of the largest energy-consuming sectors across the modelling horizon (Figure 8). Under the BAU scenario, total transport fuel consumption increases from around 445 PJ in 2024 to approximately 1,525 PJ by 2060, corresponding to an average annual growth rate of around 3%. Oil products continue to dominate the transport sector throughout the modelling horizon, reflecting continued dependence on internal combustion engine technologies. Limited penetration of electric vehicles is observed in later years, although these remain relatively small compared to oil demand.

In contrast, the NZE pathway fundamentally transforms the transport sector through large-scale electrification and fuel switching. Total transport fuel consumption peaks around 2035–2040, reaching 692 PJ in 2039, before declining significantly to around 441 PJ by 2060 despite continued growth in transport activity. This reduction is primarily driven by the rapid penetration of electric vehicles after 2045, which substantially reduces final energy requirements due to the significantly higher efficiency of electric mobility technologies compared to conventional oil-based vehicles.

Under the NZE scenario, electricity becomes one of the dominant energy carriers in the transport sector by 2050, while hydrogen also emerges in later years, particularly for harder-to-abate transport segments such as heavy trucks. As a result, oil consumption decreases significantly compared to BAU, improving energy security and reducing exposure to fossil fuel import price volatility.

Overall, the NZE pathway demonstrates that large-scale electrification of transport can significantly reduce final fuel consumption and emissions while supporting growing mobility demand across the economy.

Figure 8: Transport fuel consumption under BAU and NZE (PJ)



Buildings (including Cooking) Fuel Mix

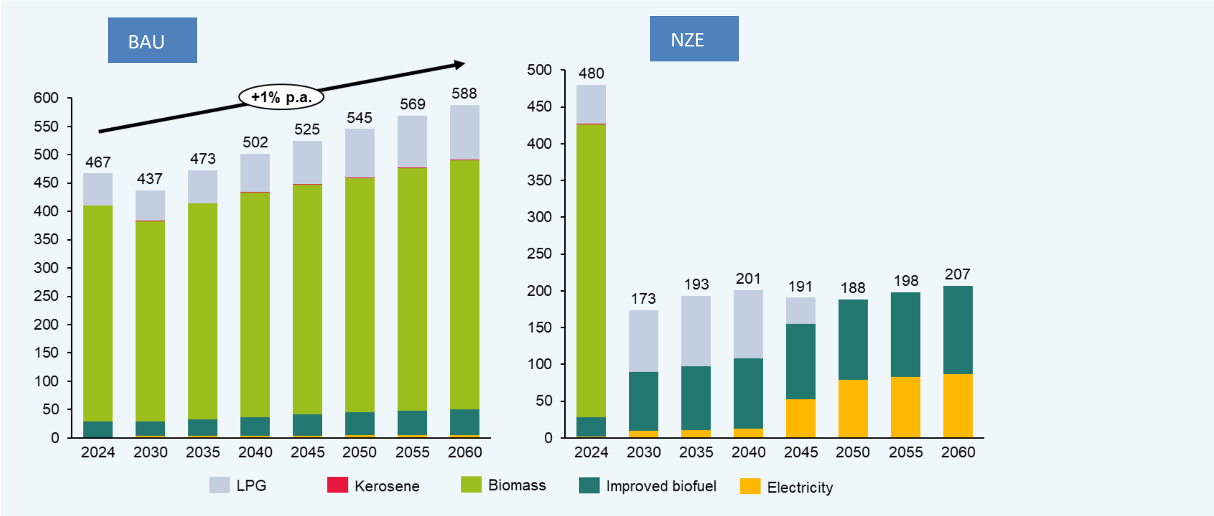
The buildings cooking sector remains heavily dependent on traditional biomass under the BAU scenario throughout the modelling horizon, from 82% in 2024 reaches to 75% in 2060 (Figure 9). As population and household numbers increase, total cooking fuel consumption also increases steadily, with traditional biomass continuing to dominate household cooking demand, particularly in rural areas. LPG penetration increases gradually over time, while electricity and other modern cooking fuels remain limited under BAU. As a result, the cooking sector continues to contribute significantly to biomass consumption and household air pollution.

In contrast, the NZE pathway fundamentally transforms the cooking sector through the implementation of a clean cooking policy by 2030 and large-scale electrification. Traditional biomass is progressively phased out after 2030 and is fully replaced by modern cooking technologies by 2050. LPG and improved biomass technologies play an important transitional role in earlier years, while electric cooking has become the dominant cooking technology in the long term.

The transition towards electric cooking significantly reduces dependence on traditional biomass and fossil fuels, supporting emissions reductions, improved indoor air quality, reduced health impacts, and lower pressure on biomass resources. At the same time, increasing electrification of cooking contributes to higher electricity demand across the buildings sector, particularly after 2040.

Overall, the NZE pathway demonstrates that achieving universal access to clean cooking requires substantial deployment of modern cooking technologies like induction cookstoves and electricity access , particularly in rural areas, while delivering important socio-economic, environmental, and public health benefits.

Figure 9: Buildings fuel consumption under BAU and NZE (PJ)

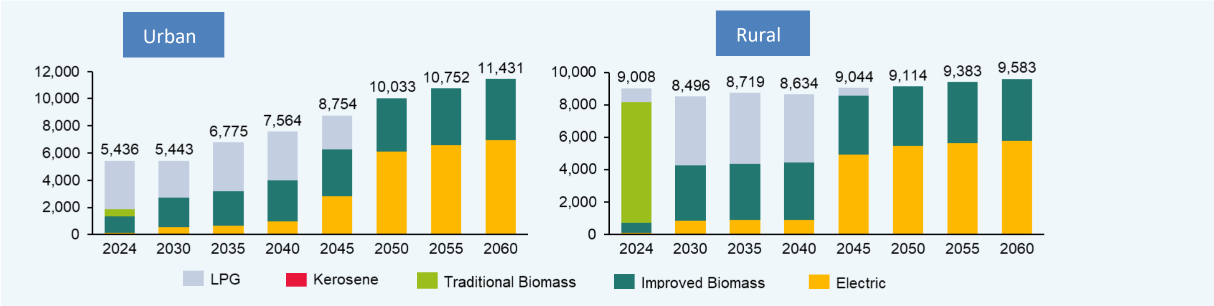


Under the NZE scenario, the cooking sector undergoes a significant technological transition in both urban and rural households, driven by the implementation of a clean cooking policy and increasing access to electricity (Figure 10). In urban areas, LPG and improved biomass technologies play an important transitional role in earlier years; however, electric cooking expands rapidly after 2040 and becomes the dominant cooking technology by 2050.

In rural areas, the transition occurs more gradually due to the initially high dependence on traditional biomass and lower access to modern cooking technologies [1]. Improved biomass and LPG technologies become important transitional solutions between 2030 and 2045, helping reduce reliance on inefficient traditional biomass stoves. After 2045, electric cooking penetration accelerates significantly, leading to the progressive replacement of traditional biomass technologies by 2050. This transition can also be correlated to the corresponding economic and social development of Kenya as a whole.

Overall, the NZE scenario demonstrates that achieving universal access to clean cooking requires a combination of electrification, transitional modern fuels, supportive policies, and expansion of electricity infrastructure, particularly in rural areas.

Figure 10: Urban and rural cooking technology mix under NZE (‘000 stoves)



Industry Sector Fuel Mix

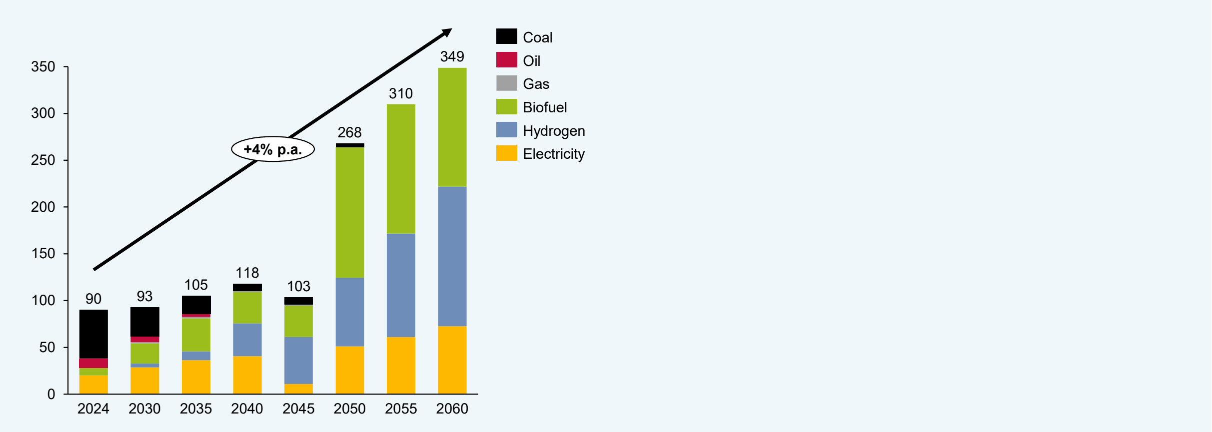
The industrial sector experiences significant growth in energy demand across the modelling horizon (Figure 11). Under the BAU scenario, industrial fuel consumption increases steadily over time, with coal and gas remaining the dominant energy carriers throughout the modelling horizon. This reflects continued reliance on conventional fossil fuel-based industrial processes, particularly in energy-intensive industries such as steel, cement and other industries

In contrast, the NZE pathway significantly transforms the industrial energy mix through electrification, efficiency improvements, and fuel switching towards low-carbon technologies. Coal consumption decreases substantially over time, while electricity becomes increasingly important in meeting industrial energy demand representing 19% of the industrial fuel consumption in 2050. Modern low-carbon fuels and hydrogen technologies also emerge from 2027 onwards with biofuels representing 52% and hydrogen 27% of industrial fuel consumption in 2050 to support decarbonization of harder-to-abate industrial processes.

The transition towards electrified and less energy-efficient industrial technologies compared to coal increases final fuel consumption compared to BAU but decreases industrial emissions, despite continued growth in industrial output. At the same time, increasing industrial electrification contributes to rapid growth in electricity demand and requires substantial expansion of low-carbon power generation capacity and industrial infrastructure.

Overall, the NZE pathway demonstrates that industrial decarbonization in Kenya requires a combination of electrification, energy efficiency improvements, adoption of low-carbon fuels, and long-term investments in modern industrial technologies to reduce dependence on coal and oil products while maintaining industrial growth and competitiveness.

Figure 11: Industry fuel consumption under NZE (PJ)



Emissions Pathway

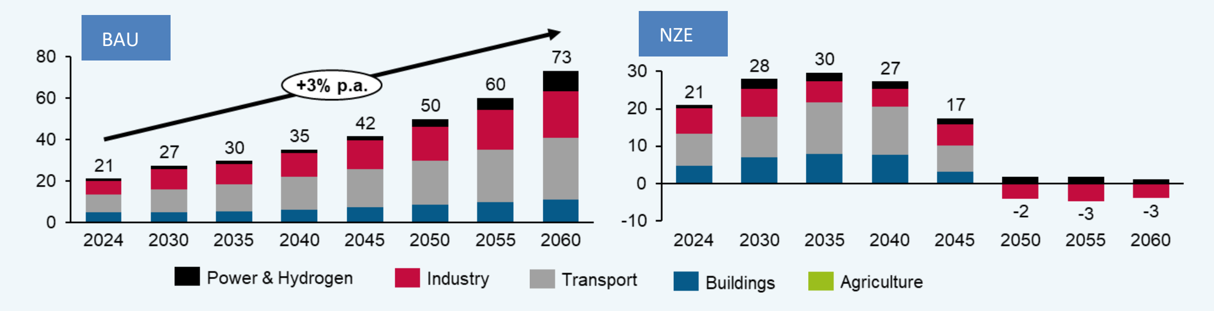
Under the BAU scenario, total CO_2 emissions increase steadily across the modelling horizon (21 $MtCO_2$ to 73 $MtCO_2$) , growing at an average annual rate of around 3% due to increasing energy demand, continued fossil fuel consumption, and expanding transport and industrial activity (Figure 12). Total emissions are primarily driven by the transport sector (41% of total emissions in 2060) followed by industry (31%) and buildings (15%), reflecting continued dependence on oil products, coal, and traditional biomass technologies. As economic activity and population increase, emissions continue rising throughout the modelling horizon under BAU.

In contrast, the NZE pathway significantly reduces economy-wide emissions through large-scale electrification, deployment of low-carbon power generation technologies, energy efficiency improvements, and fuel switching across all sectors. Emissions from transport decline substantially after 2045 as electric vehicles progressively replace internal combustion engine technologies, while emissions from buildings decrease due to the transition towards modern cooking technologies and electrification of end-use services.

Industrial emissions also decrease over time under NZE due to reduced coal consumption, increasing electrification, and penetration of low-carbon fuels and hydrogen technologies in harder-to-abate sectors. As a result, the NZE pathway achieves a near-complete decarbonization of the energy system by 2050, with residual emissions remaining only in limited hard-to-abate sectors in later years.

Overall, the results demonstrate that achieving Kenya's net-zero emissions objectives requires a system-wide transformation across transport, industry, buildings, and the power sector, supported by rapid electrification, low-carbon technology deployment, and substantial long-term investments in clean energy infrastructure.

Figure 12: CO_2 emissions by sector under BAU and NZE (million tons)

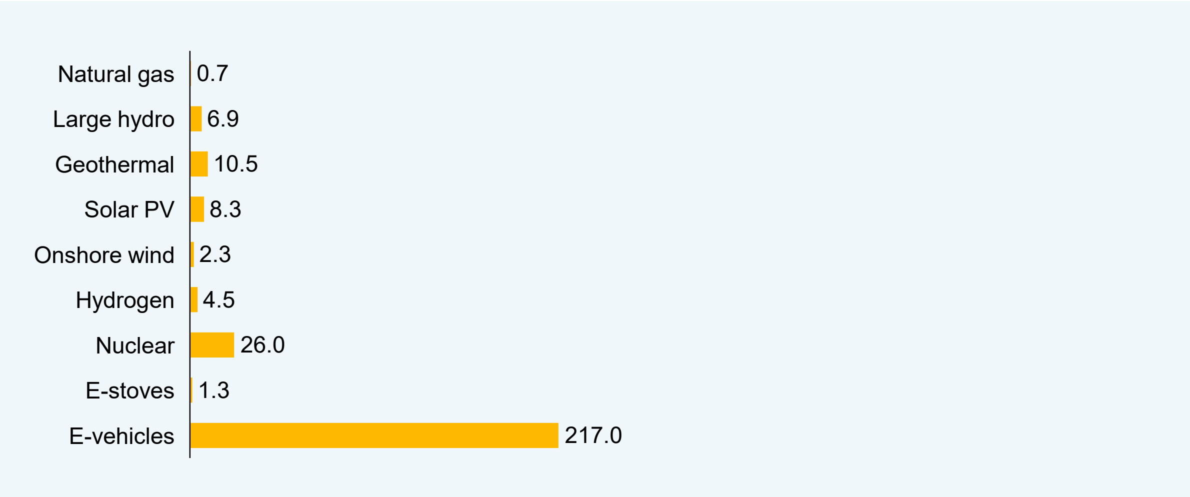


Investment and Job Creation

Achieving the NZE pathway requires substantially higher cumulative investments across the energy system compared to the BAU scenario (Figure 14). Total cumulative investments increase from around USD 557 billion under BAU to approximately USD 859 billion under NZE between 2024 and 2060, corresponding to an additional investment requirement of around USD 177 billion (+54%) by 2050.

The majority of the additional investment requirements are concentrated in the transport and power sectors. Transport accounts for the largest share of incremental investments, requiring approximately USD 196 billion in additional cumulative investments compared to BAU. This is primarily driven by the rapid deployment of electric vehicles (Figure 13). The power and hydrogen sectors also require substantial additional investments, increasing by approximately USD 70 billion, mainly due to large-scale deployment of solar PV, geothermal, hydrogen technologies and nuclear generation.

Figure 13: Cumulative capital investments in NZE by key technologies, 2024-2050, Bn USD

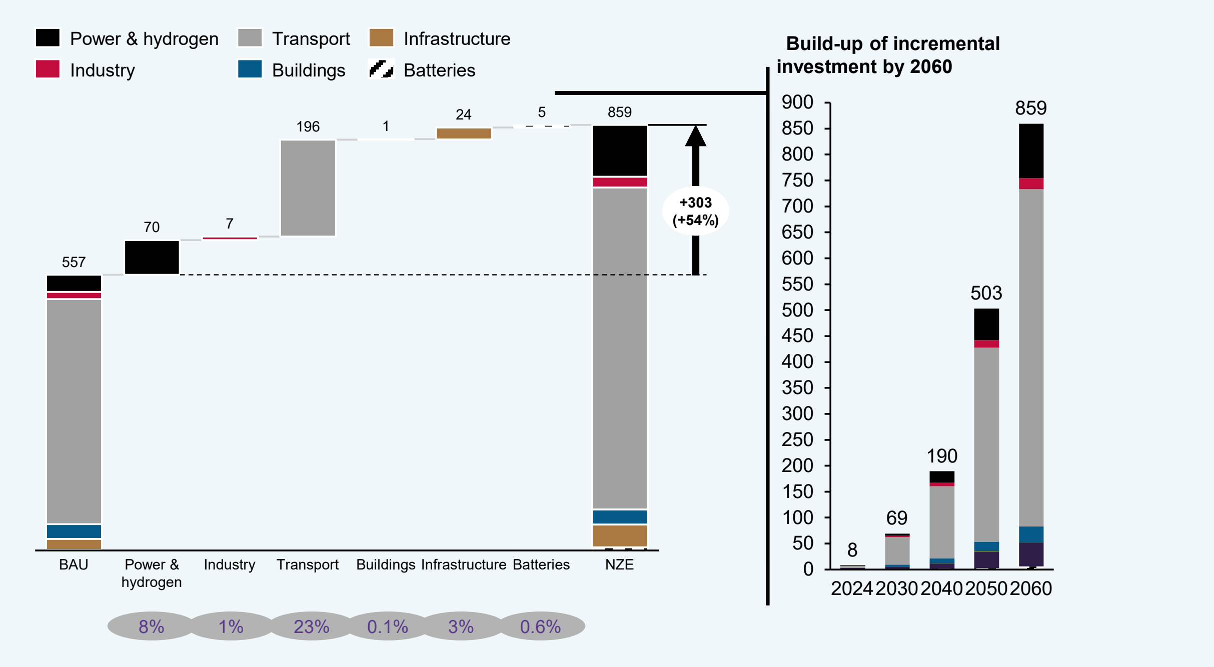


In the NZE scenario, investments are also required in transmission and distribution networks (USD 43 bn), batteries (USD 6.2 bn) and buildings (USD 30.5 bn) by 2060 to support increasing electrification across all sectors. In contrast, the industry (2.5%) and buildings sectors (3.5%) contribute a relatively smaller share of additional cumulative investment needs compared to transport and power.

The timing of investments also changes significantly under the NZE pathway. While investment growth remains moderate before 2040, the majority of additional investments occur after 2045 as electrification accelerates across transport, buildings, and industry. This reflects the rapid scale-up of low-carbon technologies and supporting infrastructure required to achieve economy-wide net-zero emissions by 2050.

Overall, the NZE pathway demonstrates that achieving deep decarbonization in Kenya requires substantial long-term capital investments across the entire energy system, particularly in transport electrification, low-carbon power generation technologies and transmission and distribution network In the NZE pathway, the transmission and distribution network needs to be expanded to account for higher share of renewables which increase the overall installed capacity. Specifically, in the NZE pathway capital investments in transmission and distribution network are USD 43 bn while in BAU there are USD 21 bn by 2060.

Figure 14: Comparison of cumulative investment by sector between BAU and NZE, 2024-2060 (M USD)



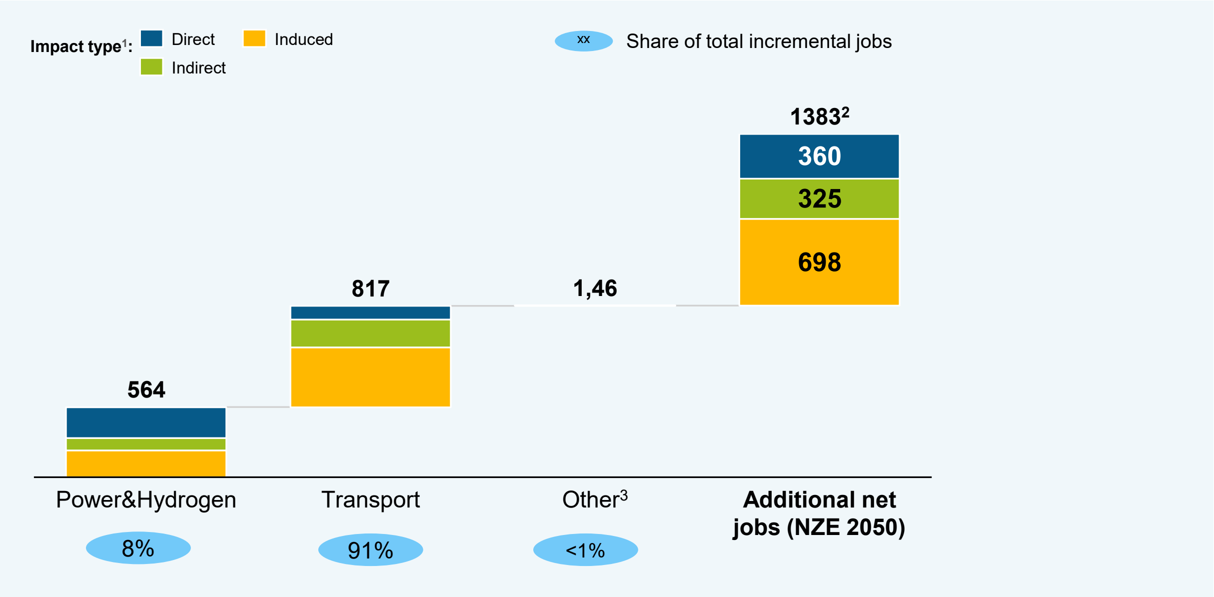
The NZE pathway could support significant additional economy-wide employment compared to the BAU scenario due to higher investments in low-carbon technologies, infrastructure, and electrification across multiple sectors (Figure 15). The analysis estimates that the additional investments required under NZE could support approximately 1.4 million additional net jobs by 2050, including direct, indirect, and induced employment effects across the economy[1].

The transport sector accounts for the largest share of additional employment, contributing around 91% of total additional jobs. This is primarily driven by large-scale deployment of electric vehicles, charging infrastructure, manufacturing and supply chains, construction activities, and operation and maintenance services associated with transport electrification. Investments in the power and hydrogen sectors also contribute additional employment opportunities through expansion of renewable generation, transmission and distribution infrastructure, and hydrogen technologies.

The majority of additional jobs are induced and direct employment effects, reflecting the broader economic impacts of increased investments and economic activity associated with the energy transition. Indirect employment effects also increase due to growing demand across supporting industries and supply chains.

Overall, the NZE pathway demonstrates that Kenya's energy transition could deliver substantial socio-economic benefits beyond emissions reductions, supporting economic growth, infrastructure development, industrial activity, and large-scale job creation across the economy.

Figure 15: Comparison of net additional jobs from key energy sector investment between BAU and NZE in 2050 ('000 jobs)



---

[1] Direct jobs are on-site positions created by the initial investment. Indirect jobs are upstream supply-chain positions. Induced jobs result from household spending of direct and indirect workers. [2] Net additional jobs include the number of jobs created in the NZE scenario compared to the BAU by 2050 including the jobs lost throughout the energy transition. [3] Other jobs includes the jobs in the cooking sector.

