Uganda Energy Transition Plan

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December 2023
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Abstract

Uganda's Energy Transition Plan (ETP) is a strategic roadmap for the development and modernisation of Uganda's energy sector. It charts an ambitious, yet feasible pathway to achieve universal access to modern energy and power the country's economic transformation in a sustainable and secure way. The plan was developed by Uganda's Ministry of Energy and Mineral Development, with support from the International Energy Agency, and provides the groundwork for the government's upcoming Integrated Energy Resource Master Plan.

The analysis does not just look at Uganda in isolation but considers how global trends are influencing and opening up new opportunities, notably driven by rapidly evolving clean technology costs and shifts in energy and climate finance. Particular focus is paid to making use of the country's considerable energy and mineral resources, and parlaying this into economic development for Uganda, a core pillar to ensure the pathway in the ETP is a just and inclusive one. The report provides detailed sector-by-sector analysis, including key targets and milestones, estimates of investment needs, and includes high-level recommendations for its implementation. While the focus of the report is from now to 2050, the ETP also highlights key steps to further the energy sector's decarbonisation beyond 2050 and estimates at what point the energy sector is poised to reach net zero.

Foreword

Uganda is in the midst of an unprecedented economic transformation. The country is among both the fastest growing populations and economies in the world, with expansion of major industries fuelling the transformation. These trends are set to continue as we head into a critical decade of economic growth and development.

Uganda has made significant strides in recent years, with a remarkable expansion of electricity access, surpassing the growth rates of sub-Saharan Africa. Over the past two decades, our power sector has grown almost fivefold, significantly reducing the inefficient use of imported oil for power generation. Since 2015, we have provided cleaner cooking alternatives to more than 3.5 million Ugandans, liberating them from the health hazards and time-consuming burdens of traditional firewood and charcoal stoves.

However, comparatively, we remain energy poor, with low levels of electricity and clean cooking access, and among countries with the lowest levels of modern energy consumption per capita globally. Around 90% of Uganda's energy needs are still met by solid bioenergy, given it is the only energy source available to many in rural areas. This is not sustainable, nor is it an option to fuel future growth in Uganda. This is the imperative that motivated the Energy Transition Plan: build the energy system foundations that will be necessary to power Uganda's future in a just, safe, secure, affordable and sustainable manner.

Therefore, we must build on the current success in accelerating access to clean energy and push further to realise our vision for a modern and prosperous Uganda. Fortunately, Uganda is blessed with ample energy resources, which the Energy Transition Plan makes use of to securely meet growing energy needs while also realising the economic growth and job creation potential that harnessing these resources holds. The Energy Transition Plan touches on all aspects of the Ministry of Energy and Mineral Development's work, covering renewables, energy efficiency, nuclear power, oil and gas resources, and deposits of critical minerals that are key to global energy transitions. It also reinforces Uganda's already prominent role as a strong regional partner for developing a more robust, integrated energy infrastructure across the region, which supports our collective goals for energy security and greater collaboration.

Uganda is fully committed to a sustainable vision for its development. Alongside the launch of the Energy Transition Plan, Uganda announces its intention to reach net zero emissions in its energy sector by 2065, which paves the way for our country to explore a formal economy-wide target for climate neutrality. Uganda recognises and affirms its responsibility to take action to mitigate rising emissions

and sees that the sustainable way of development is increasingly the economic way, allowing the country to play a significant role in growing clean energy supply chains and tapping into new opportunities for carbon-related financial flows.

The Energy Transition Plan was developed in concert with a number of international partners, who provided input and helped validate the plan's technical robustness and ambition. We are thankful for their support, especially the International Energy Agency, and look forward to deepening these partnerships as we turn to implementation.

The launch of the Energy Transition Plan is a clear signal that demonstrates Uganda's openness for investment. We welcome companies and investors to work with us, exploring public-private partnerships and new innovative approaches to financing the country's energy and critical minerals industries. We know the private sector needs to be assured of a consistent direction of travel, and this plan provides the clear, long-term strategic signals to answer that need. Even though we must remain adaptable along the way, Uganda does not intend to relent from the outcomes and key milestones of the Energy Transition Plan. The sustainable development of our energy and minerals sectors is considered vital to not only our own prosperity, but that of the world's. Uganda is committed to building a more liveable planet for future generations.

We are proud to unveil this transformative long-term strategy and invite the world to join us as we embark on the demanding yet rewarding journey of the implementation of the Energy Transition Plan.

Ruth Nankabirwa Ssentamu

Minister of Energy and Mineral Development, Uganda

Acknowledgements, contributors and credits

The **Energy Transition Plan (ETP)** was developed and produced through collaboration between Uganda's Ministry of Energy and Mineral Development (MEMD) and the International Energy Agency (IEA). The ETP was designed and directed by Laura Cozzi, Director, Sustainability, Technology and Outlooks at the IEA and Dr Gerald Banaga-Baingi, Assistant Commissioner, Technical Planning, at the MEMD.

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Valuable comments and feedback were provided by senior management and colleagues within the IEA. In particular, Yasmine Arsalane, Stéphanie Bouckaert, Joel Couse, Rebecca Gaghen, Tim Gould, Keisuke Sadamori and Cecilia Tam.