CHAPTER ONE

INTRODUCTION

1.1 Kenya's Energy System Overview

Kenya's population reached approximately 52.4 million in 2024, with around 69% residing in rural areas, although urbanization is expected to accelerate in the coming decades, and alongside an increase in national electricity connectivity access rate to the grid of 57.7% [2]. Looking ahead, the population is projected to increase to nearly 83 million by 2060, alongside a significant rise in GDP per capita from USD 2,358 in 2024 to USD 9,781 by 2060 [1]. These trends are expected to drive a substantial increase in energy demand across all sectors of the economy. Total final energy consumption is projected to grow from 1,060 PJ in 2024 to 2,828 PJ by 2060, with oil products currently accounting for approximately 51% of total consumption, primarily driven by the transport sector.

Kenya's power system is already relatively decarbonized, with total installed capacity reaching 2.97 GW in 2024, of which approximately 82% is renewable. This includes geothermal (0.94 GW), hydro (0.82 GW), onshore wind (0.44 GW), solar PV (0.21 GW), and biomass, with the remaining capacity based on oil-fired generation (0.51 GW) [3]. The country is also interconnected with neighboring systems, currently importing electricity from Uganda and Ethiopia and planning further interconnections with Ethiopia. Despite this progress in the power sector, other sectors remain heavily dependent on fossil fuels. The transport sector is almost entirely oil-based, with over 13,240 electric vehicles out of a total fleet of approximately 4.75 million vehicles [4]. In the cooking sector, traditional biomass (54%) and LPG (31%) dominate with less than 1% of approximately 14.1 million stoves being electric. In industry, total energy consumption reached 90 PJ in 2024, with coal accounting for around 57% and oil for approximately 11%.

Given these dynamics, achieving Kenya's policy objectives — including universal access to modern energy services (SDG7) by 2030, clean power generation by 2030 including gas, clean cooking adoption by 2030, and net-zero emissions by 2050 — will require a fundamental transformation of the country's energy system. This study applies the Sustainable Energy for ALL systems model (SEM), a least-cost optimization model for medium- to long-term energy planning, to assess the evolution of Kenya's energy system over the period 2024–2060. This analysis is an update to Kenya's existing Energy Transition and Investment Plan (ETIP), launched in 2024. The update to the ETIP has been undertaken to align it with recent policy updates including NDC 3.0, Mission 300 Energy Compact and strategies such as those initiated as part of Kenya's commitment to the Beyond Oil and Gas initiative.

The analysis considers all major sectors (power, transport, industry, buildings, and agriculture) in an integrated manner and evaluates three energy transition pathways: Business-as-Usual (BAU), Current Policies (CPS), and Net Zero Emissions by 2050 (NZE). The BAU scenario reflects a least-cost expansion pathway considering the achievement of universal electricity access (SDG7) by 2030. The CPS builds on BAU by incorporating the full set of existing policy commitments, including clean power development and clean cooking targets by 2030. The NZE 2050 scenario represents a more ambitious pathway aligned with achieving economy-wide net-zero emissions by 2050.

Across all scenarios, the analysis presents the evolution of CO_2 emissions, sectoral energy demand, capacity expansion, associated investment requirements, and job creation, providing a comprehensive view of Kenya's energy transition pathways in the following chapters.

CHAPTER TWO

METHODOLOGY

This study applies a least-cost energy systems optimization framework to assess the evolution of Kenya's energy system over the period 2024–2060 on an annual basis. The analysis is conducted using the Sustainable Energy for ALL systems model (SEM), a bottom-up energy system model that determines the optimal combination of technologies and fuels required to meet projected energy demand across all sectors at minimum system cost, subject to technical, economic, and policy constraints.

The model represents the entire energy system in an integrated manner, including the power, transport, industry, buildings (cooking, cooling, lighting, water heating), and agriculture (motive power and pumping) sectors. Energy demand is exogenously defined based on socio-economic projections, while the model endogenously determines the optimal supply mix, including technology deployment, fuel consumption, capacity expansion, and associated investments.

2.1 Scenario Framework

In this study, three energy transition pathways were investigated for Kenya to assess how the energy system of the country will evolve in the future under policy, technology and emission constraints.

Business-as-Usual (BAU)

The BAU scenario reflects the **least-cost expansion pathway** of the energy system, assuming the achievement of universal electricity access (SDG7) by 2030. It does not include additional policy interventions beyond those already implemented and reflected, for instance in existing project pipelines, and therefore represents a baseline trajectory driven primarily by cost optimization and demand growth.

Current Policies Scenario (CPS): “2025 aligned policies”

The CPS builds on the BAU scenario by incorporating the **full set of existing policy commitments (NDC 3.0, SDG7, Mission 300 Energy compact, BOGA)**, including targets for clean power generation by 2030 including gas investments, electrification, and clean cooking by 2030 (**Table 1**). This scenario reflects the expected evolution of the energy system under currently announced and implemented policies.

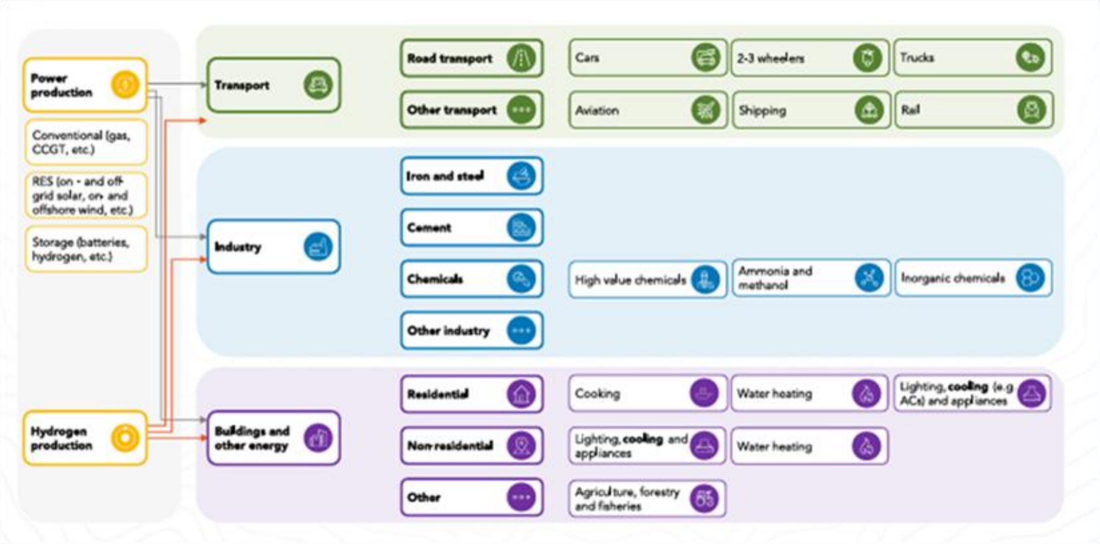
Net Zero Emissions Scenario (NZE 2050)

The NZE scenario represents an **ambitious transformation pathway** aligned with achieving economy-wide net-zero carbon dioxide emissions by 2050. It includes additional constraints and policy drivers to accelerate electrification, expand renewable energy deployment, and significantly reduce fossil fuel consumption across all sectors.

2.2 Key Assumptions

The SEforALL’s Energy Systems Model (SEM) is an integrated, technology-rich energy system model developed by SEforALL to support long-term energy planning, investment analysis, and energy transition pathways. The model represents the entire energy system, including energy supply, power generation, transmission and distribution, transport, industry, buildings, agriculture, and emerging technologies such as hydrogen and energy storage (Figure 16). SEM enables the assessment of alternative development pathways and evaluates the implications of different policy, technology, and investment choices on energy security, affordability, sustainability, and emissions reduction.

Figure 16: Overview of the SEM model structure.



The objective of the model is to identify the least-cost pathway for meeting future energy service demands while satisfying a range of technical, economic, environmental, and policy constraints. The objective function minimizes the total discounted system cost over the modelling horizon, including capital investments, fixed and variable operation and maintenance costs, fuel expenditures, technology replacement costs, and infrastructure investments. The model simultaneously determines the optimal timing, scale, and technology mix of investments required to satisfy future energy demand while respecting resource availability, technology performance characteristics, emissions constraints, energy access targets, renewable energy policies, and other country-specific objectives.

By optimizing investment and operational decisions across all sectors of the economy, SEM provides a consistent analytical framework for evaluating energy transition pathways, estimating investment requirements, assessing emissions trajectories, and identifying cost-effective strategies for achieving national energy and climate goals.

Given the increasing penetration of variable renewable energy technologies such as solar PV and wind, additional power system flexibility assessments can provide valuable insights into the operational feasibility of future electricity systems. Tools such as IRENA's FlexTool [5] enable detailed analysis of system flexibility requirements, including balancing needs, storage utilization, reserve provision, curtailment levels, and transmission constraints at high temporal resolution. Such analyses can support the identification of cost-effective flexibility options, including battery energy storage systems, demand-side management, flexible generation, and regional power trade. Future work could therefore complement the long-term energy system modelling presented in this study with dedicated flexibility assessments to ensure reliable and resilient operation of Kenya's evolving low-carbon power system (Figure 25).

Energy Demand Projections

Energy demand is a key driver of system expansion and is projected based on population growth, GDP per capita, urbanization, electricity access, and TIERS[2] of electricity [1, 2, 3].

Kenya's population is projected to increase significantly over the modelling horizon, alongside strong economic growth (Figure 17). These trends drive a substantial increase in energy demand across all sectors, particularly in transport, buildings, and industry.

Sectoral energy demand is developed using a combination of:

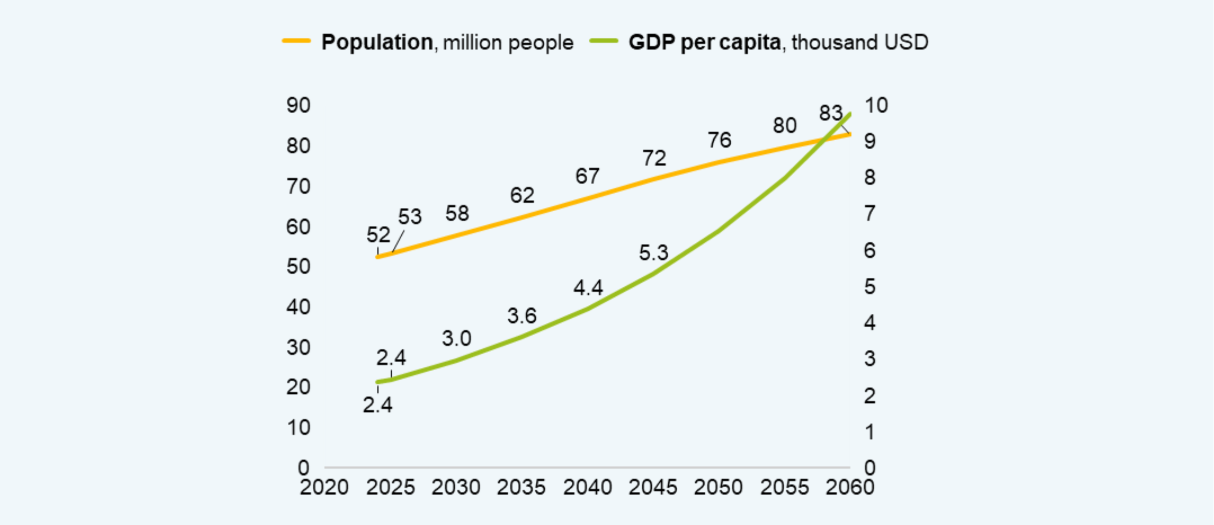
- Socio-economic drivers (population, GDP per capita)

---

[2] Electricity access in this study is assessed using the World Bank Group (WBG) and ESMAP Multi-Tier Framework (MTF), which measures not only whether households are connected to electricity but also the quality and adequacy of the service provided. The framework classifies electricity access into six levels, from Tier 0 (no access) to Tier 5 (full access), based on attributes such as capacity, duration, reliability, affordability, and quality of supply. Lower tiers provide basic services such as lighting and phone charging, while higher tiers enable the use of productive appliances and support economic development [6].

- Sector-specific activity indicators (e.g. vehicle stock, industrial output, household energy use)
- Technology and efficiency assumptions. Efficiency improvements in technologies across all sectors are considered throughout the modelling period such as efficient AC's compared to standard ones, efficiency motors in industries, and efficiency in electric vehicles is improving, and others.

Figure 17: Projected population and GDP growth in Kenya



The model explicitly represents energy demand across:

- **Transport** (passenger and freight mobility)
- **Industry** (energy-intensive and non-energy-intensive processes)
- **Buildings** (cooking, cooling, lighting, water heating)
- **Agriculture** (motive power and irrigation)
- **Electricity demand** (residential, commercial, and industrial)

These demand projections constitute the **primary inputs to the model**, driving the required expansion of supply-side infrastructure.

Energy demand increases across all sectors, particularly in transport, industry and, buildings. The transport sector becomes one of the largest contributors to future energy demand growth due to increasing vehicle ownership and mobility needs (Figure 19). At the same time, industrial energy demand expands in line with economic growth and industrialization (Figure 20) while demand in buildings increases due to growing population, number of households and increasing income levels (Figure 18).

Figure 18: Energy demand projection for buildings sector

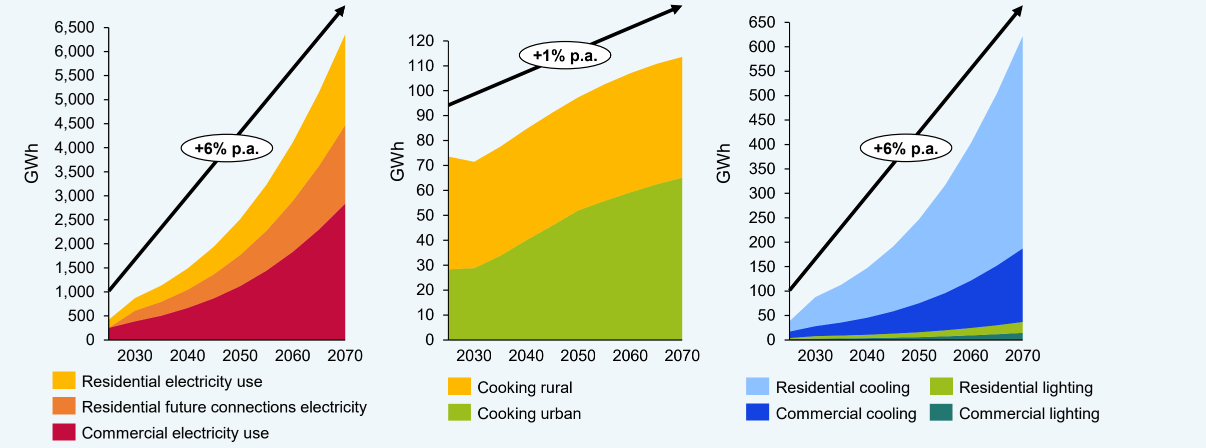


Figure 19: Energy demand projection for the transport sector

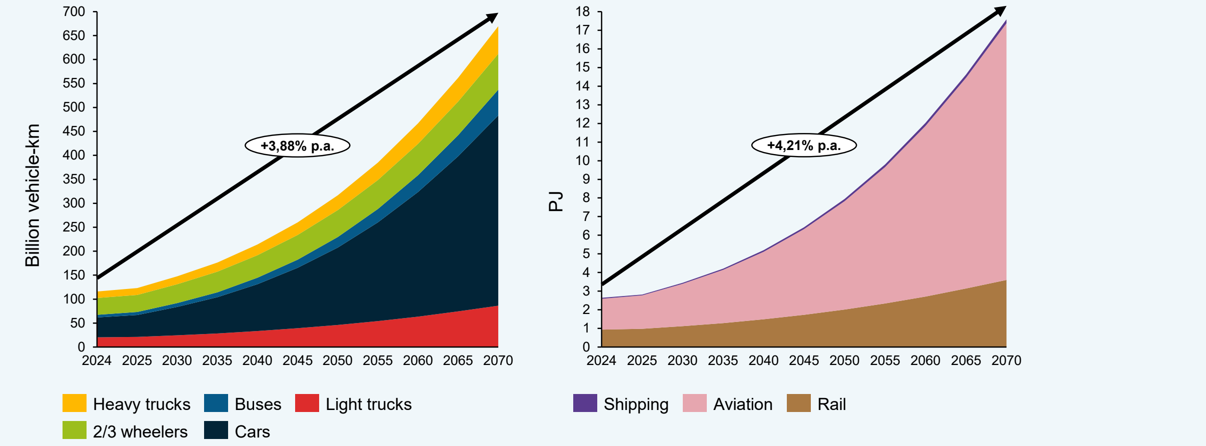
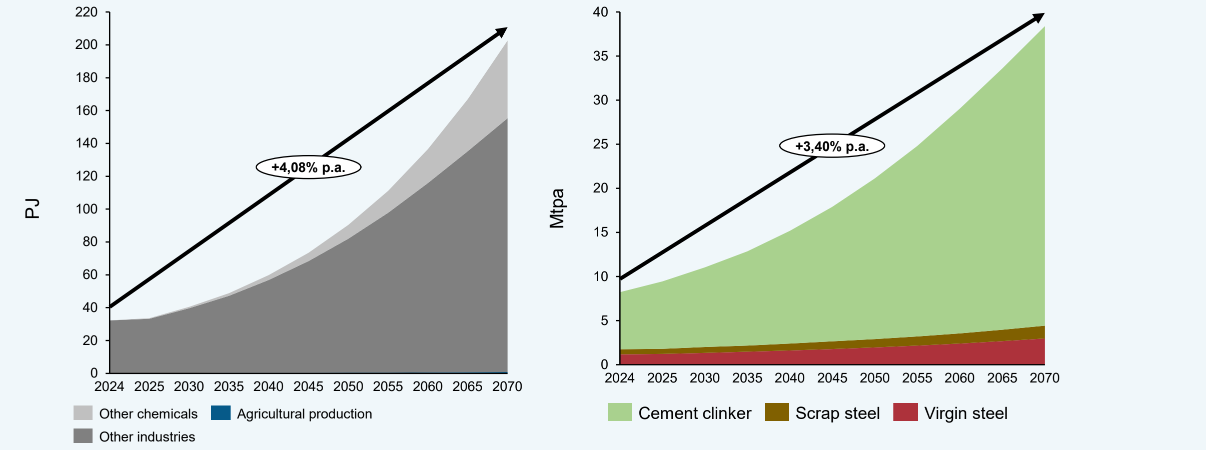


Figure 20: Energy demand projection for the industry and agriculture sectors.



Technology Cost and Performance

Technology cost assumptions include **capital costs, operation and maintenance (O&M) costs, efficiency and capacity factors parameters, and lifetimes** for all technologies across the energy system (APPENDIX A).

Future cost trajectories reflect expected technology learning and market developments, particularly for:

- Renewable energy technologies (solar PV, wind)
- Energy storage systems (batteries)
- Electric mobility technologies
- Clean cooking solutions

These assumptions are critical in determining the relative competitiveness of technologies and the resulting least-cost system configuration.

Fuel Costs

Fuel cost assumptions are based on international benchmarks [7, 8, 9] and reflect expected trends in global energy markets (APPENDIX A, Figure 55). The model includes price projections for key fuels such as crude oil, natural gas, coal and biomass.

Policy and System Constraints

Each scenario incorporates a set of policy and system constraints aligned with government priorities that influence the evolution of the energy system. Electricity interconnectors are also considered in the study, imports and exports to Kenya with electricity import and export costs (APPENDIX A) The policies and constraints considered include:

- Electricity access targets (SDG7) by 2030
- Clean power generation targets
- Clean cooking targets
- Net-zero emissions constraints (in NZE scenario)

Table 1: Targets imposed in CPS and NZE scenario across sectors

Targets	2024	2030	2050
Electricity access 100% by 2030 (also in BAU)			
- Urban - Rural	90.7% 36.9%	100% 100%	100% 100%
Clean power generation	-	No investments in oil (2030-2060) Investments in gas are allowed	-
Clean cooking by 2030	-	LPG (50% of households)	

		Bioethanol (30% of households) Electric (10% of households) Biogas 3% Improved biomass 7%	
Net zero emissions (NZE scenario only)	-	-	0 CO_2 emissions from 2050 onwards

Additional constraints include:

- Technical limits (e.g. capacity factors, resource availability)
- System requirements (e.g. balancing, reliability considerations)

These constraints ensure that the model reflects both **real-world system limitations and policy objectives**, providing a realistic representation of possible energy transition pathways.

CHAPTER THREE

ENERGY SYSTEM OUTLOOK

This chapter presents the results of Kenya's energy transition pathways for BAU and NZE 2050 during the period 2024-2060. The analysis covers the evolution of fuel consumption, power generation, sectoral technology transitions, emissions, and socio-economic impacts. In addition, a sensitivity analysis is conducted to assess the impact of uncertainties related to energy demand growth, fuel costs, and hydrological conditions on the evolution and resilience of Kenya's future energy system.

3.1 Power Sector

Under the BAU scenario, electricity consumption increases at an average annual growth rate of approximately 5% until 2060, growing over six times from 2024 level (Figure 21). The residential sector accounts for the largest share (48%) of electricity demand by 2060, mainly driven by growing access and increasing penetration of cooling and lighting appliances. This is followed by industries (23%) and the commercial sector (15%) where increasing demand for cooling and lighting services results in higher electricity consumption over time. In contrast, the transport sector remains only partially electrified (15%) under BAU due to continued reliance on oil- technologies

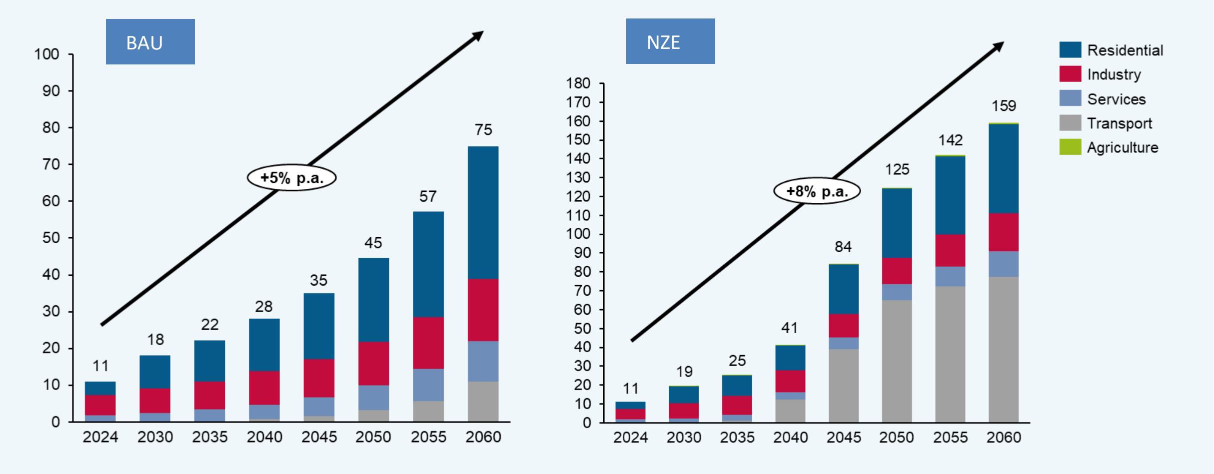
Under the NZE scenario, electricity consumption grows more rapidly, reaching an average annual growth rate of around 8% by 2060 due to accelerated electrification across transport, buildings, and industry. Large-scale electrification of transport after 2040 significantly increases total electricity demand compared to the BAU in 2060 resulting in it becoming one of the largest electricity-consuming sectors by 2060.

Industrial electricity demand also increases substantially under NZE, rising by approximately 19% by 2060 compared to BAU. This increase is primarily driven by replacement of coal- and oil-based boilers with electric boilers, increased deployment of electric motors, and electrification of low-temperature industrial heat processes.

The electricity demand for cooling and lighting due to the adoption of more efficient technologies such as air conditioning systems and lighting appliances may decrease electricity consumption in the residential by 31% by 2060 and commercial sectors by 22% by 2060 but the higher penetration of e-stoves for cooking increase electricity consumption by 12 TWh by 2060.

Overall, the NZE pathway significantly accelerates electrification across the economy, transforming Kenya's energy system towards a more electricity-based and energy-efficient structure.

Figure 21: Electricity consumption by sector under BAU and NZE (TWh)



Electricity Generation

To meet rising consumption, electricity generation must be ramped significantly to ensure reliable, affordable and environmentally sustainable supply. In the BAU scenario, electricity generation increases significantly by 2060, growing approximately 5 times compared to 2024 levels, mainly driven by increasing electricity demand in the residential and commercial sectors (Figure 22). Total electricity generation increases from around 12 TWh in 2024 to approximately 83 TWh by 2060. Electricity imports increase during 2025–2035, as a new interconnector comes into operation, to support additional generation needs to achieve universal electricity access by 2030; however, imports represent only around 17% of total electricity supply by 2050. Electricity exports remain relatively stable throughout the modelling period at 0.45 TWh.

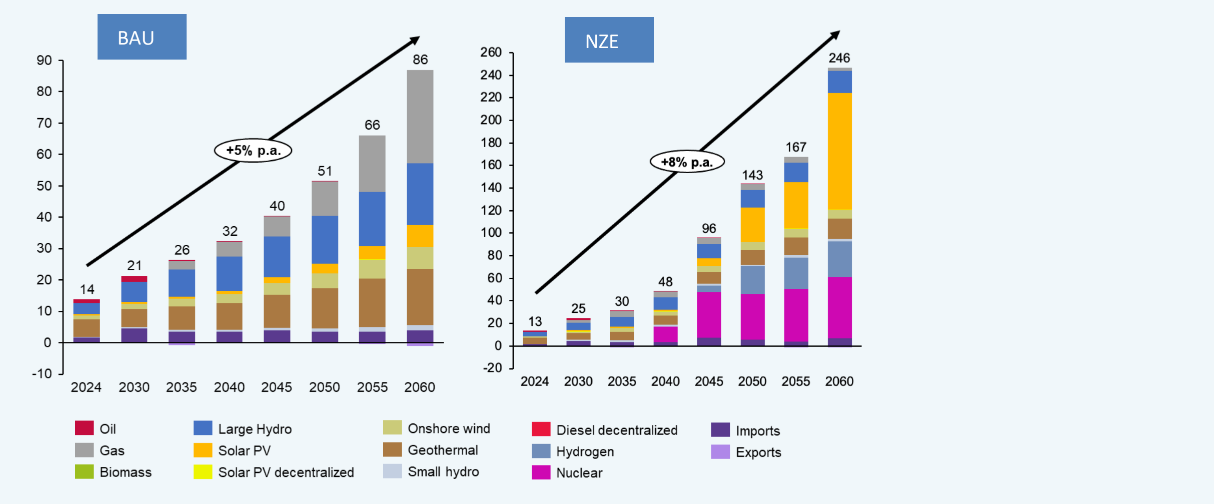
Geothermal remains the backbone of the power system under BAU, representing around 27% of total electricity generation by 2050. Geothermal generation increases approximately 2 times by 2050, while natural gas generation expands significantly, by around 11 times, to support growing electricity demand and system flexibility. Solar PV generation also increases substantially, by around 8 times, while large hydropower generation grows more moderately, by approximately 4 times. As a result of increased natural gas deployment, the renewable energy technology (RET) share decreases from around 91% in 2024 to approximately 77% by 2050 – a decreased softened by continued expansion of geothermal and solar PV generation.

In contrast, under the NZE scenario, electricity generation grows more rapidly, with an average annual growth rate of around 8%, driven primarily by large-scale electrification of transport and industry. Renewable technologies dominate the generation mix by 2050, accounting for around 49% of total generation, followed by nuclear (29%), hydrogen (18%), and natural gas (4%). Achieving net-zero emissions requires substantial expansion of low-carbon generation technologies, particularly solar PV and geothermal, which increase approximately 79 times and 3 times, respectively, compared to 2024 levels.

Nuclear generation penetrates the system from 2036 onwards, progressively replacing natural gas generation in later years. Hydropower continues to play an important role as a stable baseload contributor together with geothermal generation, while natural gas remains important for flexibility in earlier years before being fully phased out by 2064. Consequently, the NZE pathway results in a highly diversified and low-carbon electricity system, enhancing Kenya's long-term energy security and reducing exposure to fossil fuel price volatility.

Electricity imports and exports remain at similar levels to the BAU scenario, as regional interconnection capacities are assumed to remain unchanged between scenarios.

Figure 22: Power generation mix under BAU and NZE (TWh)



Power Capacity

In the BAU scenario, installed power generation capacity expands significantly, growing at an average annual rate of around 5% until 2060 as electricity demand increases across the economy (Figure 23). The capacity mix becomes progressively more diversified, mainly through expansion of geothermal, natural gas, and solar PV technologies. Natural gas investments emerge from 2031 onwards to support growing electricity demand and provide additional system flexibility. Although the renewable energy share increases from around 82% in 2024 to 86% in 2030 due to large hydropower penetration, it subsequently decreases to approximately 82% by 2050 due to natural gas capacity installation. Large hydropower remains the dominant installed capacity technology in the long term due to Kenya's strong hydro resource potential.

As variable renewable energy penetration increases, particularly solar PV, investments in electricity storage systems become increasingly important to support system flexibility and reliability. Consequently, battery storage capacity reaches approximately 1.5 GW by 2050 under BAU. In parallel, regional electricity interconnections continue to play an important role in balancing the system, with imports and exports increasing from around 320 MW in 2024 to approximately 0.92 GW by 2060.

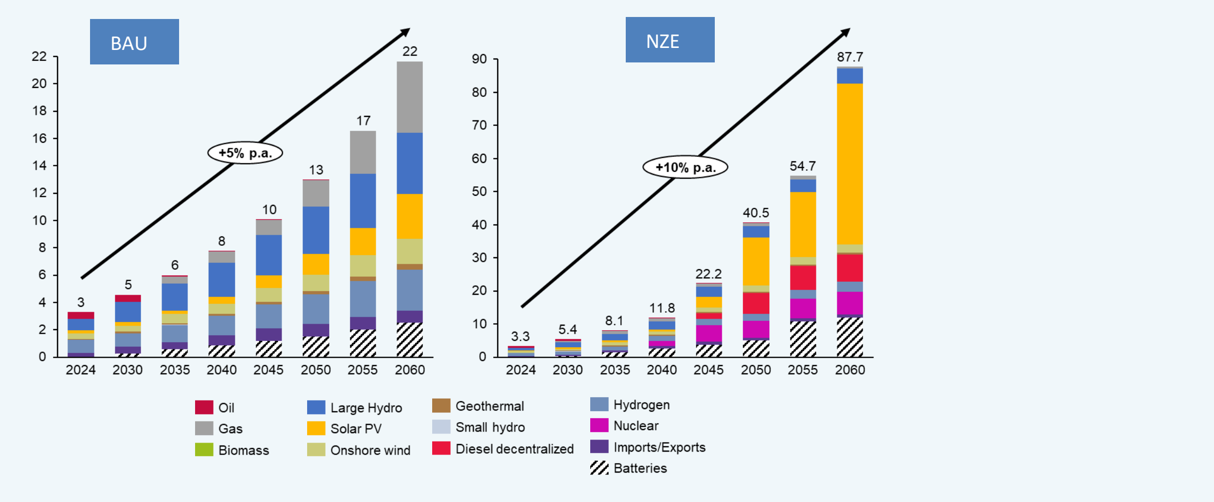
In contrast, under the NZE scenario, installed capacity expands much more rapidly, growing at an average annual rate of approximately 10% as large-scale electrification accelerates across transport, and industry. Renewable technologies dominate future capacity additions, accounting for around 64% of total installed capacity by 2050. Solar PV becomes the largest generation technology, reaching approximately 14.5 GW by 2050, followed by geothermal (2.2 GW) and onshore wind (1.8 GW).

The NZE pathway also requires substantial deployment of firm and flexible low-carbon capacity to ensure system reliability under high renewable penetration. Nuclear generation (5 GW) and hydrogen technologies (6.4 GW) progressively expand and diversify the power mix by 2050, while hydropower continues to provide an important stable baseload contribution together with natural gas in earlier years of the transition. Increasing renewable penetration and system electrification also require significantly higher investments in storage systems, with battery capacity increasing to approximately 5 GW by 2050.

Nuclear power provides a firm, low-carbon source of electricity that can complement variable renewable energy generation and support long-term energy security. However, introducing nuclear generation into Kenya's power system presents substantial technical, financial, institutional, and regulatory challenges. Nuclear projects typically require very high upfront investments, long development timelines, and strong government commitment over multiple decades. In addition, the deployment of nuclear energy requires the establishment of robust regulatory institutions, highly skilled human resources, nuclear safety and security frameworks, radioactive waste management systems, and public acceptance. Given the relatively small size of Kenya's current electricity system, careful planning will also be required to ensure that nuclear generation can be integrated efficiently without creating system operational challenges or increasing overall electricity costs.

Overall, the NZE pathway transforms Kenya’s power system into a highly diversified, low-carbon, and electricity-intensive system capable of supporting rapid electrification and long-term net-zero emissions objectives.

Figure 23: Power installed capacity under BAU and NZE (GW)



Hydrogen

In the NZE scenario, hydrogen begins penetrating Kenya's energy system from 2027 onwards, supporting decarbonization of hard-to-abate sectors and enhancing long-term system flexibility. Green hydrogen production initially emerges at relatively small scale, around 1 PJ in 2027, primarily to support decarbonization of the steel sector and aligned with increasing deployment of renewable electricity generation.

Hydrogen production expands significantly over time, reaching approximately 294 PJ by 2050 as electrification and decarbonization accelerate across the economy (Figure 24). While green hydrogen plays an important role in earlier years, blue hydrogen production scales up rapidly after 2035 and becomes the dominant hydrogen production pathway by 2050. This expansion is mainly driven by the need to decarbonize hard-to-abate industrial processes and heavy-duty transport segments, while also supporting flexibility requirements in the power sector under high renewable energy penetration.

However, blue hydrogen is associated with residual greenhouse gas emissions due to upstream methane leakage and incomplete carbon capture rates, and therefore does not represent a fully zero-emission fuel pathway. Its long-term role in achieving net-zero emissions depends on the availability of reliable carbon capture and storage (CCS) infrastructure, suitable geological storage potential, and effective methane management across the natural gas supply chain. Consequently, blue hydrogen should primarily be considered as a transitional low-carbon fuel rather than a fully zero-emission solution.

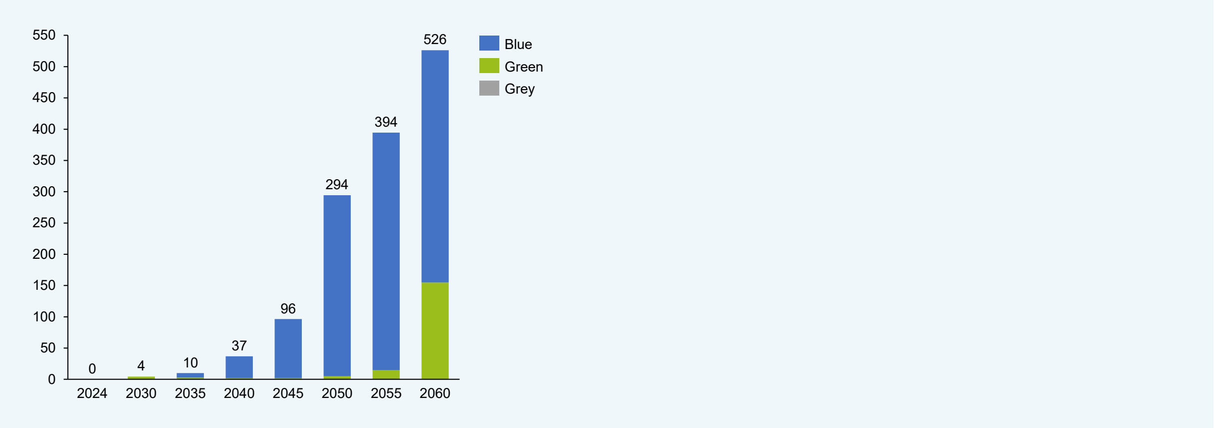
Nevertheless, within the NZE scenario, blue hydrogen emerges as an important transitional flexibility option, particularly after 2040, supporting the decarbonization of hard-to-abate sectors where direct electrification remains technically or economically challenging. The model deploys blue hydrogen mainly in heavy-duty transport, cement, industrial high-temperature heat applications, and the power sector to provide long-duration system flexibility during periods of low renewable generation. The deployment of blue hydrogen is therefore driven by system reliability requirements, seasonal balancing needs, and limitations associated with direct electrification of certain end uses.

At the same time, green hydrogen production expands significantly in parallel with renewable electricity deployment, particularly solar PV, reflecting increasing sector coupling between the power sector and hydrogen production. Over time, green hydrogen progressively increases its generation (2058 onwards) as renewable electricity availability increases and electrolyzer deployment scales up. The pace of green hydrogen expansion may further be influenced by the pace of cost reduction and technology adoption, alongside other global factors including industrial goods decarbonization targets.

The hydrogen balance further demonstrates that hydrogen demand is concentrated primarily in heavy-duty transport, industrial processes (including cement, chemicals, steel and high-temperature heat applications), and flexible power generation.

The rapid increase in hydrogen production occurs in parallel with expansion of the electricity system, highlighting strong sector coupling between the power, industry, and transport sectors. Overall, hydrogen becomes an important low-carbon energy carrier under the NZE pathway, supporting system flexibility, industrial decarbonization, and long-term energy system diversification.

Figure 24: Hydrogen production mix under NZE (PJ)



System Flexibility

The flexibility assessment highlights the increasing importance of system flexibility as Kenya's power system transitions towards higher shares of variable renewable energy under the NZE pathway. Under the BAU scenario, the power system remains relatively stable throughout the modelling horizon, with geothermal generation providing the majority of baseload electricity supply while natural gas, hydropower, and electricity imports contribute to balancing short-term variability in demand and renewable generation.

In contrast, under the NZE scenario, the significantly higher penetration of solar PV and other variable renewable technologies results in much larger intra-day and seasonal variability in electricity generation. As electrification accelerates across transport, buildings, and industry, the power system requires substantially higher levels of flexibility to maintain reliability and system stability.

The results indicate that batteries, hydrogen technologies, hydropower, flexible thermal generation, and electricity interconnections play a critical role in balancing the system under high renewable penetration. Battery storage becomes particularly important in managing short-term solar PV variability and shifting electricity generation across different timeslices (APPENDIX A)[3], while hydrogen technologies and firm generation sources support longer-duration flexibility and reliability requirements.

The NZE pathway therefore requires not only large-scale renewable deployment, but also significant investments in demand- and supply-side system flexibility infrastructure, storage technologies, transmission networks, and dispatchable low-carbon generation capacity to ensure secure and reliable operation of the future power system.

The flexibility assessment highlights the increasing operational challenges of integrating large shares of variable renewable energy technologies into Kenya's future power system, particularly under the NZE scenario (Figure 25). The figures illustrate hourly electricity generation profiles across

---

[3] Timeslices are representative periods of the year used to capture seasonal and intra-day variations in electricity demand and renewable resource availability. In this study, the year is divided into 36 timeslices representing different seasons and times of day, allowing the model to assess how technologies such as batteries, hydropower, and flexible generation balance the system under varying operating conditions and high shares of renewable energy.

representative periods, showing the contribution of different technologies to meeting electricity demand and balancing the system.

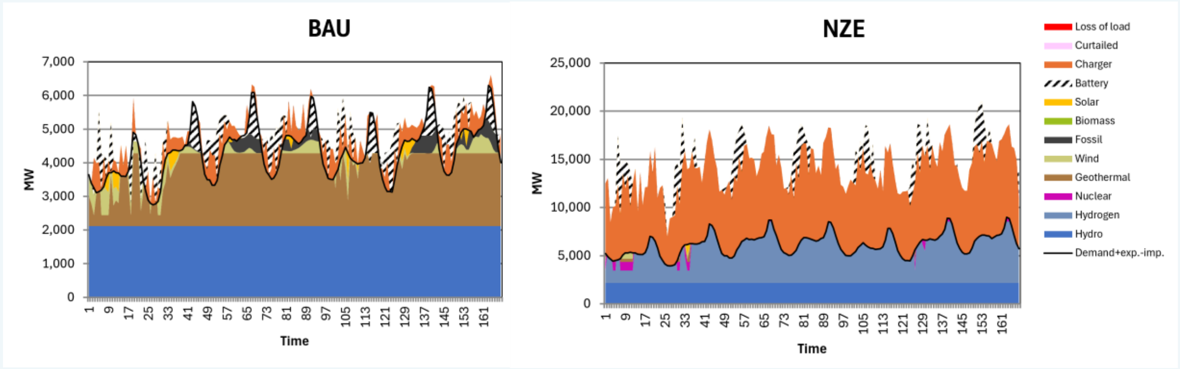
Under the BAU scenario, the electricity system remains relatively stable and dominated by dispatchable generation technologies, particularly geothermal, hydropower, and natural gas. Variable renewable energy penetration remains comparatively moderate, resulting in limited short-term variability in the generation mix. Consequently, the system requires relatively low levels of storage and flexibility resources to maintain reliability and balance supply and demand.

In contrast, the NZE scenario exhibits significantly higher variability in electricity generation due to the large-scale deployment of solar PV and other renewable technologies. Strong fluctuations in renewable generation create periods of surplus electricity production during high renewable output hours, followed by steep ramping requirements during low renewable generation periods. At the same time, rapid electrification of transport, buildings, hydrogen production, and industry substantially increases electricity demand and system peaks.

To maintain system reliability and ensure secure operation under these conditions, substantial flexibility resources are required. Battery storage plays a critical role by shifting excess renewable generation across time periods, reducing renewable curtailment, managing peak demand, and providing short-term balancing services. Hydrogen production and storage further contribute to long-duration and seasonal flexibility by absorbing excess renewable electricity and supplying energy during periods of lower renewable availability.

The flexibility assessment therefore justifies the recommendation for approximately 12.5 GW of battery storage capacity by 2050 under the NZE pathway. These investments are essential to support high renewable penetration, maintain grid stability, reduce dependence on fossil-fuel peaking plants, and enable a reliable low-carbon electricity system. Overall, the NZE scenario demonstrates that achieving deep decarbonization requires not only renewable capacity expansion, but also significant investments in storage, system flexibility, and grid integration infrastructure. Supply-side flexibility measures must be complemented by demand-side instruments, including energy efficiency improvements to target peaks, load-shifting from peak to non-peak hours, as well as market regulations incentivizing such flexibility measures.

Figure 25: Flexibility assessment of BAU and NZE (MW)



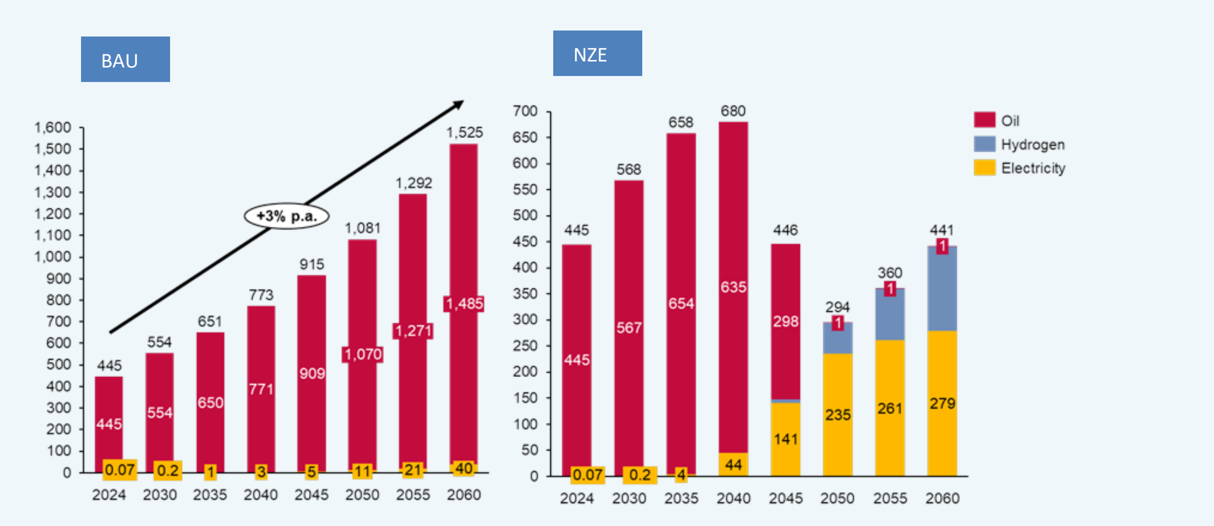
3.2 Transport Sector

In the BAU scenario, transport energy demand increases significantly, growing by approximately three times by 2060 as oil products remain the dominant energy carrier throughout the modelling horizon (Figure 26). Increasing vehicle ownership, economic growth, and rising mobility demand drive strong growth in gasoline and diesel consumption across all transport segments. Electricity penetration remains limited under BAU, growing only gradually over time following the National Electric Mobility study [10].

In contrast, the NZE scenario fundamentally transforms the transport sector through large-scale electrification and fuel switching. Final fuel consumption decreases substantially compared to BAU despite continued growth in transport activity, mainly due to the penetration of more energy-efficient electric vehicles and hydrogen-based heavy-duty transport technologies. Oil-based vehicles are progressively phased out, resulting in a near-complete transition away from conventional fossil fuel transport technologies by 2050.

Electricity becomes the dominant energy carrier in the transport sector by 2050 due to rapid electrification of passenger vehicles, buses, and light-duty transport. Hydrogen consumption also increases significantly in later years, particularly after 2050, as hydrogen-powered heavy trucks penetrate the market and support decarbonization of harder-to-abate transport segments. Overall, the NZE pathway demonstrates that large-scale transport electrification can substantially reduce fossil fuel consumption and emissions while supporting growing mobility demand across the economy.

Figure 26: Transport fuel consumption under BAU and NZE (PJ)



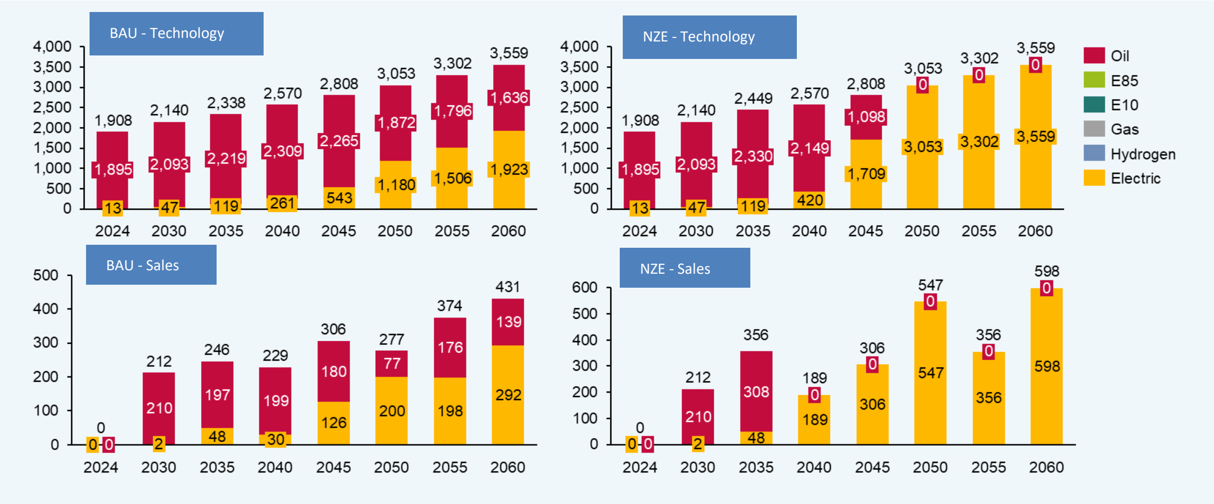
In the BAU scenario, the stock and sales of 2/3 conventional fuel-based wheelers continue to dominate almost the entire fleet throughout the modelling horizon, while penetration of electric and alternative fuel technologies remains limited (Figure 27). As a result, the sector remains largely locked into fossil fuel consumption and associated emissions.

In contrast, the NZE scenario results in a rapid transition towards electrified 2/3 wheelers. Electric vehicles begin penetrating the market more rapidly after 2040, progressively replacing conventional oil-based vehicles. By 2050, electric 2/3 wheelers account for almost the entire vehicle stock and sales, leading to a complete phase-out of oil-based technologies in this transport segment.

The transition towards electric 2/3 wheelers significantly reduces final energy consumption and emissions due to the higher efficiency of electric mobility technologies compared to conventional internal combustion engine vehicles. At the same time, increased electrification contributes to higher electricity demand in the transport sector, requiring additional investments in charging infrastructure and electricity generation capacity.

Overall, the NZE pathway demonstrates that electrification of 2/3 wheelers can play a major role in reducing fossil fuel dependence and decarbonizing urban mobility in Kenya.

Figure 27: 2/3 wheeler technology and sales mix under BAU and NZE (‘000 vehicles)



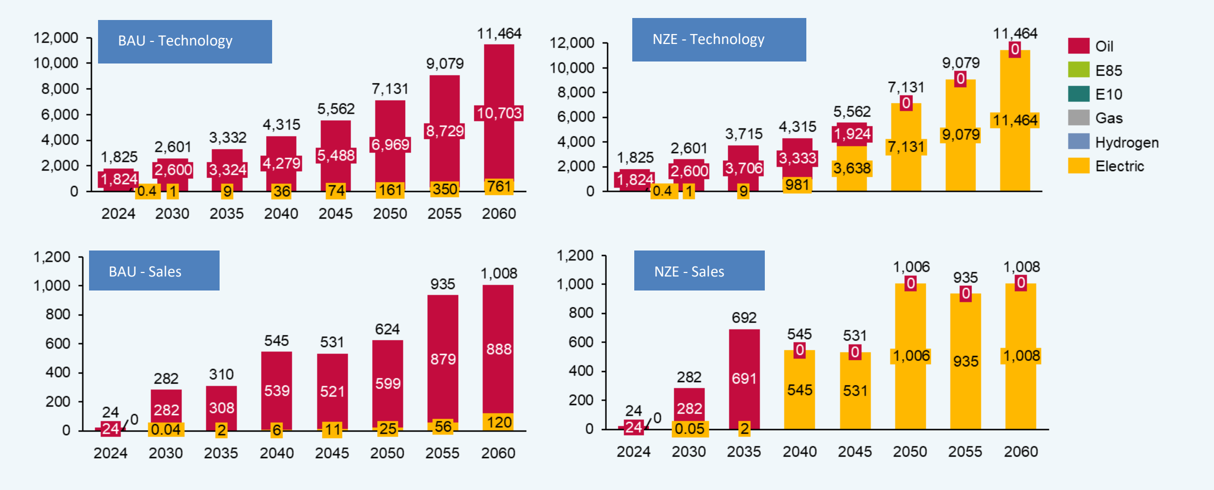
The total passenger car stock increases significantly over the modelling horizon, growing by approximately six times by 2060 due to population growth, urbanization, rising income levels, and increasing mobility demand (Figure 28). Under the BAU scenario, fuel-based vehicles continue to dominate almost the entire passenger car fleet throughout the modelling horizon, while penetration of electric vehicles remains relatively limited. As a result, the sector remains heavily dependent on fossil fuels and associated emissions continue increasing over time.

In contrast, the NZE scenario results in a complete transformation of the passenger car fleet through large-scale electrification. Electric vehicles progressively penetrate the market from the early years of the transition and fully dominate the vehicle fleet by 2050, while oil-based vehicles are gradually phased out over the same period. To achieve full decarbonization of the passenger car sector by 2050, the transition process needs to begin early, with sales of new oil-based passenger vehicles phased out after 2035.

The rapid penetration of electric vehicles significantly reduces final energy consumption by 71% by 2060 in NZE compared to BAU and transport emissions from 30 MtCO2 in BAU in 2060 to 0.04 MtCO2 in NZE due to the substantially higher efficiency of electric mobility technologies compared to conventional internal combustion engine vehicles. At the same time, increasing electrification of passenger transport contributes to rapid growth in electricity demand and requires expansion of charging infrastructure and low-carbon electricity generation capacity.

Overall, the NZE pathway demonstrates that early and accelerated electrification of passenger vehicles is critical for achieving long-term transport decarbonization objectives in Kenya.

Figure 28: Car technology and sales mix under BAU and NZE ('000 vehicles)



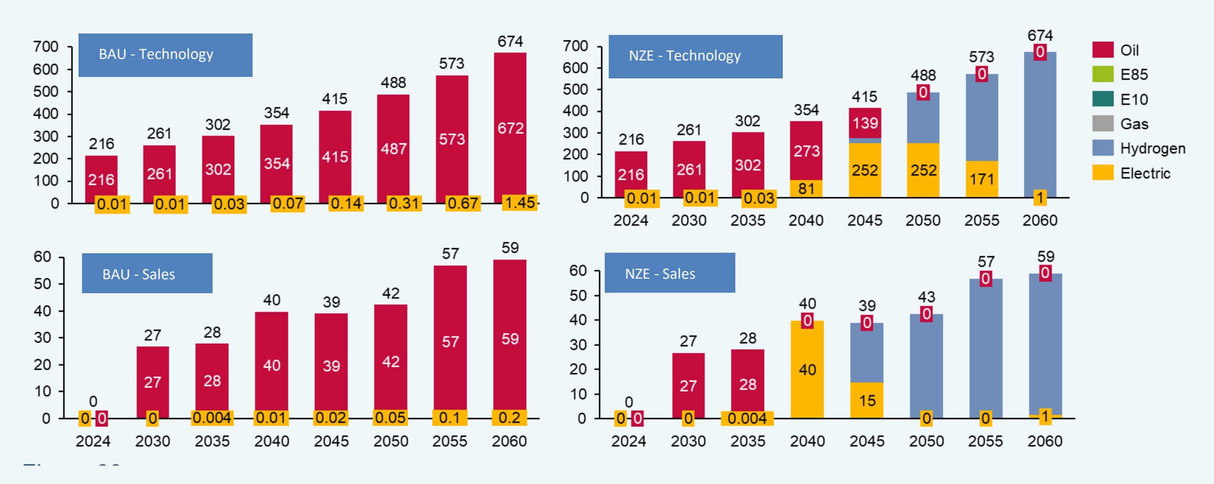
Under the BAU scenario, conventional oil-based heavy trucks continue to dominate the fleet throughout the modelling horizon, with diesel technologies remaining the primary energy carrier (Figure 29). Penetration of electric vehicles remains minimal, around 1,450 electric vehicles in 2060, resulting in continued dependence on fossil fuels and increasing transport emissions over time.

In contrast, the NZE scenario significantly transforms the heavy-duty transport sector through gradual penetration of low-carbon technologies. Electric heavy trucks mainly increase their share from 2036 onwards, 10180 electric vehicles in 2036, particularly for shorter-distance freight applications, while hydrogen-powered heavy trucks expand rapidly after 2045 and become increasingly important in later years. By 2050, oil-based heavy trucks are almost fully phased out as electric (252,000) and hydrogen (236,000) technologies dominate both vehicle sales and fleet composition.

Hydrogen technologies play a particularly important role in decarbonizing heavy-duty freight transport due to their suitability for long-distance operations and higher energy density requirements compared to battery-electric alternatives. As a result, hydrogen demand increases significantly in later years under the NZE pathway.

Overall, the transition towards electric and hydrogen-based heavy trucks substantially reduces fossil fuel consumption and transport emissions while supporting growing freight transport demand across the economy.

Figure 29: Heavy truck technology and sales mix under BAU and NZE ('000 vehicles)

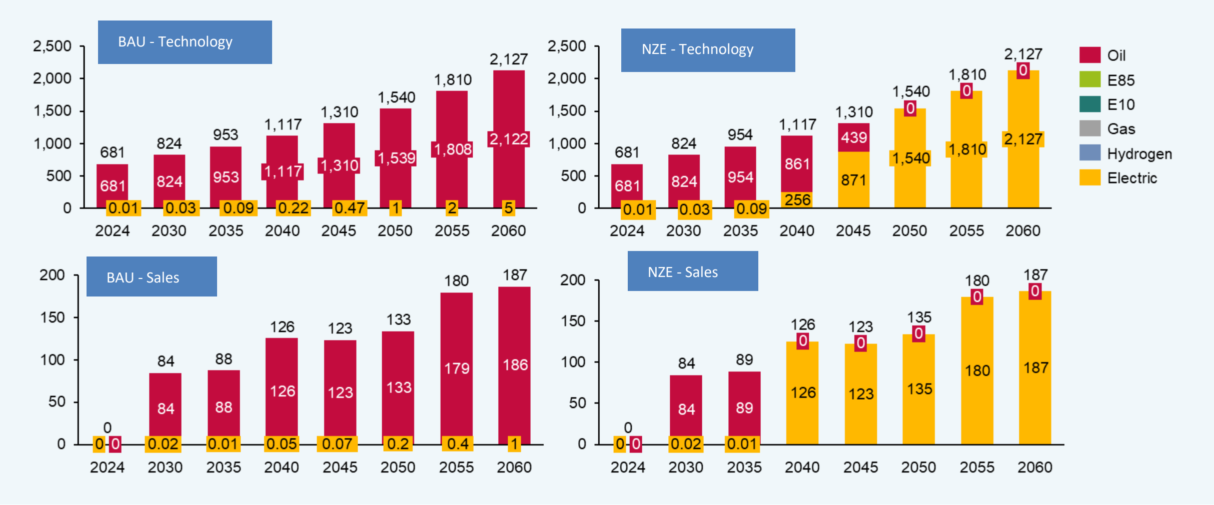


Under the BAU scenario, oil-based technologies continue to dominate the light truck fleet throughout the modelling horizon, with diesel vehicles representing the majority of both stock and new vehicle sales (Figure 30). Penetration of electric vehicles remains limited, reaching 4,800 electric vehicles in 2060, resulting in continued dependence on fossil fuels and increasing transport emissions over time.

In contrast, the NZE scenario results in a rapid transition towards electrified light-duty freight transport. Electric light trucks mainly begin penetrating the market after 2036 and expand rapidly in later years, progressively replacing conventional oil-based technologies. By 2050, electric vehicles dominate both light truck sales and fleet composition, while oil-based technologies are almost completely phased out.

Overall, the NZE pathway demonstrates that electrification of light-duty freight transport can play an important role in reducing fossil fuel dependence and decarbonizing Kenya's transport sector while supporting increasing freight mobility demand.

Figure 30: Light truck technology and sales mix under BAU and NZE ('000 vehicles)

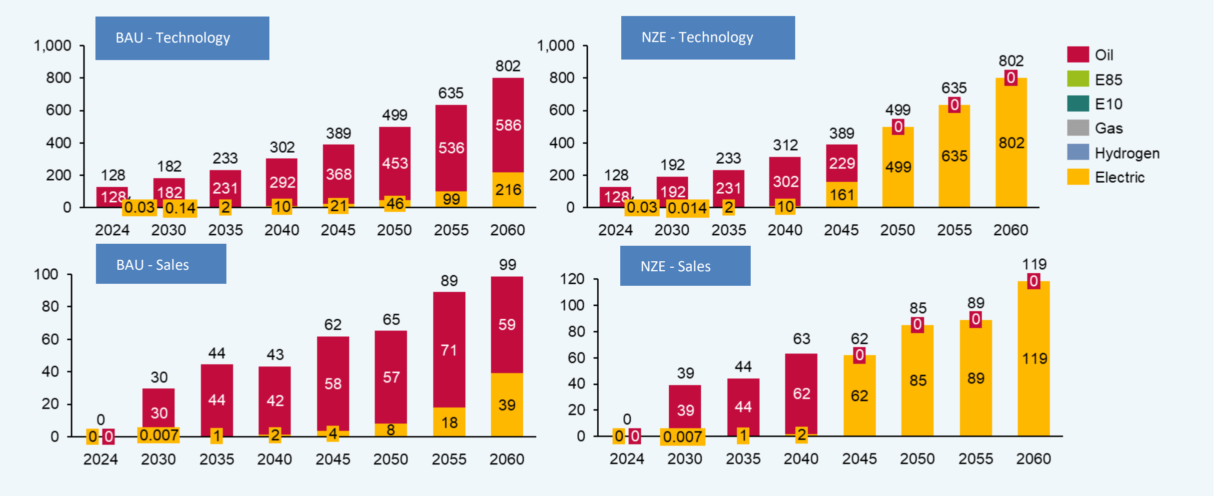


Under the BAU scenario, the bus fleet remains almost entirely dependent on conventional diesel technologies throughout the modelling horizon, with only marginal penetration of alternative technologies. Consequently, fossil fuel consumption and associated emissions from the bus sector continue increasing over time.

In the NZE pathway, the bus sector undergoes an accelerated transition towards electric mobility, particularly after 2035 (2,320 electric buses) as electric bus deployment becomes economically competitive and supported by decarbonization policies (Figure 31). Electric buses progressively replace diesel technologies in both annual sales and total fleet stock, becoming the dominant public transport technology by 2050.

Overall, electrification of the bus fleet represents an important component of Kenya's long-term transport decarbonization strategy under the NZE pathway.

Figure 31: Bus technology and sales mix under BAU and NZE ('000 vehicles)



3.3 Industry Sector

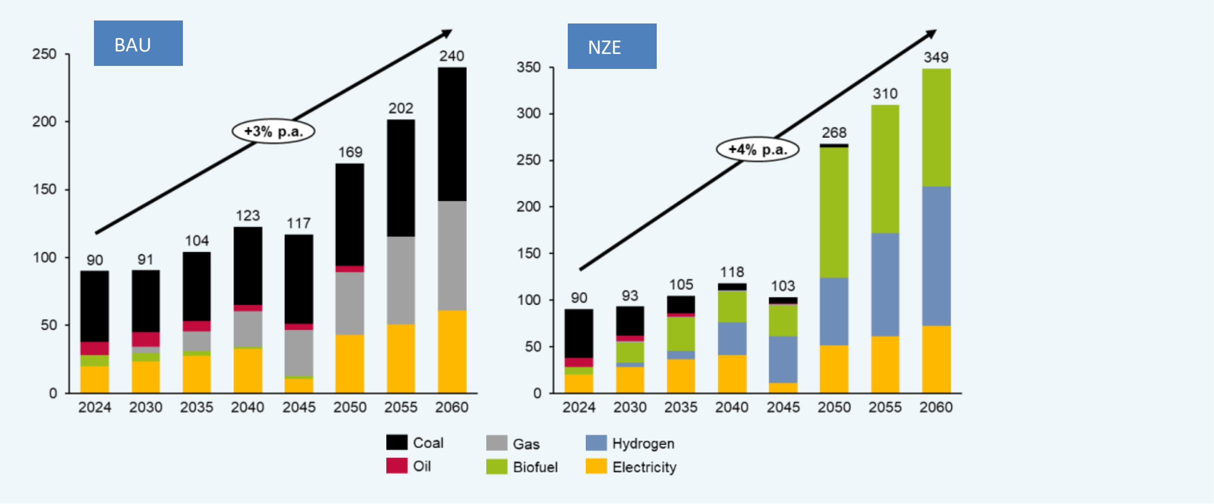
Industrial fuel consumption increases significantly under both the BAU (240 PJ) and NZE (349 PJ) by 2060 scenarios due to growing industrial activity, economic growth, and rising demand for energy-intensive products and services (Figure 32). Under the BAU scenario, industrial fuel demand grows at an average annual rate of around 3%, with coal remaining the dominant industrial fuel throughout the modelling horizon. Oil products and natural gas also continue expanding over time, reflecting continued reliance on fossil fuel-based industrial processes and conventional thermal technologies.

In contrast, under the NZE scenario, industrial fuel demand grows more rapidly, at around 4% annually, due to the penetration of less efficient technologies (biofuel) compared to coal and gas boilers. However, the structure of industrial energy consumption changes significantly. Coal consumption progressively declines and is fully phased out by 2055, while hydrogen (43% of total industrial fuel consumption in 2060) followed by biofuels (36%) are the dominant energy carriers in the sector. Also, electricity (21% of total industrial fuel consumption in 2060) contributes significantly to the industrial fuel mix due to electrification of industrial heat processes, deployment of electric motors, and adoption of electric boilers.

Hydrogen also begins penetrating the industrial sector from 2027 onwards, particularly in hard-to-abate industrial applications such as steel production and high-temperature heat processes. Biofuels and natural gas continue playing transitional roles in certain industrial applications during earlier years of the transition.

Overall, the NZE pathway demonstrates that industrial decarbonization requires large-scale electrification, fuel switching, and deployment of low-carbon fuels such as hydrogen and biofuels to reduce dependence on fossil fuel products and vulnerability to supply shocks while supporting continued industrial growth and competitiveness.

Figure 32: Industry fuel consumption under BAU and NZE (PJ)



Steel

Steel production increases steadily under both the BAU and NZE scenarios, driven by economic growth, industrialization, and increasing demand for construction materials and manufactured products (Figure 33). Under the BAU scenario, steel production grows from around 2 Mtpa in 2024 to approximately 4 Mtpa by 2060, corresponding to an average annual growth rate of around 2%. Conventional blast furnace-basic oxygen furnace (BFBOF) technologies remain dominant throughout the modelling horizon, resulting in continued dependence on coal-based steel production processes and associated emissions.

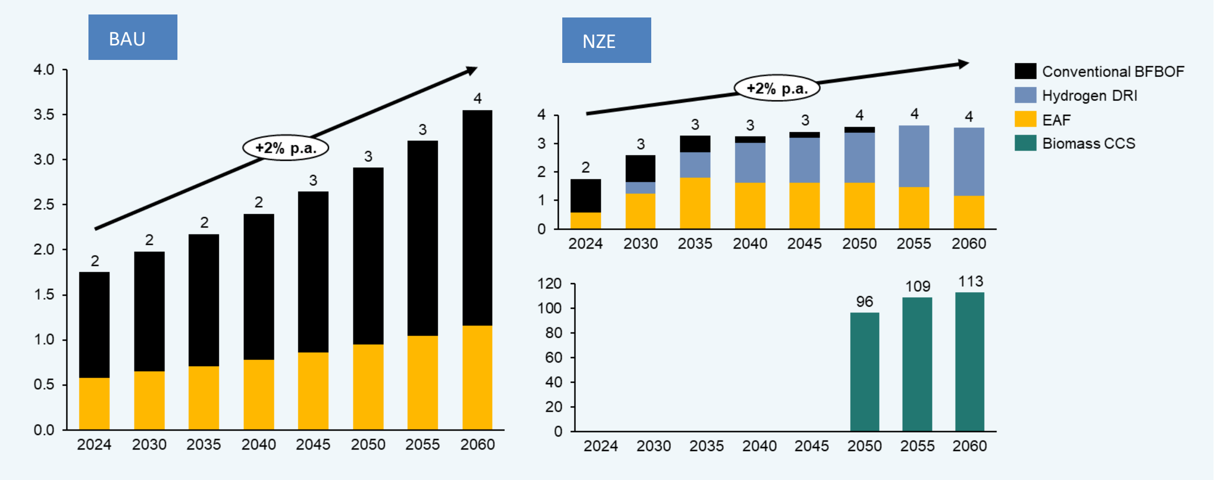
In contrast, under the NZE scenario, steel production follows a similar growth trajectory in total output; however, the production technologies and fuel mix change significantly over time. Conventional BF-BOF technologies are progressively replaced by electric arc furnaces (EAF) and hydrogen-based direct reduced iron (DRI) processes from 2045 onwards. Electrification and hydrogen penetration increase substantially in later years, supporting decarbonization of one of the most energy-intensive industrial sectors.

Hydrogen consumption in the steel sector grows from 2027 onwards as hydrogen-based DRI technologies penetrate the market, while electricity demand also increases significantly due to deployment of EAF technologies. Biomass and biofuels continue playing a smaller supporting role in certain industrial processes.

Biomass with carbon capture and storage (BECCS) technologies begin penetrating the energy system in later years from 2050 onwards under the NZE pathway to offset residual carbon dioxide emissions from hard-to-abate sectors, particularly the power sector where natural gas generation continues operating until around 2055 to provide system flexibility and reliability. The deployment of BECCS technologies enables negative emissions, supporting achievement of economy-wide net-zero emissions targets while maintaining secure operation of the electricity system during the transition period.

The results highlight the strong interlinkages across the energy system, where decarbonization pathways in one sector directly influence technology deployment and investment requirements in other sectors. In particular, continued use of natural gas generation in earlier years increases the need for negative emission technologies in industry and biofuel sectors to compensate for remaining emissions. This demonstrates that achieving net-zero emissions requires coordinated transformation across all sectors of the economy rather than isolated sectoral changes.

Figure 33: Steel production by technology under BAU and NZE (Mtpa)



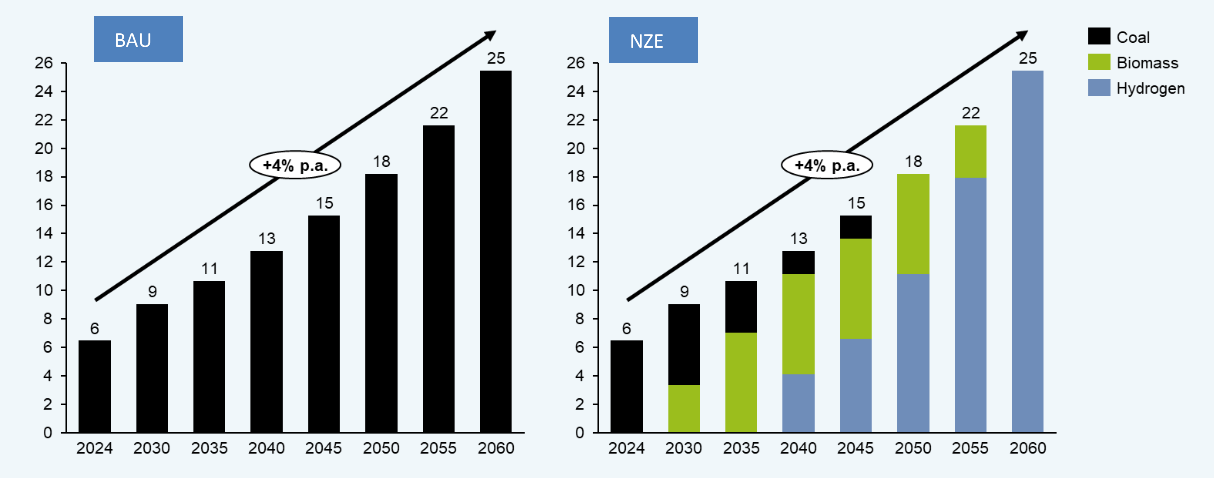
Cement

Cement production increases significantly under both the BAU and NZE scenarios (Figure 34). Under the BAU scenario, cement production grows steadily at an average annual rate of around 4%, relying primarily on conventional fossil fuel-based clinker production technologies. Coal continues to dominate the sector throughout the modelling horizon, resulting in increasing industrial emissions over time.

In contrast, under the NZE scenario, cement production follows a similar growth trajectory in total output; however, the fuel mix and production technologies progressively shift towards lower-carbon alternatives. Biofuel technologies increasingly penetrate the sector in earlier years, while hydrogen deployment gradually expands over time, reducing dependence on conventional fossil fuels. By 2060, hydrogen becomes the dominant fuel carrier in cement production, supporting deep decarbonization of one of the most energy-intensive industrial sectors. This transition significantly reduces industrial emissions while maintaining long-term growth in cement production required to support infrastructure development and urbanization.

Overall, the NZE pathway demonstrates that decarbonization of cement production requires a combination of fuel switching, biomass utilization, carbon capture technologies, and low-carbon industrial processes while maintaining long-term industrial growth and infrastructure development.

Figure 34: Cement production by technology under BAU and NZE (Mtpa)



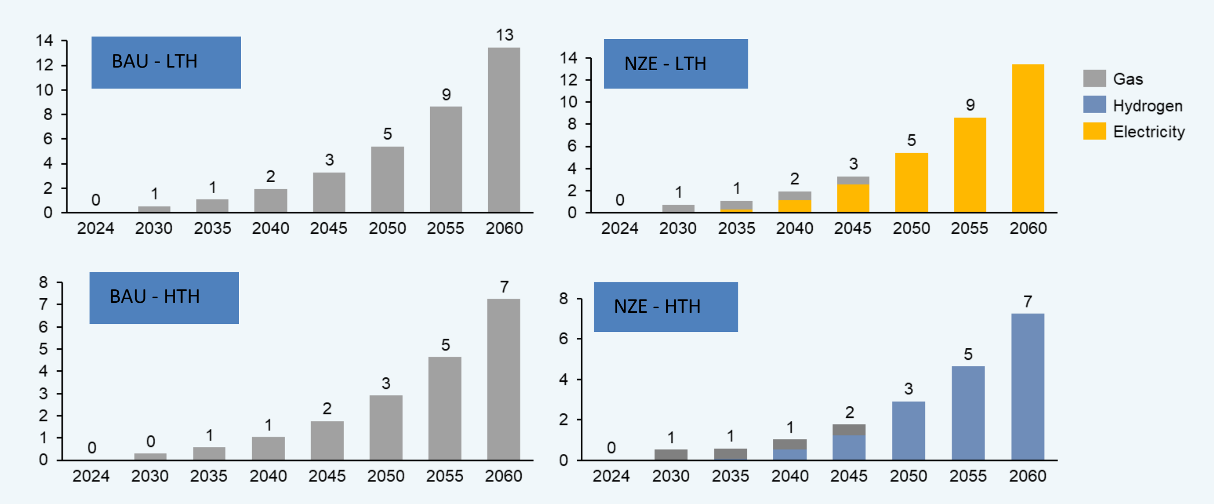
Chemicals

Chemical heat demand increases steadily under both the BAU and NZE scenarios (Figure 35). Under the BAU scenario, heat demand grows progressively over time and continues to rely primarily on conventional fossil fuel-based technologies, particularly for high-temperature heat processes. Natural gas remains the dominant energy source throughout the modelling horizon, resulting in continued industrial emissions growth.

In contrast, under the NZE scenario, although total chemical heat demand follows a similar growth trajectory, the technologies and fuels used to supply industrial heat change significantly over time. Electrification increasingly penetrates low- and high-temperature heat processes through deployment of electric boilers and efficient electric heating systems. At the same time, hydrogen technologies progressively expand in high-temperature industrial applications where direct electrification is more challenging.

Hydrogen penetration accelerates particularly after 2045, progressively replacing conventional fossil fuels in high-temperature chemical processes and becoming one of the dominant energy carriers by 2060.

Figure 35: Chemicals heat process by technology (PJ)

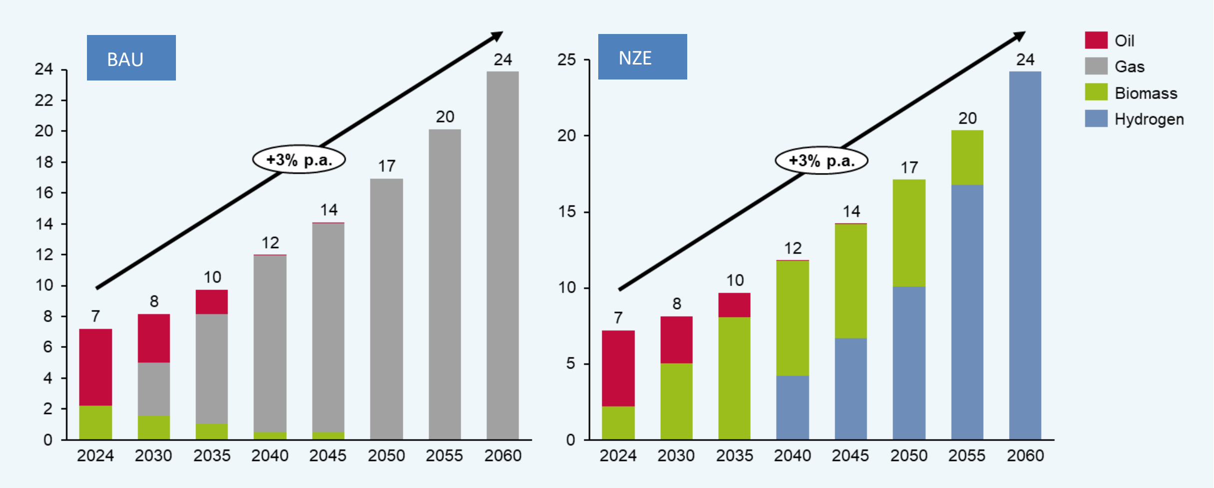


Other high-temperature heat (HTH) industrial processes increase steadily over the modelling horizon (Figure 36). Under the BAU scenario, these processes continue relying predominantly on conventional fossil fuel-based technologies, particularly natural gas and oil, throughout the modelling horizon. As industrial production increases, fossil fuel consumption and associated emissions from high-temperature industrial applications continue rising over time.

In contrast, under the NZE scenario, high-temperature industrial processes progressively transition towards lower-carbon energy carriers and technologies. Biofuel technologies initially penetrate the sector in earlier years as transitional low-carbon solutions, while hydrogen deployment accelerates significantly after 2045. Hydrogen progressively replaces fossil fuels in high-temperature applications where direct electrification remains technically challenging, becoming one of the dominant energy carriers by 2060.

The transition towards hydrogen and biofuel-based industrial heat significantly reduces industrial emissions while maintaining industrial growth and competitiveness. At the same time, increased hydrogen demand strengthens the interconnection between the industrial and power sectors, requiring substantial expansion of low-carbon electricity generation and hydrogen production infrastructure.

Figure 36: Other industry HTH process by technology (PJ)

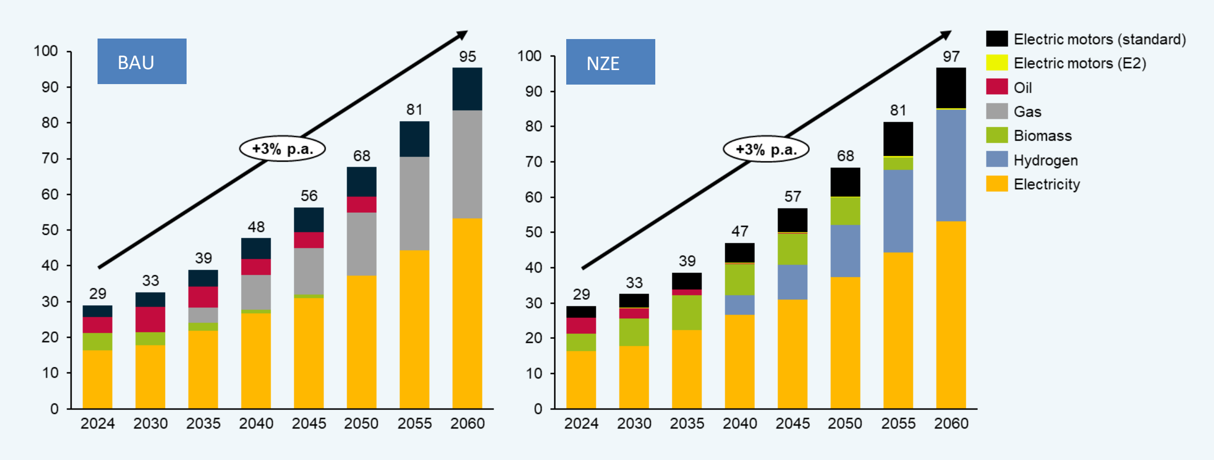


Other low-temperature heat (LTH) industrial processes increase steadily under both the BAU and NZE scenarios (Figure 37). Under the BAU scenario, low-temperature heat demand continues to rely mainly on conventional fossil fuel-based technologies, particularly oil and natural gas boilers, throughout the modelling horizon. As industrial production expands, fossil fuel consumption and associated emissions continue increasing over time.

In contrast, under the NZE scenario, low-temperature industrial heat processes progressively transition towards electrified technologies and low-carbon energy carriers. Electric boilers and efficient electric motors technologies increasingly penetrate the sector from earlier years due to their high efficiency and suitability for low-temperature applications. Hydrogen also contributes to reducing fossil fuel dependence in certain industrial processes.

By 2060, electricity becomes the dominant energy carrier for low-temperature industrial heat processes, significantly reducing dependence on conventional fossil fuels and lowering industrial emissions. The transition towards electrified industrial heat also increases electricity demand across the industrial sector, requiring expansion of low-carbon electricity generation and supporting infrastructure.

Figure 37: Other industry LTH process by technology (Mtpa)



3.4 Buildings (Cooking, Cooling, Lighting) Sector

The buildings sector undergoes a major transformation under the NZE pathway compared to the BAU scenario, particularly in cooking technologies and energy efficiency improvements across residential and commercial services (Figure 38). Under the BAU scenario, traditional biomass continues to dominate cooking demand (75% of total fuel consumption in the cooking sector in 2060), especially in rural households, while LPG penetration gradually increases over time, from 12% in 2024 to 16% in 2060 (Figure 39). As population and household numbers grow, the total number of cooking devices and associated energy demand continue increasing throughout the modelling horizon.

In contrast, the NZE scenario accelerates the transition towards modern and clean cooking technologies, more efficient than traditional biomass, aligned with the clean cooking strategy in 2030. Electric cooking technologies progressively penetrate both urban and rural households from 2040 onwards, almost fully replacing improved biomass stoves by 2050, representing 42% of total fuel consumption in cooking in 2060, while traditional biomass is fully phased out by 2030. LPG stoves play an important transitional role during earlier years of the transition, particularly in rural areas where dependence on traditional biomass is initially high. By 2060, improved biomass stoves become the dominant cooking technology (58% of total cooking fuel consumption) across both urban and rural households.

Figure 38: Buildings (residential) fuel consumption under BAU and NZE (PJ)

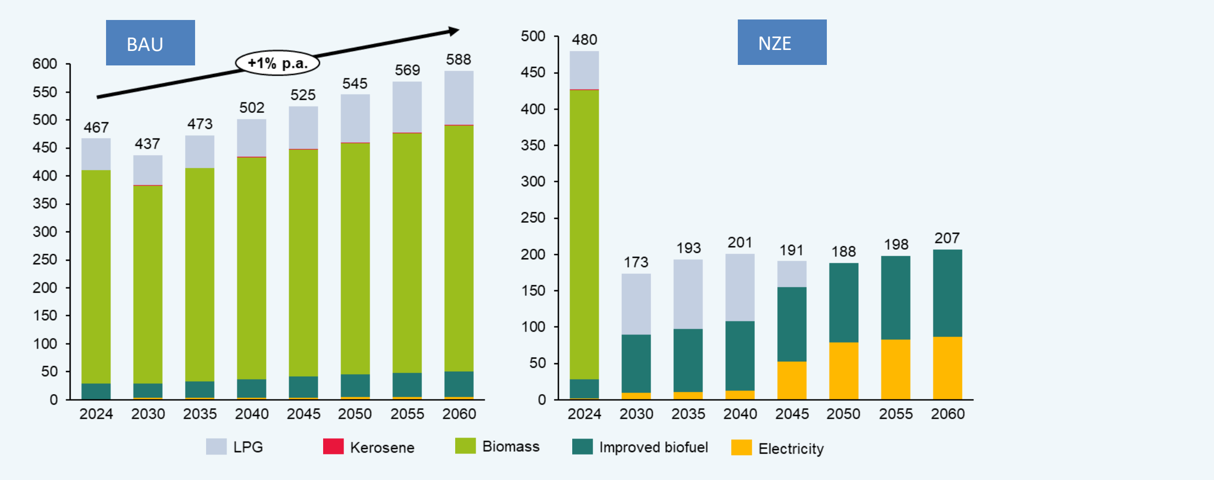
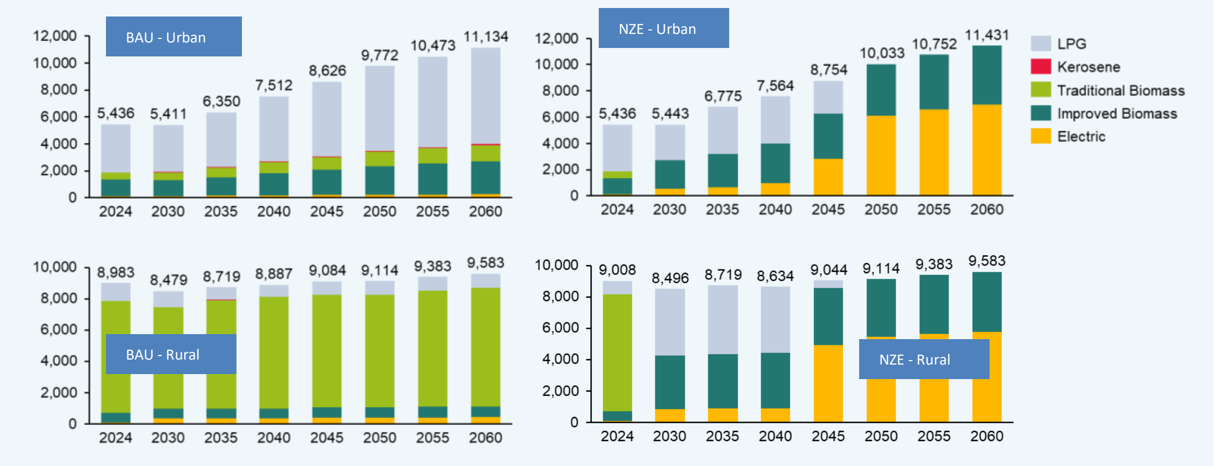


Figure 39: Urban and rural cooking technology mix under BAU and NZE (‘000 stoves)



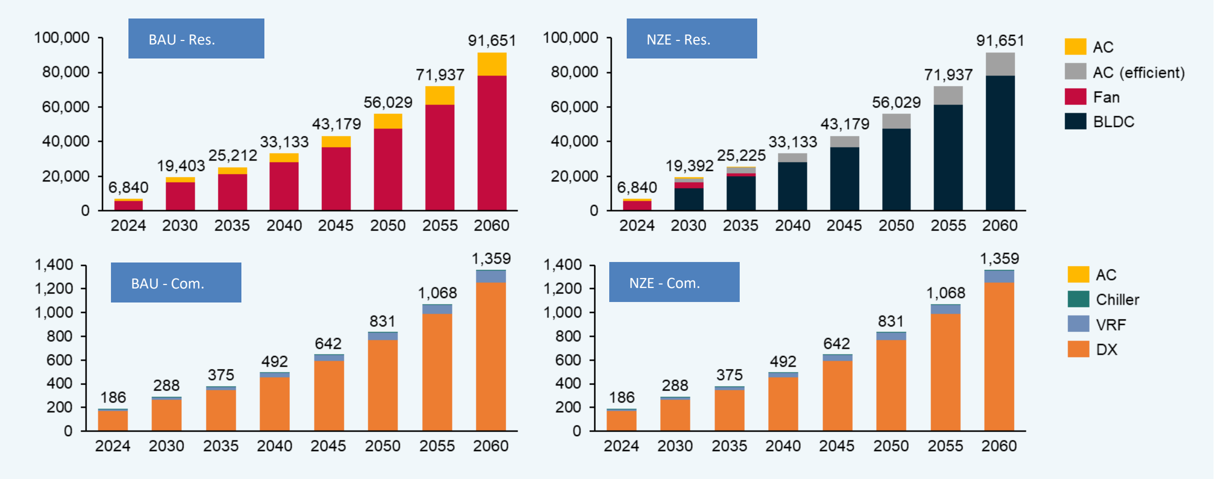
Under the BAU scenario, cooling demand continues to rely mainly on fans and conventional air conditioning technologies with moderate efficiency improvements over time in the Residential sector while in the Commercial sector on direct expansion (DX) and variable refrigerant flow (VRF) technologies (Figure 40). As cooling appliance ownership expands, electricity consumption in both residential and commercial buildings increases steadily throughout the modelling horizon.

In contrast, under the NZE scenario, the technology mix progressively shifts towards more energy-efficient cooling appliances. Efficient air conditioning systems increasingly penetrate the residential sector, reducing overall electricity requirements compared to conventional technologies while maintaining the same level of cooling services.

The adoption of efficient cooling technologies significantly improves energy efficiency across the buildings sector and helps moderate the growth in electricity demand despite increasing appliance penetration and higher cooling needs. At the same time, electrification of cooling services contributes to continued growth in electricity demand across the economy, reinforcing the need for expansion of low-carbon power generation and electricity infrastructure.

Overall, the NZE pathway demonstrates that deployment of efficient cooling technologies can play an important role in reducing electricity consumption growth and improving energy efficiency in Kenya’s buildings sector while supporting increasing living standards and urban development.

Figure 40: Residential and commercial cooling technology mix under BAU and NZE (‘000 units)



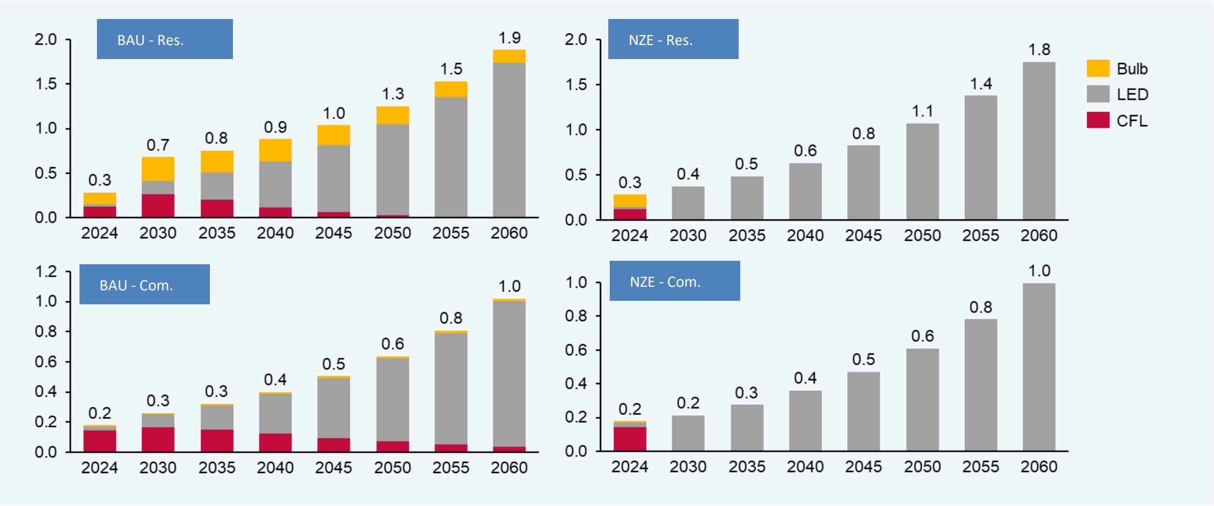
Residential and commercial lighting demand increases steadily under both the BAU and NZE scenarios (Figure 41). Under the BAU scenario, lighting services continue relying on a combination of conventional and efficient lighting technologies in earlier years; however, efficient lighting technologies progressively dominate the market over time due to technology replacement and declining technology costs. As a result, electricity demand for lighting continues increasing, although at a moderated pace compared to overall growth in buildings energy demand.

In contrast, under the NZE scenario, efficient lighting technologies penetrate the residential and commercial sectors more rapidly, resulting in earlier phase-out of conventional lighting systems. High-efficiency lighting technologies become almost fully dominant by 2050 across both sectors, significantly reducing electricity consumption per unit of lighting service delivered.

The accelerated deployment of efficient lighting technologies under NZE improves overall energy efficiency in the buildings sector and helps limit electricity demand growth despite increasing lighting service demand driven by rising living standards and economic growth. Consequently, lighting efficiency improvements contribute to reducing overall system costs and lowering the required expansion of electricity generation capacity compared to less efficient technology pathways.

Overall, the NZE pathway demonstrates that widespread adoption of efficient lighting technologies represents one of the most cost-effective energy efficiency measures for reducing electricity demand growth while supporting improved access to modern energy services. The penetration of efficient technologies decreases the residential electricity consumption by 31% by 2060 between NZE and BAU while commercial by 23% by 2060.

Figure 41: Residential and commercial lighting technology mix under BAU and NZE (GW)



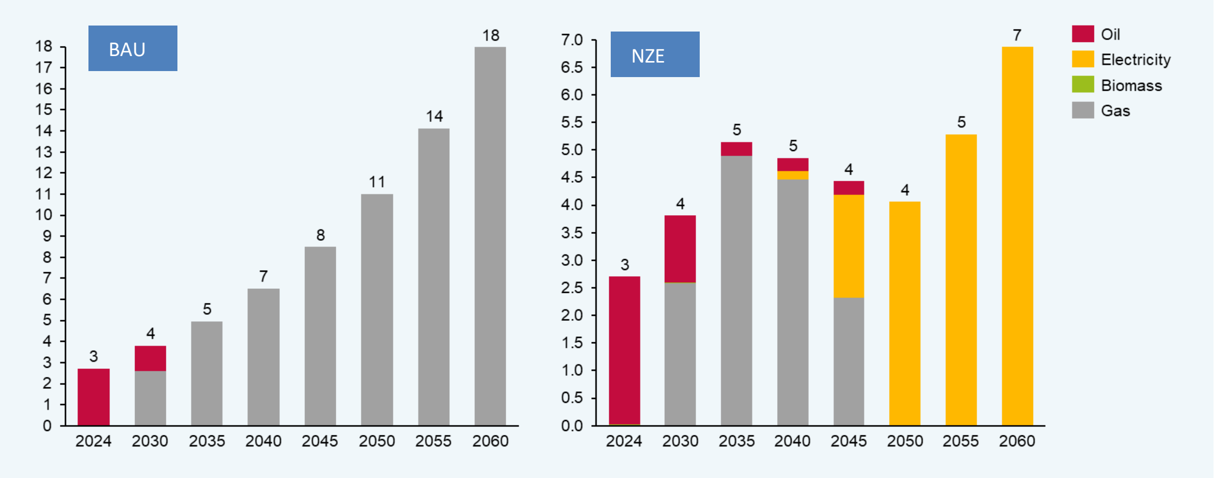
Under the BAU scenario, commercial water heating continues to rely on fossil fuel-based technologies throughout the modelling horizon (Figure 42). As commercial buildings expand, natural gas water heaters gradually penetrate the mix and oil-based ones are fully retired by 2035.

In contrast, under the NZE scenario, the commercial water heating sector progressively transitions towards more energy-efficient technologies, particularly advanced electric water heating systems. Efficient electric water heaters increasingly penetrate the sector due to their significantly higher efficiency compared to conventional resistance-based technologies, reducing overall electricity demand for water heating services despite increasing commercial energy needs.

The adoption of efficient water heating technologies contributes to improved energy efficiency across the buildings sector and helps moderate long-term electricity demand growth under the NZE pathway. At the same time, increasing electrification of commercial water heating supports further reduction in fossil fuel consumption and associated emissions.

Overall, the NZE pathway demonstrates that deployment of efficient electric water heating technologies can significantly improve energy efficiency and reduce emissions in Kenya's commercial buildings sector while supporting growing demand for modern energy services.

Figure 42: Water heaters (commercial) technology mix under BAU and NZE (GW)



3.5 Agriculture Sector

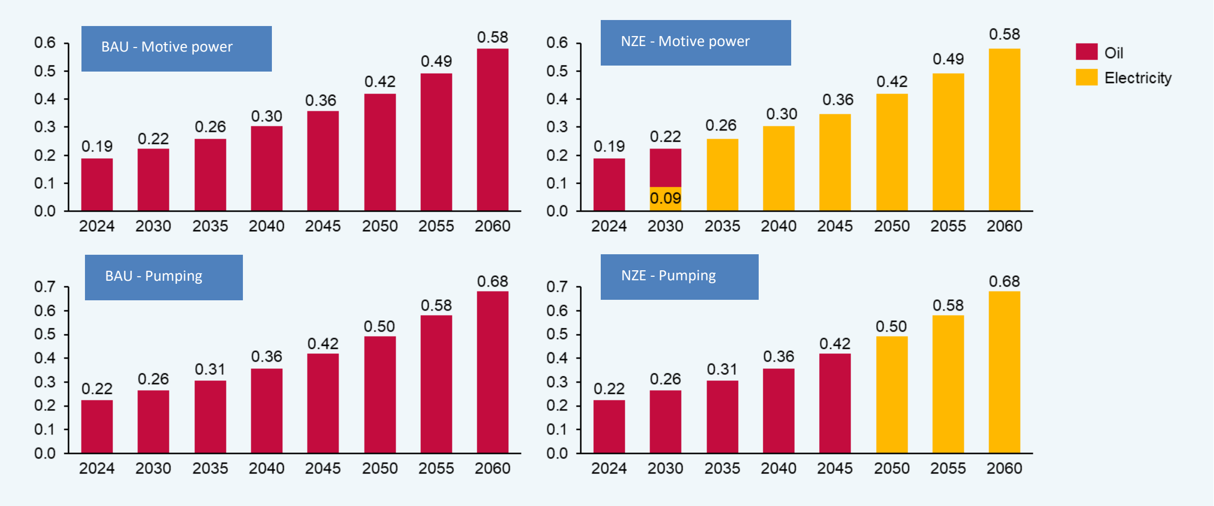
Agricultural motive power and water pumping demand increase steadily under both the BAU and NZE scenarios due to expanding agricultural activity, increasing mechanization, irrigation needs, and rising food production requirements (Figure 43). Under the BAU scenario, agricultural motive power and pumping continue relying predominantly on conventional oil-based technologies throughout the modelling horizon, resulting in steadily increasing fossil fuel consumption as agricultural production expands.

In contrast, under the NZE scenario, agricultural motive power and pumping progressively transition towards electrified technologies. Electric motors and electric pumping systems increasingly penetrate the sector over time, gradually replacing conventional diesel-based equipment. By 2050, electricity becomes the dominant energy carrier for agricultural pumping and motive power applications due to the higher efficiency and lower operating costs of electric technologies.

The transition towards electrified agricultural systems significantly reduces oil consumption and associated emissions while improving overall energy efficiency in the agriculture sector. At the same time, increasing electrification contributes to higher electricity demand in rural areas and requires expansion of electricity infrastructure and reliable low-carbon power supply.

Overall, the NZE pathway demonstrates that electrification of agricultural motive power and pumping systems can play an important role in reducing fossil fuel dependence and improving energy efficiency while supporting long-term agricultural productivity and rural development.

Figure 43: Motive power and pumping under BAU and NZE (PJ)



3.6 Emissions Pathway

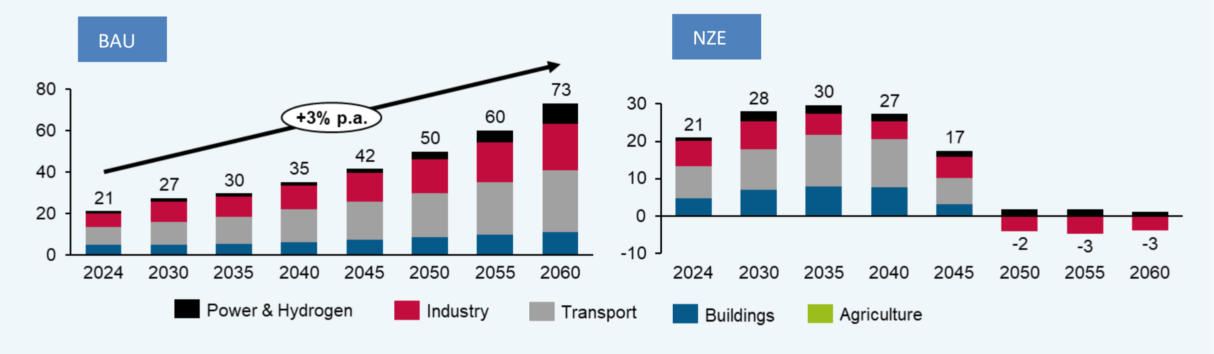
Under the BAU scenario, total CO_2 emissions increase steadily across the modelling horizon, growing at an average annual rate of approximately 3% due to rising energy demand (Figure 44). The transport sector remains the largest contributor to emissions throughout the period due to continued dependence on oil-based fuels (30 $MtCO_2$ in 2060), followed by industry (22 $MtCO_2$) and buildings (11 $MtCO_2$). As fossil fuel consumption continues expanding across all sectors, total emissions increase significantly by 2060 under BAU reaching to 73 $MtCO_2$.

In contrast, the NZE scenario results in a rapid decline in economy-wide emissions through large-scale electrification, deployment of renewable energy technologies, energy efficiency improvements, and fuel switching across all sectors. Emissions from transport decrease substantially after 2045, 7.1 $MtCO_2$ in 2045 in NZE compared to 18.3 MtCO2 in BAU, as electric vehicles progressively replace oil-based technologies, while emissions from buildings decline due to the transition towards electric cooking, efficient appliances, and modern energy services.

Industrial emissions also reduce significantly under NZE reaching to -4 $MtCO_2$ in 2050 through electrification of low-temperature heat processes, penetration of hydrogen and biofuels in high-temperature applications, and deployment of low-carbon industrial technologies. Residual emissions from hard-to-abate sectors are further offset through negative emission technologies such as biomass with carbon capture and storage (BECCS).

Overall, the NZE pathway demonstrates that achieving net-zero emissions in Kenya is possible but requires a system-wide transformation across transport, power, buildings, and industry, supported by rapid electrification, renewable energy deployment, energy efficiency improvements, and long-term investments in low-carbon technologies and infrastructure.

Figure 44: CO_2 emissions by sector under BAU and NZE (million tons)



3.7 Sensitivity Analysis

Sensitivity analysis is conducted on the NZE 2050 scenario, as it represents the primary policy pathway assessed in this study. The analysis focuses on testing the robustness of the net-zero transition under key uncertainties related to hydrology (low), electricity demand (low/high), and fuel costs (low/high). The following sensitivity cases were evaluated:

- **Low hydrology:** a 25% reduction in hydropower availability, reducing the average capacity factor for hydropower
- **Electricity demand:** +/- 25% variation in residential and commercial electricity demand
- **Fuel prices:** +/- 25% variation in fuel costs

These sensitivities capture key risks related to climate variability, demand growth uncertainty, and global fuel cost volatility.

Under the high-demand sensitivity, where residential and commercial electricity demand increases by 25%, natural gas plays a larger role in the power mix to meet additional system needs as well as solar PV. By 2030, total installed capacity increases by approximately 30 MW, driven by an additional 20 MW of gas capacity, and 10 MW of solar PV. By 2050, total installed capacity increases by around 100 MW, with gas capacity increasing by approximately 10 MW and solar PV 50 MW. This shift leads to a increase in system costs, with power and hydrogen CAPEX rising by around 0.2% and OPEX by around 0.14% by 2050, while annual CO_2 emissions increase by approximately 0.03 Mt.

Under the low-demand sensitivity, total installed capacity decreases by approximately 40 MW by 2030 and around 40 MW by 2050 compared to the central NZE scenario. The reduction is primarily driven by lower natural gas deployment, with gas capacity decreasing by approximately 20 MW by 2030 and 20 MW by 2050. Renewable capacity expansion is also reduced, particularly onshore wind, which decrease by around 10 MW by 2050. As a result, total system CAPEX decreases by approximately 0.06% by 2050, while OPEX decreases by around 0.16%. Annual CO_2 emissions from the power sector are estimated to decrease by approximately 0.04 Mt by 2050.

Under the low fuel price sensitivity, the main impact occurring in the cooking sector where improved biomass stoves increase in the cooking mix resulting in less electric stoves which impact power generation. Lower fuel prices increase the competitiveness of improved biomass stoves, with their share rising from around 39% in the NZE scenario in 2050 to approximately 75% under this sensitivity. As a result, electricity demand from cooking decreases, reducing total electricity generation requirements by around 18 TWh by 2050.

Lower electricity demand reduces the need for new power generation capacity. By 2050, total installed capacity decreases significantly, by around 6 GW, primarily driven by lower solar PV deployment (approximately 5 GW lower), natural gas capacity decrease by around 110 MW and hydrogen 1.5 GW.

Consequently, the lower fuel price trajectory reduces overall system costs, resulting in approximately USD 8 billion lower cumulative CAPEX investments and around USD 79 billion lower OPEX and variable costs, including fuel expenditures, by 2050.

Under the high fuel cost sensitivity, limited structural changes are observed across most sectors, with the main impact occurring in the power sector. Higher fuel costs improve the competitiveness of renewable electricity generation, resulting in additional solar PV capacity by 2050, partly replacing around 30 MW of blue hydrogen production capacity based on natural gas.

While the impact on cumulative CAPEX is relatively modest, increasing by approximately USD 10 billion due to additional solar PV investments, higher fuel costs significantly increase cumulative OPEX and fuel-related expenditures across all sectors, by approximately USD 83 billion by 2050.

Under the low hydrology sensitivity, the hydropower capacity factor decreases by 25%. However, the resulting changes in the power sector remain relatively limited due to the comparatively low contribution of hydropower in the electricity mix by 2050 (around 10%). Hydropower generation decreases by approximately 4 TWh in 2050 although capacity remains the same due to long lifetime operation of existing hydro plants, with most of the reduction compensated by additional solar PV generation (50 MW) and gas 240 MW. Consequently, the results indicate that Kenya's future power system remains relatively resilient to reduced water availability, as the limited role of hydropower in the generation mix allows losses in hydroelectric output to be largely compensated by other generation sources, including solar PV and gas-fired generation.

CHAPTER FOUR

INVESTMENT AND EMPLOYMENT IMPACTS

Under the BAU scenario, cumulative capital investments across the energy system exceed USD 556 billion between 2024 and 2060 (Figure 45). Total annual investments increase steadily over time, growing at an average annual rate of approximately 3% as additional energy infrastructure and technologies are required to meet increasing demand across all sectors.

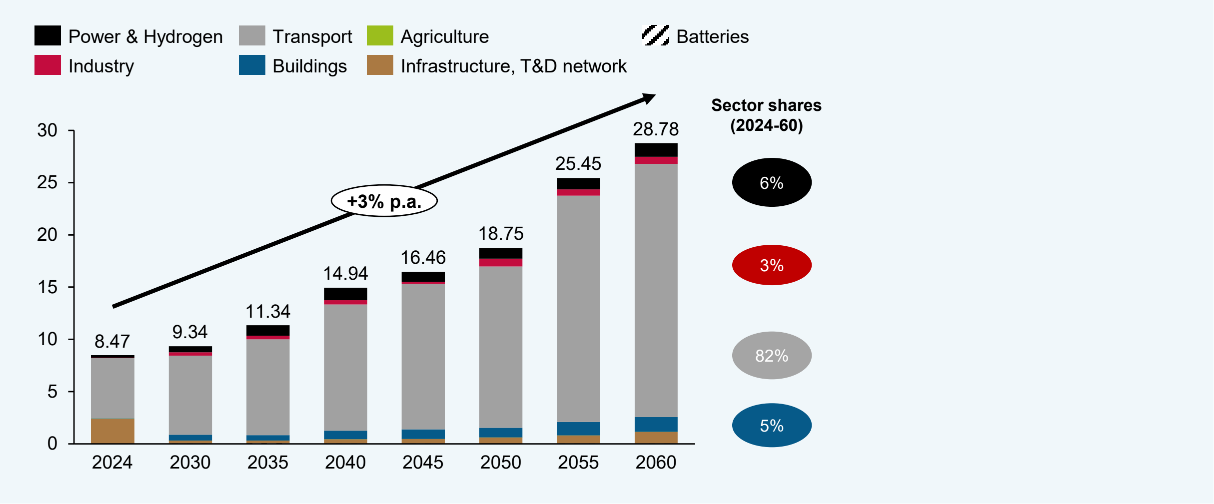
The transport sector accounts for the largest share of cumulative investments, representing around 78% of total system investments over the modelling horizon. This is mainly driven by increasing ownership of private vehicles, freight transport expansion, and continued deployment of conventional (fuel-based) transport technologies as mobility demand grows rapidly over time.

Investments in the power and hydrogen sectors account for approximately 6% (USD 34 billion) of total cumulative investments and are mainly associated with the expansion of electricity generation capacity, including geothermal and solar PV deployment, transmission and distribution infrastructure, and system flexibility requirements as shown below. Additional investments are also required in electricity networks (USD 21 bn), battery storage systems (USD 1.3 bn), and supporting infrastructure (USD 1.2 bn) to maintain reliable operation of the expanding energy system.

The buildings sector represent the third-largest investment category, accounting for around 5% of total investments mainly associated with investments in cooling, cooking, lighting, and water heating technologies.

Overall, the BAU pathway demonstrates that even without strong decarbonization policies, Kenya’s rapidly growing economy and energy demand require substantial long-term investments across transport, power, and buildings sectors.

Figure 45: Total annual capital investment required by sector under BAU (Bn USD)



Under the NZE scenario, cumulative capital investments across the energy system increase substantially, exceeding USD 859 billion between 2024 and 2060 (Figure 46). Total annual investments grow at an average annual rate of approximately 5%, higher than under the BAU scenario, driven by accelerated electrification, deployment of low-carbon technologies, expansion of renewable energy systems, and additional infrastructure requirements needed to achieve net-zero emissions by 2050.

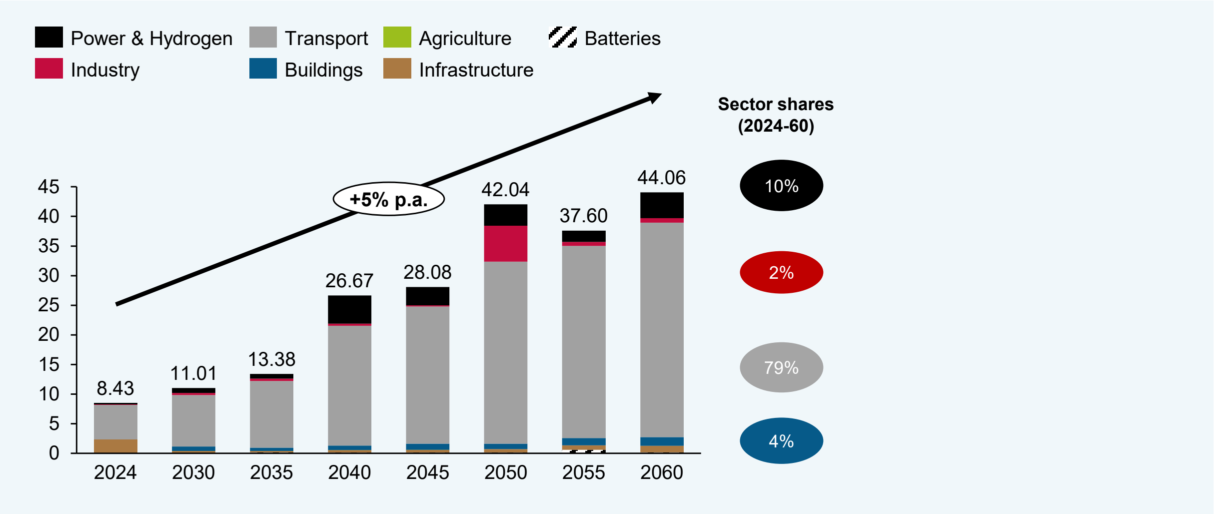
The transport sector continues to represent the largest share of cumulative investments, accounting for around 76% of total system investments. Compared to BAU, transport investments become significantly more capital-intensive due to large-scale adoption of electric mobility technologies.

The power and hydrogen sectors also require substantially higher investments (USD 105 billion) compared to BAU due to rapid expansion of solar PV, geothermal, batteries, hydrogen production, nuclear generation, and supporting transmission and distribution infrastructure. Electrification across transport, buildings, and industry significantly increases electricity demand, requiring major investments in power generation capacity, electricity networks (USD 43 billion), storage systems (USD 2.9 billion), and system infrastructure (USD 2.9 billion).

The buildings sector accounts for around 3% (USD 30.5 billion) of total cumulative investments, driven by deployment of efficient cooling technologies (USD 23.8 billion), electric cooking (USD 1.3 billion) and lighting systems (USD 2.4 billion).

Overall, the NZE pathway demonstrates that achieving deep decarbonization in Kenya requires substantial long-term investments across all sectors of the economy, particularly in transport electrification and low-carbon power infrastructure, while also creating opportunities for modernization, energy security improvements, and long-term economic development.

Figure 46: Total annual capital investment required by sector under NZE (Bn USD)



The comparison between the BAU and NZE scenarios highlights the substantial additional investments required to achieve Kenya's net-zero emissions pathway by 2050 (Figure 47). Total cumulative investments increase from approximately USD 556 billion under BAU to over USD 859 billion under NZE between 2024 and 2060, corresponding to an additional investment requirement of around USD 303 billion, or approximately 54% higher than BAU.

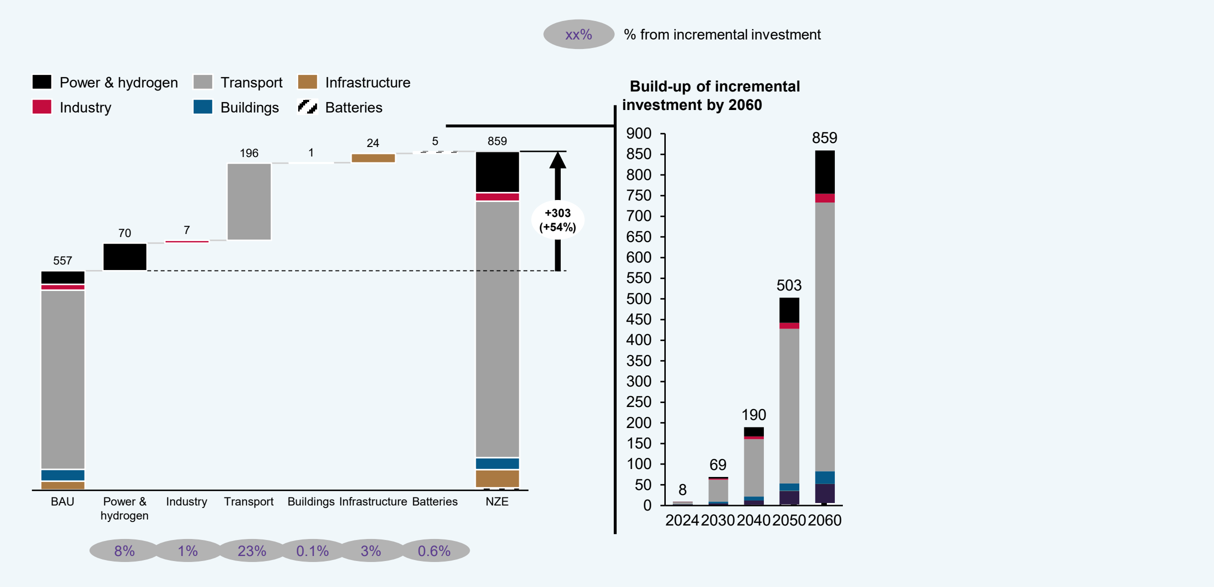
The transport sector accounts for the majority of incremental investments, contributing approximately USD 196 billion of additional cumulative investments compared to BAU by 2060. The power and hydrogen sectors also experience significant increases in investment requirements, with approximately USD 70 billion of additional investments needed to support expansion of renewable energy technologies, nuclear and hydrogen production by 2060, while USD 4.9 billion more are needed for battery storage, and USD 22 billion in transmission and distribution electricity infrastructure.

Additional investments are also required in buildings (USD 777 million) and industry (USD 6.9 billion) due to increasing electrification and deployment of more energy-efficient technologies across the economy.

The annual investment profile also changes substantially under the NZE pathway. While investments remain relatively similar to BAU before 2040, annual capital requirements increase rapidly after 2045 as electrification accelerates across transport, industry, and buildings. By 2050, annual investments under NZE are significantly higher (USD 177 billion) than under BAU, reflecting the large-scale deployment of low-carbon technologies, hydrogen and nuclear and supporting network required to achieve economy-wide decarbonization.

Thus, the NZE scenario requires cumulative investments of approximately USD 859 billion between 2024 and 2060, compared to USD 557 billion under BAU, implying an additional investment requirement of around USD 303 billion. Relative to Kenya's projected cumulative GDP of approximately USD 14 trillion over the same period, total NZE investments represent around 6% of cumulative GDP, while the additional investments required to achieve net zero correspond to approximately 2% of cumulative GDP. These investment levels are broadly consistent with global net-zero pathways assessed by IRENA and the IEA. IRENA estimates that achieving the global 1.5°C pathway requires energy transition investments of approximately USD 6.3–6.7 trillion annually through 2050, while the IEA estimates that global clean energy investments will reach approximately USD 2.2 trillion in 2025, accounting for around two-thirds of total energy investments [11, 12]. While the NZE pathway requires higher upfront capital investments, it is expected to deliver long-term benefits through reduced fossil fuel imports, enhanced energy security, and lower exposure to fuel price volatility.

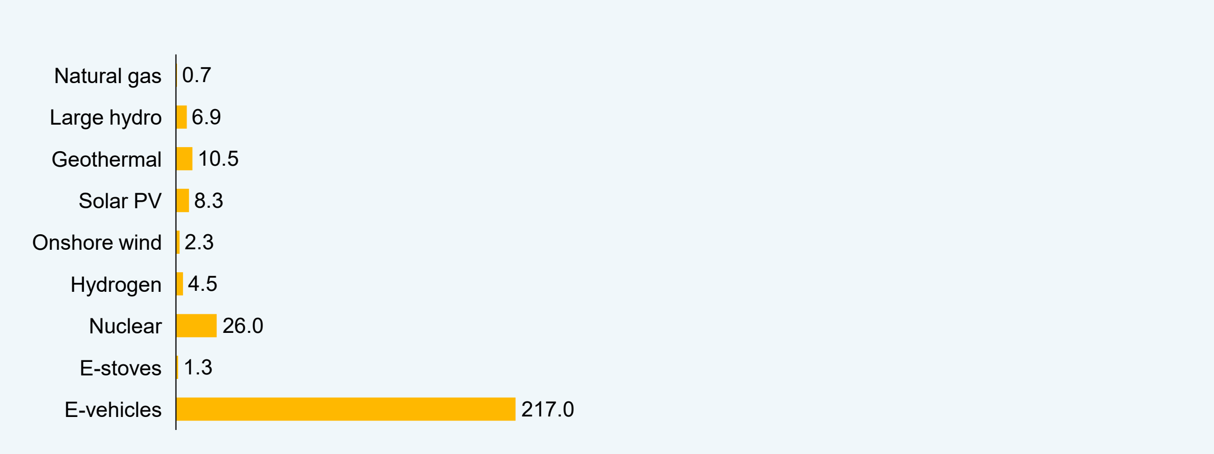
Figure 47: Comparison of cumulative investment by sector between BAU and NZE, 2024-2060 (Bn USD)



Total cumulative investments under the NZE pathway are dominated by electric vehicles, highlighting the critical role of electric mobility in achieving Kenya's net-zero emissions target by 2050. There are also significant investments required in renewable power generation, hydrogen infrastructure, and nuclear to support electrification across the economy.

The investment profile demonstrates a structural shift from fossil fuel expenditures towards capital-intensive low-carbon technologies, improving long-term energy security while reducing dependence on imported fossil fuels and exposure to fuel price volatility (Figure 48).

Figure 48: Cumulative capital investments in NZE by key technologies, 2024-2050 (Bn USD)



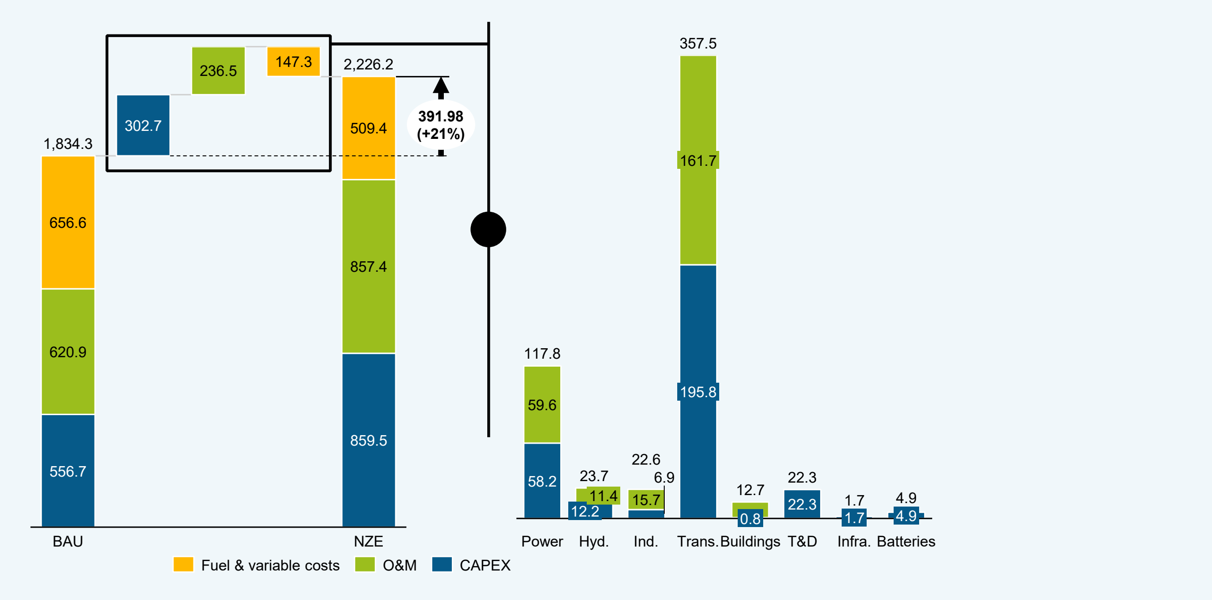
The comparison of cumulative system spending between the BAU and NZE scenarios highlights the significant structural changes in Kenya's future energy system costs (Figure 49). Achieving the NZE pathway requires approximately USD 303 billion in additional cumulative capital investments and around USD 236 billion in higher operation and maintenance (O&M) costs compared to BAU between 2024 and 2060.

However, these higher upfront investments are partially offset by substantial reductions in fuel expenditures. Under the NZE scenario, cumulative fuel and variable costs decrease by approximately USD 147 billion compared to BAU due to the significant reduction in fossil fuel consumption. Large-scale electrification and deployment of renewable energy technologies reduce dependence on imported oil products, coal, and natural gas, particularly after 2040 as electric mobility and clean energy technologies rapidly penetrate the energy system.

The transport sector represents the largest source of fuel cost savings due to the replacement of oil-based vehicles with electric mobility technologies, which are substantially more energy efficient. Similarly, increased renewable electricity generation and electrification across end-use sectors reduce exposure to international fossil fuel price volatility and imported fuel costs.

As a result, although the NZE pathway requires higher capital investments, the reduction in long-term fuel expenditures significantly improves Kenya's energy security by lowering dependence on imported fossil fuels and increasing reliance on domestic renewable energy resources. This transition enhances resilience against future fuel price shocks and strengthens long-term economic stability while supporting achievement of net-zero emissions objectives.

Figure 49: Comparison of cumulative spending between BAU and NZE, 2024-2060 (Bn USD)



It should be noted that the investment estimates presented in this analysis primarily reflect technology and equipment costs and do not fully capture associated enabling infrastructure, transaction costs, or broader economic adjustments that may be required to support the transition. Furthermore, these investments should not be interpreted as direct public expenditures. A significant share of the required investments—particularly in transport, industry, and buildings—is expected to be financed by households, consumers, and private sector entities. In the power sector, investments are likely to be mobilized through a combination of public financing, private capital, and development finance. Therefore, achieving the NZE pathway will require not only public investment but also the creation of enabling policy and regulatory frameworks that can attract private capital and accelerate clean energy deployment.

Employment Impacts

The NZE pathway could support substantial additional employment across Kenya's economy due to higher investments in low-carbon technologies, electrification, renewable energy deployment, and supporting infrastructure (Figure 50). The analysis estimates that the additional investments required under the NZE scenario could support approximately 1.4 million additional net jobs by 2050 compared to the BAU scenario, including direct, indirect, and induced employment effects across the economy[4].

In the BAU scenario, the transport sector accounts for most of the additional employment creation, contributing around 91% of total incremental jobs. However, in the NZE scenario the number of jobs in the transport sector significantly increase (APPENDIX A, Figure 56 - Figure 59) primarily driven by large-scale deployment of electric vehicles, vehicle manufacturing and assembly supply chains, construction activities, operation and maintenance services, and broader economic activity associated with transport electrification. The power and hydrogen sectors also contribute significant employment opportunities through investments in renewable energy generation, hydrogen infrastructure, and related supply chains.

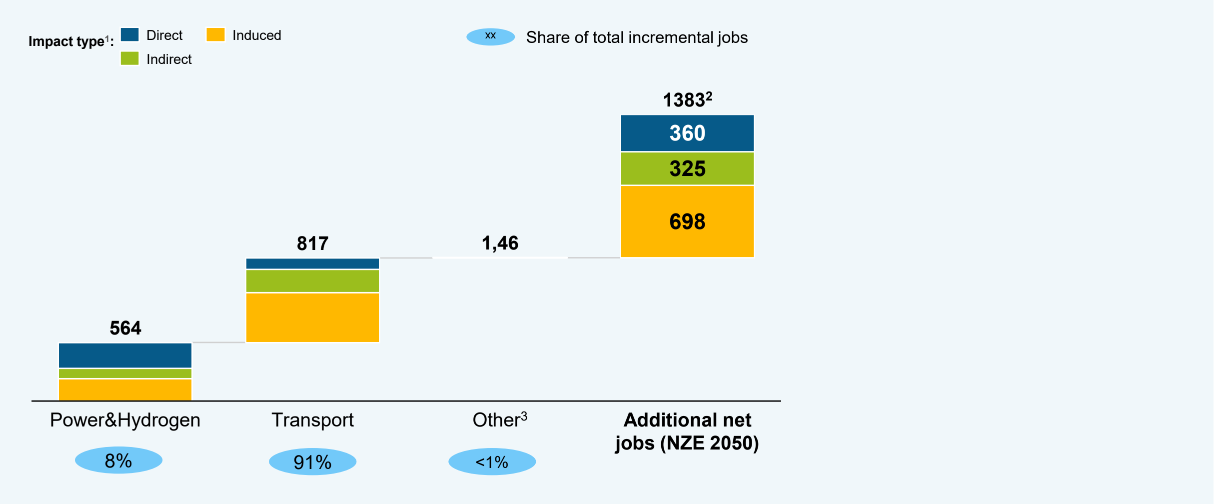
The majority of additional jobs are associated with induced and direct employment effects, reflecting the broader economic benefits generated by increased investments and infrastructure deployment across the economy. These investments stimulate demand across multiple industries and services, supporting wider economic development beyond the energy sector itself.

Overall, the results demonstrate that Kenya's energy transition could deliver significant socio-economic benefits in addition to emissions reductions and improved energy security. The NZE pathway therefore represents not only a decarbonization strategy, but also an opportunity to support industrial development, infrastructure expansion, economic modernization, and large-scale job creation across the country.

---

[4] Direct jobs are on-site positions created by the initial investment. Indirect jobs are upstream supply-chain positions. Induced jobs result from household spending of direct and indirect workers. Net additional jobs include the number of jobs created in the NZE scenario compared to the BAU by 2050 including the jobs lost throughout the energy transition. Other jobs includes the jobs in the cooking sector.

Figure 50: Comparison of net additional jobs from key energy sector investment between BAU and NZE in 2050 ('000 jobs)



CHAPTER FIVE

POLICY IMPLICATIONS AND KEY INSIGHTS

Kenya’s energy system stands at a critical juncture as it reconciles equitable access, industrialization and climate agendas. This report provided an update to Kenya’s 2024 Energy Transition and Investment Plan (ETIP) aligning with recent policy updates including NDC 3.0, Mission 300 Energy Compact and strategies such as those initiated as part of Kenya’s commitment to the Beyond Oil and Gas initiative. This plan will help Kenya frame an energy transition agenda that will attract investment, while at the same time ensuring a just transition from fossil fuels and fully supporting Kenya’s rapid economic growth trajectory.

Kenya's total final energy demand is projected to increase more than four-fold by 2060, driven by population growth, economic development, urbanization, and expanding access to modern energy services. Under BAU, this translates into fuel consumption rising from approximately 1,028 PJ in 2024 to 2,663 PJ by 2060. The transport sector is the single largest driver of this growth, accounting for the majority of incremental fuel demand, followed by industry and buildings. Under the NZE scenario, however, total fuel demand by 2060 falls to approximately 1,041 PJ despite serving the same underlying growth in population and economic activity. This dramatic reduction is achieved not by constraining development, but by switching to inherently more efficient technologies: electric vehicles, electric cooking appliances, and electrified industrial processes all deliver the same or greater energy services from a fraction of the primary energy input. Efficiency therefore sits at the heart of the transition's economic case: it reduces the total capacity that must be built, lowers the infrastructure investment required, and compresses long-term operating costs across every sector.

The **power sector** undergoes a major transition under Kenya’s NZE pathway compared to the BAU scenario as electricity demand increases rapidly due to electrification across transport, buildings, and industry. Under BAU, the power system expands through a combination of geothermal, natural gas, hydropower, solar PV, and electricity imports, with geothermal remaining the backbone of the electricity mix while natural gas plays an increasingly important role in providing system flexibility and meeting rising demand. Although renewable energy penetration remains high, fossil fuel generation continues contributing to the system throughout the modelling horizon.

In contrast, the NZE scenario accelerates deployment of low-carbon generation technologies, resulting in a highly diversified electricity system dominated by solar PV, geothermal, hydropower, batteries, hydrogen, and nuclear generation in later years. Solar PV experiences the largest capacity expansion due to its cost competitiveness and strong resource availability, while geothermal continues providing an important stable baseload contribution. Nuclear generation penetrates the system from 2036 onwards and progressively becomes one of the main firm low-carbon generation sources, supporting long-term system reliability and replacing natural gas in later years. Natural gas therefore plays a transitional role in earlier years before being fully phased out by 2064. Scaling capacity at scale would require holistic policies that facilitate deployment across market segments (e.g. decentralized, utility-scale), address key investment risks and align complementary infrastructure development (e.g. transmission and distribution networks).

Nuclear and blue hydrogen involve multi-decade development timelines. Regulatory frameworks, safety standards, site assessments and technology specific national strategies therefore need to be established within this decade to align with the deployment trajectory as shown in the model. The rapid increase in renewable energy penetration significantly increases the need for system flexibility, leading to large-scale investments in battery storage, hydrogen technologies, transmission infrastructure, and flexible low-carbon generation capacity.

Overall, the NZE pathway transforms Kenya’s power sector into a highly electrified, diversified, and low-carbon energy system capable of supporting economy-wide decarbonization while improving long-term energy security and reducing dependence on imported fossil fuels. The results point to the need for long-term policy frameworks that can contract and build at scale, grid infrastructure build-out that can absorb large volumes of variable renewable generation, a functioning storage and flexibility market, and regulatory clarity on newer technologies, particularly nuclear, green and blue hydrogen.

Compared to the BAU scenario, the **transport sector** experiences the largest transformation under the NZE pathway. Under BAU, oil products remain the dominant energy carrier across passenger vehicles, buses, freight transport, and 2/3 wheelers throughout the modelling horizon. As a result, transport becomes one of the largest contributors to fossil fuel consumption and emissions in the energy system. In contrast, the NZE scenario results in large-scale electrification and fuel switching across all transport segments. Electric vehicles progressively dominate passenger cars, buses, light trucks, and 2/3 wheelers, while hydrogen technologies increasingly penetrate heavy-duty freight transport and other hard-to-abate applications in later years. Oil-based vehicle sales are gradually phased out after 2035, leading to near-complete decarbonization of the transport sector by 2050. This transition significantly reduces final fuel consumption and emissions due to the substantially higher efficiency of electric mobility technologies compared to conventional internal combustion engine vehicles. At the same time, transport electrification becomes one of the largest drivers of future electricity demand growth, highlighting the strong interconnection between the transport and power sectors in achieving Kenya’s long-term net-zero emissions objectives.

Transport accounts for USD 196 billion of the USD 303 billion in additional capital investment required under the NZE pathway by 2060 and generates more than 90% of the 1.4 million additional net jobs projected by 2050. Achieving NZE 2050 will require the complete phase-out of oil-based transport by

2050, with electricity becoming the dominant energy source and hydrogen serving heavy-duty freight.

The scale of required investment makes transport electrification a strategic priority alongside power sector expansion, requiring a dedicated financing and policy architecture of comparable scale. Most of the transition occurs between 2035 and 2050, meaning that fiscal incentives, charging infrastructure and regulatory conditions for EV cost competitiveness would need to be established within the current decade aligning with recent efforts through the launch of the Kenya National Electric Mobility Policy in 2026.

Given the concentration of direct, indirect and induced employment effects, the economic rationale for early action in transport is stronger than in any other sector covered by the ETIP. Kenya would benefit from policies supporting local EV assembly, component manufacturing and maintenance supply chains thereby turning the transition's most capital-intensive sector into its largest economic dividend.

The **industrial sector** also undergoes a significant transformation under the NZE pathway compared to the BAU scenario. While industrial activity and energy demand continue increasing due to economic growth and industrialization, the fuel mix and production technologies progressively shift towards lower-carbon alternatives. Under BAU, industrial processes remain heavily dependent on coal, oil products, and natural gas across cement, steel, chemical, and other industrial heat applications. In contrast, the NZE pathway accelerates electrification of low-temperature heat processes, while hydrogen, biofuels, biomass, and carbon capture technologies progressively penetrate high-temperature and hard-to-abate industrial applications. Electric boilers, electric arc furnaces, hydrogen-based direct reduced iron technologies, biofuels, and biomass with carbon capture and storage (BECCS) become increasingly important in reducing industrial emissions while maintaining industrial growth and competitiveness. To achieve NZE 2050 industrial decarbonization depends fundamentally on power sector expansion. EAF steelmaking and electrified low-temperature heat processes would require clean electricity at scale and at competitive prices, reinforcing the power sector as the foundational enabler across different sectors. Incentive frameworks for early adoption of EAF technology could accelerate the steel transition. Carbon pricing or carbon intensity standards for energy-intensive industries, starting with monitoring, reporting and verification and progressing toward binding performance standards, would create the market signal for technology switching. Hydrogen and biofuels also become significant industrial energy carriers post-2045, meaning production facilities, transport infrastructure and storage capacity need to be developed in the 2030s through pilot programmes and early-stage investment support. Industrial energy pricing reform such as addressing subsidies for coal and petroleum coke while incentivizing support for firms investing in low-carbon process technologies would align price signals with the transition pathway. The results demonstrate that achieving industrial decarbonization in Kenya requires a combination of electrification, hydrogen deployment, fuel switching, efficiency improvements, and negative emission technologies, highlighting the strong interconnection between the industrial and power sectors in the future low-carbon energy system.

The **buildings sector** also plays an important role in the transition towards a low-carbon energy system under the NZE pathway. Clean cooking policies progressively phase out traditional biomass technologies and accelerate deployment of electric cooking, LPG, and efficient biomass stoves, particularly in rural areas.

At the same time, efficient cooling appliances, lighting systems, and electric water heaters significantly improve **energy efficiency** across residential and commercial buildings. Although electrification increases electricity demand in the buildings sector, deployment of more efficient technologies moderates long-term energy consumption growth while improving access to modern energy services and reducing indoor air pollution and health impacts associated with traditional cooking practices.

Phasing out traditional biomass by 2030 aligning with Kenya's clean cooking policy will grants or other upfront transition financing directed especially at the vulnerable populations to ensure equitable access to modern energy. The phase-out will also affect biomass-sector workers. Reskilling programs are needed to and prevent job losses and income insecurity. Large-scale adoption of electric cooking is only feasible if generation capacity, distribution networks and tariff structures support the resulting increase in demand. Clean cooking targets therefore cannot advance independently of underlying electrification efforts including on the policy side. Targeted subsidy or results-based financing programmes for electric appliances will be needed, with differentiated approaches for urban and rural households. For example, distribution network capacity and mini-grid deployment in rural areas must be planned to support household demand including cooling, water heating and cooking loads.

To support the phase-out of fossil fuels and accelerate electrification, strong policy support for clean energy adoption and standards will be essential. Public-awareness campaigns are important to the implementation of sustainability. Robust warranty structures and performance guarantees can also help reduce consumer perceived risk, and increase adoption rate. Also, maintenance and repair for biomass cooking stoves are mature, but electric appliance servicing requires new technician training and supply chains. The government can provide training programs, create certification standards for technicians, publish repair pricing standards to prevent overcharging, and more to fill the skill gap. Policy must establish dedicated stove replacement financing mechanisms in the rural area where requires upfront capital expenditure, for example, direct stove subsidies, pay-as-you-go via utility bill, and bulk procurement to lower the cost. In the meantime, these stove replacements would require decentralized appliance supply chains, such as manufacturing, distribution, and installation, which operationally far more complex than organic adoption. Considering also simultaneous grid expansion and reinforcement to deliver equivalent electricity to replace LPG and biomass, and managing peak loads during cooking hours.

The **agriculture sector** progressively transitions towards more electrified and energy-efficient technologies under the NZE pathway. Electric motive power and pumping systems increasingly replace conventional diesel-based technologies, reducing fossil fuel consumption and improving overall energy efficiency in agricultural activities. Electrification of agricultural services also supports rural development and increases the need for expansion of reliable electricity infrastructure across rural areas.

Achieving the NZE pathway requires substantially higher cumulative investments compared to the BAU scenario, particularly in transport electrification, renewable energy deployment, electricity networks, storage systems, hydrogen production, and industrial decarbonization technologies. However, these higher capital investments are partially offset by significant reductions in long-term fuel expenditures due to lower dependence on imported fossil fuels. As electrification and renewable energy penetration increase, Kenya's exposure to international fossil fuel price volatility declines substantially, improving long-term energy security and economic resilience.

The NZE pathway requires an additional USD 303 billion in cumulative capital investment relative to BAU, with the majority of expenditure occurring after 2040. Approximately 23% of this incremental investment is concentrated in power and hydrogen, while transport accounts for a further 65%. In the power sector, the required instruments are relatively well established: blended finance, concessional capital, long-term PPAs and risk mitigation mechanisms provided by MDBs and DFIs. By contrast, the financing architecture for transport remains significantly less developed. No direct equivalent currently exists to the IPP or PPA framework for fleet electrification, charging infrastructure or hydrogen refueling networks. Mobilizing capital at this scale will require a dedicated energy transition financing vehicle or window that can blend concessional and commercial capital, supported by a pipeline of bankable projects across each sector aligned to the ETIP investment trajectory with standardized project preparation and due diligence processes that reduce transaction costs for private investors. Also, risk mitigation instruments such as guarantees, first-loss tranches, currency hedging will need to be calibrated to the maturity of each technology pathway, with mature renewable technologies requiring different de-risking than green hydrogen, nuclear or industrial CCS.

The NZE pathway also delivers significant socio-economic benefits through large-scale job creation across the economy. Additional investments in renewable energy, transport electrification and low-carbon technologies could support approximately 1.4 million additional net jobs by 2050 compared to the BAU scenario. The transport sector contributes the largest share of employment creation, followed by investments in power generation, hydrogen infrastructure, and supporting industrial supply chains. Beyond emissions reductions, the energy transition therefore represents an important opportunity for economic modernization, industrial development, and sustainable long-term growth.

Overall, the results demonstrate that achieving Kenya’s net-zero emissions pathway requires a system-wide transformation across transport, power, buildings, industry, and agriculture, supported by rapid electrification, deployment of renewable energy technologies, expansion of system flexibility infrastructure, and substantial long-term investments in low-carbon technologies and supporting infrastructure. At the same time, the NZE pathway provides important socio-economic benefits, including improved energy security through reduced dependence on imported fossil fuels, lower long-term fuel expenditures, modernization of infrastructure, and creation of significant additional employment opportunities across the economy.

BIBLIOGRAPHY

[1] IIASA (2026). Shared Socioeconomic Pathways Scenario Database (SSP). Available at: https://iiasa.ac.at/models-tools-data/ssp

[2] Government of Kenya. Kenya National Bureau of Statistics (2026). 2025/26 Kenya Integrated Household Budget Survey (KIHBS). Available at: https://www.knbs.or.ke/2025-26-kenya-integrated-household-budget-survey-kihbs/

[3] Kenya Power (2026). Available at: https://kplc.co.ke/

[4] Government of Kenya. National Transport and Safety Authority (2026). Available at: https://www.ntsa.go.ke/

[5] IRENA (2026). FlexTool. Available at: https://www.irena.org/Energy-Transition/Planning/Flextool

[6] Bhatia and Angelou (2015). Beyond Connections: Energy Access Redefined. Available at: https://www.worldbank.org/content/dam/Worldbank/Topics/Energy%20and%20Extract/Beyond_Connections_Energy_Access_Redefined_Exec_ESMAP_2015.pdf

[7] Allington, L., Cannone, C., Pappis, I., Cervantes Barron, K., Usher, W., Pye, S., Brown, E., Howells, M., Zachau Walker, M., Ahsan, A., Charbonnier, F., Halloran, C., Hirmer, S., Cronin, J., Taliotis, C., Sundin, C., Sridharan, V., Ramos, E., Brinkerink, M., et al. (2022). Selected 'Starter Kit' Energy System Modelling Data for Selected Countries in Africa, East Asia, and South America (#CCG, 2021). Data in Brief, 42, 108021.

[8] U.S. Energy Information Administration (2026). Available at: https://www.eia.gov/

[9] IRENA (2021). The Renewable Energy Transition in Africa. Available at: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/March/Renewable_Energy_Transition_Africa_2021.pdf

[10] Government of Kenya. Ministry of Roads and Transport (2026). National Electric Mobility Policy. Available at: https://www.transport.go.ke/sites/default/files/Emobility%20Policy%20Final.pdf

[11] International Renewable Energy Agency (IRENA) (2024). World Energy Transitions Outlook 2024: 1.5°C Pathway. Abu Dhabi: IRENA. Available at: https://www.irena.org/Publications/2024/Nov/World-Energy-Transitions-Outlook-2024

[12] International Energy Agency (IEA) (2025). World Energy Investment 2025. Paris: IEA. Available at: https://www.iea.org/reports/world-energy-investment-2025

APPENDIX A

DEMAND ASSUMPTIONS

Figure 51: Number of households (million) and national access rate (%)

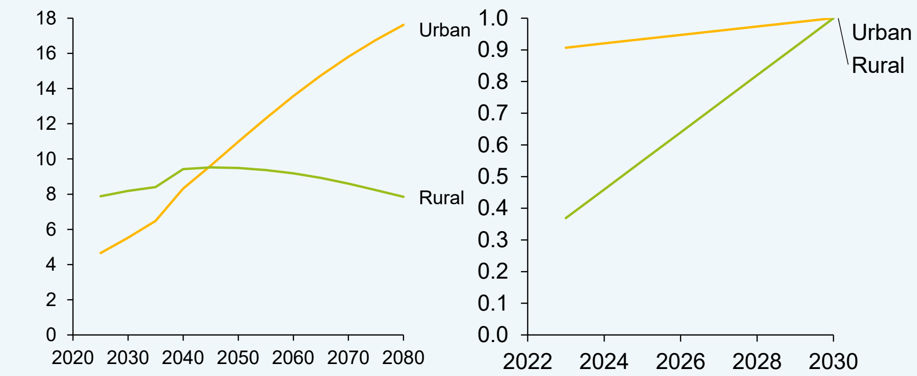
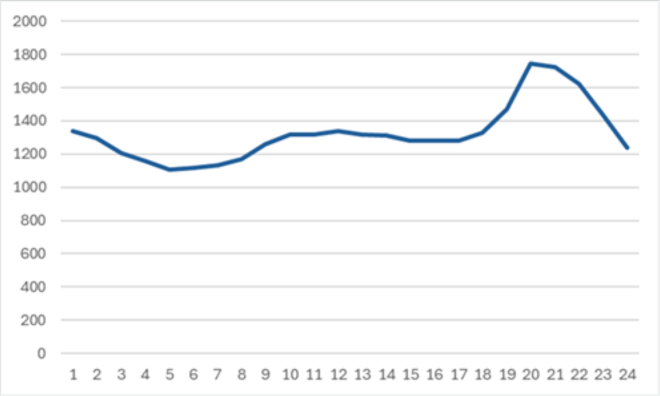


Figure 52: Monthly electricity load profile (MWh)

Figure 53: Monthly electricity load profile (MWh)



DEMAND PROJECTIONS

Table 2: Demand projections

Sector	2024	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070	2075	2080
Agricultural production (PJ)	0.19	0.19	0.22	0.26	0.3	0.36	0.42	0.49	0.58	0.68	0.79	0.91	1.04
Cooking rural (PJ)	45.2	41.0	42.7	43.8	44.6	45.3	45.4	46.8	47.6	48.3	48.5	49.3	49.9
Cooking urban (PJ)	28.3	24.3	28.8	33.8	40.0	45.9	52.0	55.7	58.7	62.4	65.2	66.3	67.1
Residential electricity use (GWh)	169.4	197.2	258.3	336.1	441.6	577.8	747.2	961.1	1222.2	1533.3	1891.7	2300	2758.3
Residential future connections electricity (GWh)	0	27.8	222.2	288.9	380.6	497.2	644.4	827.8	1055.6	1322.2	1633.3	1983.3	2380.6
Commercial electricity use (GWh)	250	294.4	388.9	505.6	663.9	866.7	1122.2	1441.7	1833.3	2300	2838.9	3450	4138.9
Residential cooling thermal (PJ)	20.94	27.54	59.46	77.36	101.59	132.39	171.73	220.46	280.84	352.24	434.68	528.01	633.7
Commercial cooling thermal (PJ)	13.34	15.65	20.64	26.86	35.26	45.98	59.56	76.51	97.38	122.11	150.72	183.13	219.71
Residential lighting (PJ)	2.25	2.89	5.35	5.96	6.93	8.18	9.87	12.06	14.85	18.19	22.11	26.57	31.67
Commercial lighting (PJ)	1.63	1.90	2.39	2.94	3.68	4.63	5.87	7.43	9.36	11.67	14.34	17.38	20.80
Other chemicals (PJ)	0.00	0.31	0.83	1.64	2.96	5.05	8.30	13.26	20.71	31.65	47.27	68.90	98.38
Other industries (PJ)	31.99	33.06	39.46	46.93	56.56	68.03	81.61	97.37	115.29	134.60	154.50	174.01	192.27
Cement clinker (Mtpa)	6.48	7.65	9.05	10.68	12.78	15.27	18.21	21.61	25.48	29.65	33.98	38.25	42.29
Scrap steel (Mtpa)	0.58	0.59	0.65	0.71	0.78	0.86	0.95	1.05	1.16	1.29	1.44	1.61	1.83
Virgin steel (Mtpa)	1.17	1.21	1.34	1.46	1.62	1.78	1.96	2.16	2.39	2.66	2.97	3.33	3.77
Heavy trucks (bn veh km)	13.63	14.25	16.50	19.07	22.36	26.23	30.82	36.23	42.58	49.78	57.80	66.58	76.16
2/3 wheelers (bn veh km)	35.04	35.84	39.39	43.02	47.29	51.67	56.18	60.77	65.49	70.16	74.71	79.12	83.37
Buses (bn veh km)	5.59	6.16	7.97	10.22	13.23	17.05	21.86	27.84	35.15	43.77	53.68	64.84	77.35
Cars (bn veh km)	41.37	45.56	58.97	75.55	97.82	126.09	161.66	205.84	259.91	323.64	396.95	479.47	571.95
Light trucks (bn veh km)	20.40	21.32	24.69	28.54	33.45	39.25	46.11	54.20	63.70	74.48	86.48	99.61	113.94
Shipping (PJ)	0.05	0.05	0.06	0.07	0.09	0.10	0.12	0.14	0.16	0.18	0.21	0.24	0.27
Aviation (PJ)	1.65	1.79	2.27	2.85	3.62	4.60	5.82	7.32	9.16	11.31	13.78	16.55	19.65

Rail (PJ)	0.94	0.98	1.12	1.29	1.49	1.73	2.01	2.34	2.71	3.14	3.60	4.10	4.64

TECHNICAL ASSUMPTIONS

The model considers 36 timeslices:

Seasons (5):

- Season 1: March – May
- Season 2: June – September
- Season 3: October – December
- Season 4: January – February
- Season 5: 1 day (no renewables)

Daytypes (2):

- Daytype 1: Weekday (5/7)
- Daytype 2: Weekend (2/7)

Time blocks (4):

- Time block 1: 00:00 – 06:00
- Time block 2: 06:00 – 12:00
- Time block 3: 12:00 – 18:00
- Time block 4: 18:00 – 24:00

Transmission & distribution losses:

- Transmission 4.2% between 2024 – 2028
- Distribution 8.9% in 2025 decreases to 5% in 2035

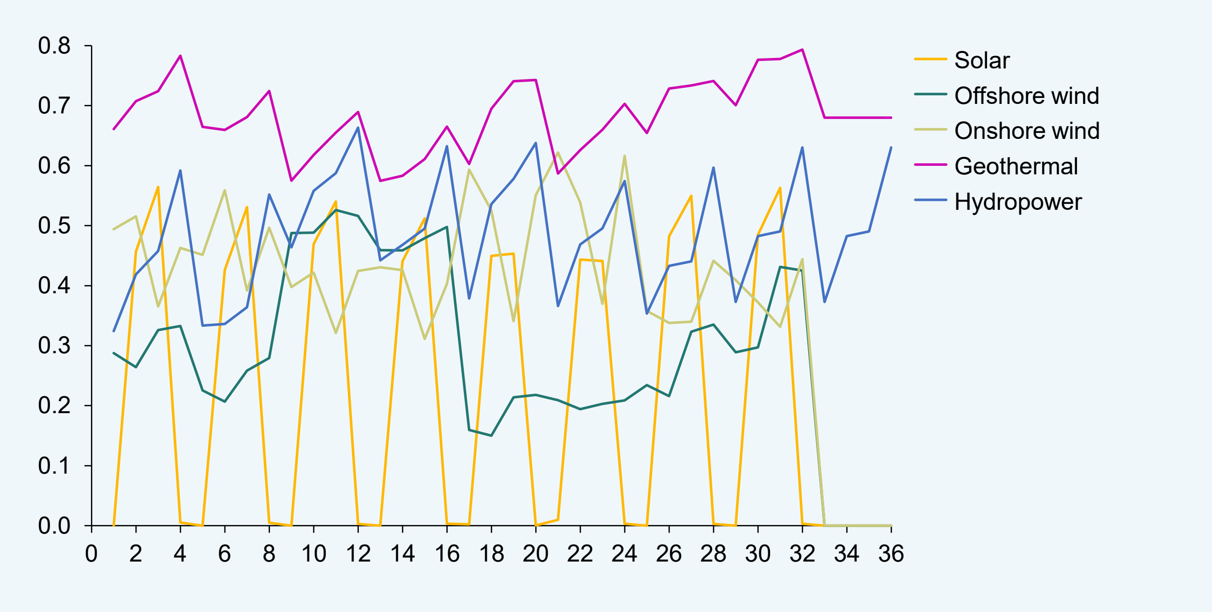
Electricity interconnectors:

- Ethiopia – Kenya, 200 MW, 2022 (OPR)
- Kenya – Uganda, 120 MW, 1957 (OPR)
- Ethiopia - Kenya, 200 MW, 2027 (CON)

Reserve margin: 13%

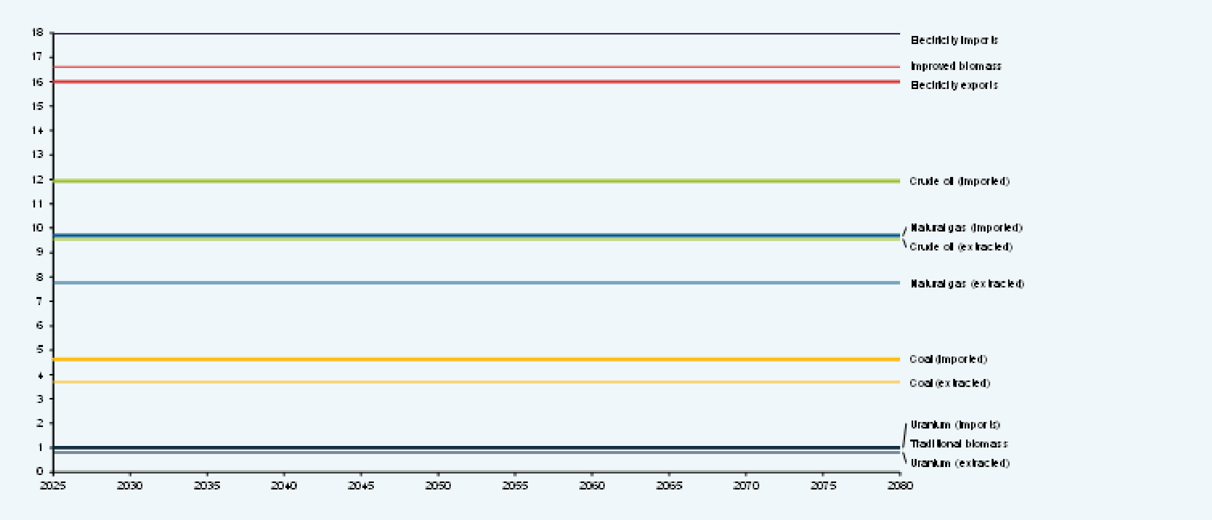
CAPACITY FACTORS

Figure 54: Capacity factors of renewable sources



FUEL COSTS

Figure 55: Fuel costs (USD/GJ)



CAPITAL COSTS

Table 3: Capital costs of power plant technologies

USD/kW	2024	2030	2040	2050	2060
Coal	1557	1557	1557	1557	1557
Oil	1421	1421	1421	1421	1421
Gas	700	700	700	700	700
Large hydro	2610	2610	2610	2610	2610
Small hydro	2784	2784	2784	2784	2784
Geothermal	4836	4836	4836	4836	4836
Biomass	3327	3327	3327	3327	3327
Solar PV	1255	957	722	525	512
Solar PV decentralized	1400	1250	1000	800	700
Solar PV decentralized	6510	6510	6510	6510	6510
Onshore wind	1722	1463	1272	1115	1105
Offshore wind	3684	2820	2400	1980	1980
Nuclear	4000	4000	4000	4000	4000
Nuclear SMR	6000	6000	6000	6000	6000
Hydrogen	667	667	667	667	667
Blue hydrogen	1654	1616	1552	1488	1424
Electrolyser	890	842	762	680	599
Grey hydrogen from coal	2670	2670	2670	2670	2670
Grey hydrogen from gas	651	651	651	651	651
Hydrogen storage (USD/kWh)	0.3	0.3	0.3	0.3	0.3
Electric battery storage (USD/kWh)	150	145	136	127	118
Biomass CCS	4485	4485	4485	4485	4485
Coal CCS	2687	2687	2687	2687	2687
Gas with CCS	1493	1493	1493	1493	1493

Table 4: Capital costs of vehicle modes

M USD/'000 vehicles	2024	2030	2040	2050	2060
2/3 wheeler: electric	1.2	1.2	1.1	1	1
2/3 wheeler: liquid fuel	0.6	0.6	0.6	0.6	0.6
2/3 wheeler: natural gas	0.6	0.6	0.6	0.6	0.6
2/3 wheeler: bioethanol E85	0.7	0.7	0.7	0.7	0.7
2/3 wheeler: bioethanol E10	0.6	0.6	0.6	0.6	0.6
Bus: electric	140	136	130	122.2	115.4
Bus: hydrogen	141	136	128	120.2	112.2
Bus: liquid fuel	76	76	76	76	76
Bus: gas	76	76	76	76	76
Bus bioethanol E85	76	76	76	76	76
Bus bioethanol E10	75	75	75	75	75
Car: electric	8	8	8	7	7
Car: hydrogen	12	11	10	9	8
Car: liquid fuel	5	5	5	5	5
Car: gas	5	5	5	5	5
Car bioethanol E85	5	5	5	5	5
Car bioethanol E10	4.9	4.9	4.9	4.9	4.9
Heavy truck: electric	134	129	122	114	106
Heavy truck: hydrogen	155	148	137	125	114
Heavy truck: liquid fuel	58	59	61	63	65
Heavy truck: natural gas	58	59	61	63	65
Heavy truck bioethanol E85	58	58	58	58	58
Heavy truck bioethanol E10	57	57	57	57	57
Light truck: electric	49	48	45	43	39
Light truck: hydrogen	69	65	58	51	44
Light truck: liquid fuel	24	24	24	24	25
Light truck: gas	24	24	24	24	25
Light truck bioethanol E85	24	24	24	24	24
Light truck bioethanol E10	22	22	22	22	22

Table 5: Capital costs of cook stove types

M USD/'000 units	2024	2030	2040	2050	2060
Cook stove: biomass	0.001	0.001	0.001	0.001	0.001
Cook stove: electric	0.1	0.1	0.1	0.1	0.1
Cook stove: natural gas	0.3	0.3	0.3	0.3	0.3
Cook stove: oil	0.02	0.02	0.02	0.02	0.02
Cook stove: improved biomass	0.05	0.05	0.05	0.05	0.05
Cook stove: LPG	0.2	0.2	0.2	0.2	0.2
Cook stove: Kerosene	0.02	0.02	0.02	0.02	0.02

JOB CREATION POTENTIAL

Figure 56: Total direct and indirect number of jobs in the BAU scenario in 2050 across all technologies

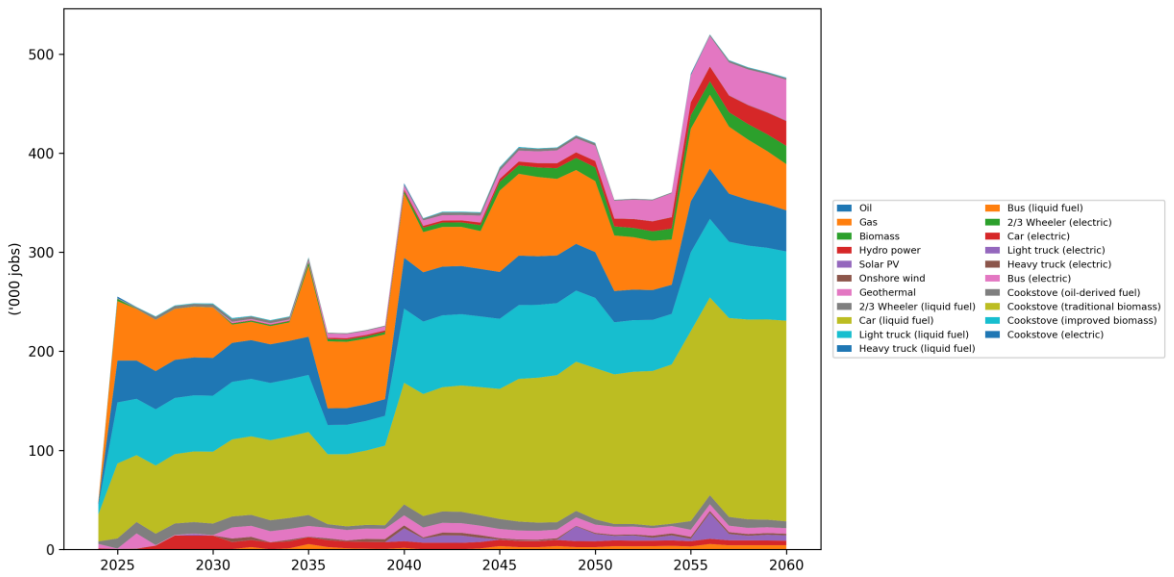


Figure 57: Total induced number of jobs in the BAU scenario in 2050 across all technologies

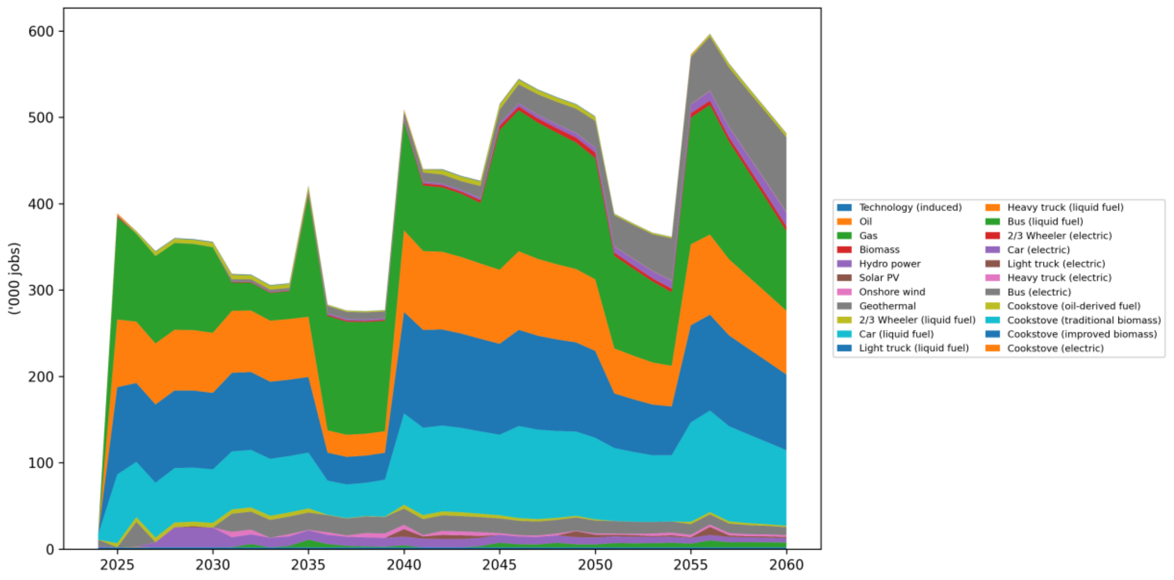


Figure 58: Total direct and indirect number of jobs in the NZE scenario in 2050 across all technologies

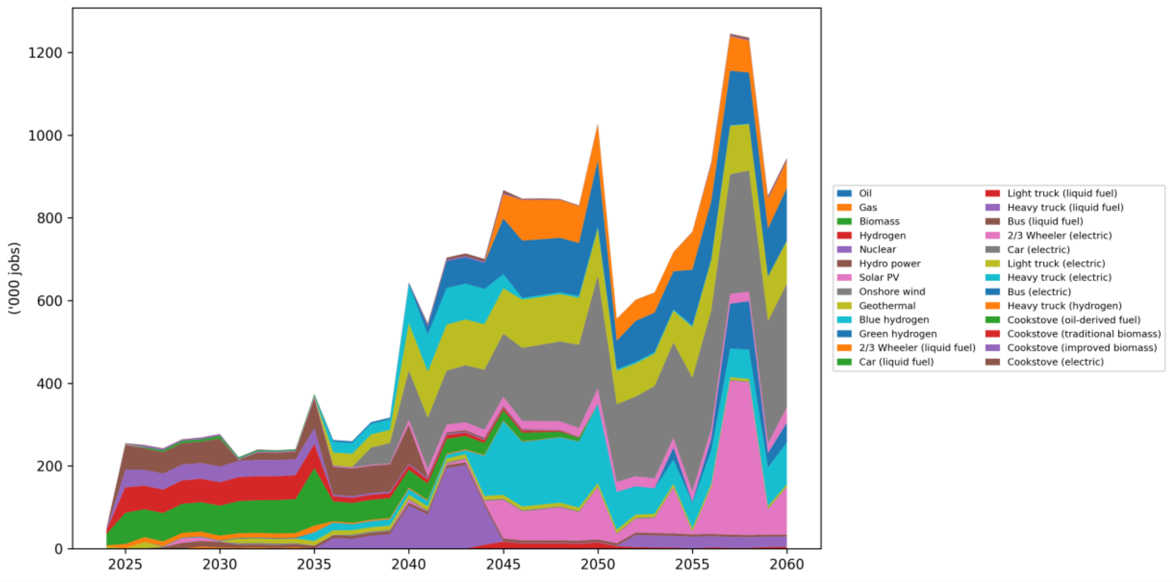
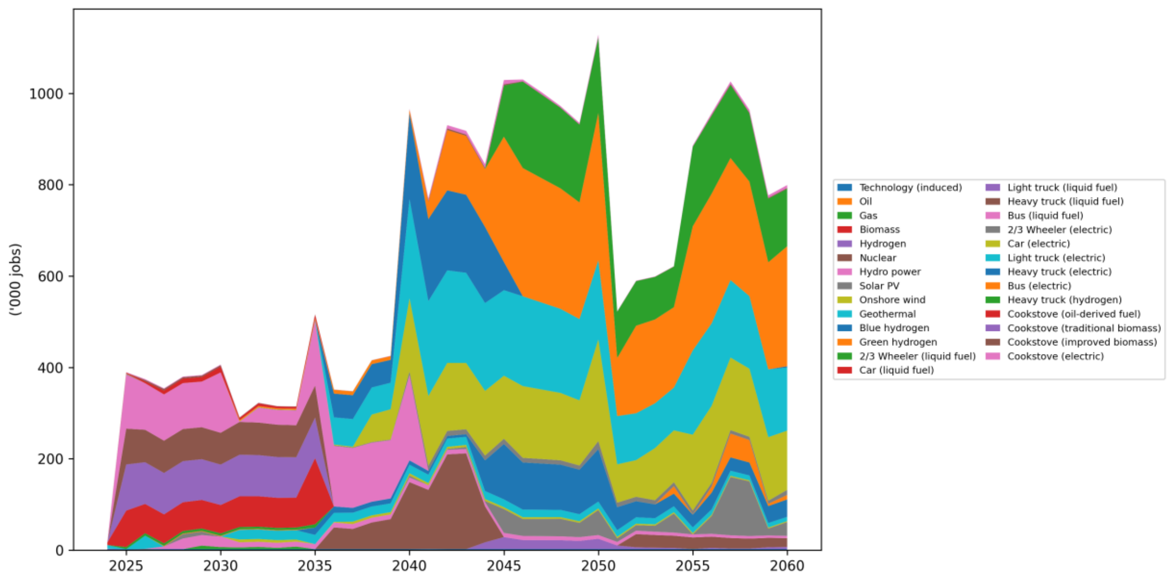


Figure 59: Total induced number of jobs in the NZE scenario in 2050 across all technologies



About SEforALL

Sustainable Energy for All has a global mandate to accelerate progress on the energy transition in emerging and developing countries. Hosted by UNOPS, we work at the intersection of energy, climate and development, partnering with governments and organizations worldwide to end energy poverty, double energy efficiency, significantly expand renewable energy and combat climate change.

SEforALL.org