Marina Dos Santos and Reka Koczka provided essential support.

Diane Munro carried editorial responsibility for the report.

Thanks go to the IEA's Communications and Digital Office for their help in producing the report and website materials, particularly to Jethro Mullen, Poeli Bojorquez, Curtis Brainard, Jon Custer, Hortense de Roffignac, Astrid Dumond, Merve Erdil, Grace Gordon, Julia Horowitz, Oliver Joy, Isabelle Nonain-Semelin, Julie Puech, Robert Stone, Sam Tarling, Clara Vallois, Lucile Wall, Therese Walsh and Wonjik Yang. The IEA's Office of the Legal Counsel, Office of Management and Administration, and the Energy Data Centre provided assistance throughout the preparation of the report. Support for energy modelling was also provided by Sylvain Cail and Aurélien Peffen from EnerData.

This report benefited from Uganda's participation in the Energy Modelling Platform for Africa and Joint Summer School on Modelling Tools for Sustainable Development run by the IEA in partnership with Climate Compatible Growth.

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The International Energy Agency and Government of Uganda would like to express appreciation to Agence Française de Développement for their contribution to the Clean Energy Transitions Programme at the IEA, which made this report possible.

Peer reviewers

Many government officials and international experts provided input and reviewed preliminary drafts of the report. Their comments and suggestions were of great value. They include:

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Kimball Chen	The Global LPG Partnership
Paulina Chiwangu	UN Women
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Elisa Derby	Clean Cooking Alliance
Santos José Díaz Pastor	Universidad Pontificia Comillas

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Jesus Gavilan Marin	Delegation of the European Union to Uganda
Geir Hermansen	Norad
Samuel Kajoba	Norwegian Embassy in Kampala
Matthew Leach	Modern Energy Cooking Services
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Executive summary

A vision for energising Uganda's economic transformation

Uganda is among the fastest growing countries in the world. Maintaining this pace of growth would amount to an economic transformation for the country. Uganda is still a low-income country, with a GDP per capita 40% below the sub-Saharan Africa average. However, in the last two decades, real GDP has grown by around 6% annually. The IMF is forecasting similar growth on the horizon, which would need to be sustained to meet Uganda's development and poverty reduction goals, including reaching upper-middle-income status by 2040.

Energy systems must modernise and expand rapidly to meet these ambitions, prompting Uganda's decision to develop the Energy Transition Plan (ETP). The objectives of the plan, stated by Uganda's Ministry of Energy and Mineral Development (MEMD), are:

- Provide universal access to electricity and cleaner cooking by 2030.
- Modernise and diversify Uganda's energy mix and promote its efficient use across all sectors to support industrial growth, poverty reduction and socio-economic transformation.
- Ensure secure and affordable energy supply.
- Mitigate energy emissions in line with Uganda's conditional climate commitments, which imply a 20% reduction compared to baseline emissions in 2030.
- Position Uganda as an energy hub for the East African region.

This report, produced in close collaboration with Uganda, provides an ambitious yet feasible pathway for the energy sector to meet these strategic objectives.

Given Uganda's point of departure, efforts must be stepped up to develop the country's energy systems. Electricity and clean cooking access rates remain low, at around 45% and 15%, respectively, despite recent progress driven by strong government programmes. Modern energy consumption per capita remains low – around 30 times lower than the average in advanced economies. Solid biomass, largely firewood, charcoal, and bagasse used in buildings and industry, accounts for 90% of the country's final energy consumption today.

Importantly, the country has many domestic energy and mineral resources that can help realise the energy transition. Uganda has ample potential for solar, hydroelectric and geothermal power. With the opening of the Tilenga and Kingfisher oil fields in 2025, Uganda is set to become an oil producer and exporter for the first time. Currently the country imports all its oil products. It also has new graphite and rare earth projects in Orom and Makuutu under development and holds important deposits of other critical minerals. These resources, if harnessed well, could reinforce the transition and contribute to Uganda's economic growth.

The first step of the transition is reaching universal energy access

The rate of progress required to reach universal access is steep, but not unprecedented. Prior to disruptions from the Covid-19 pandemic, electricity access rates improved at 5% annually, and clean cooking rates around 1.5%. To reach universal access to electricity by 2030, over 800 000 households would need to gain a connection each year to 2030. Kenya, Rwanda, Bangladesh and India have all achieved similar rates of progress in the past. For clean cooking, Uganda would need to deploy more than one million improved biomass or clean cooking stoves each year to reach its target, roughly 4% of the estimated global clean cookstove market today.

Reaching universal access this decade relies on all solutions available. Grid connections reach around 45% of those without access today in the transition plan, leaving the majority of connections to off-grid systems by 2030. Smaller systems provide an important first step for many households with acute affordability challenges and are gradually provided with more robust connections over time. Similarly, liquified petroleum gas (LPG) and electric cooking reach more than half of those gaining clean cooking access by 2030, but improved biomass cookstoves are an important transitional solution for many rural households with limited means to pay for fuel on an ongoing basis.

Universal energy access delivers huge benefits for development, health and gender equality. Extending electricity access to rural areas provides an essential lifeline to modernisation, improving economic productivity, access to information, and allows for a more decentralised economy. It can power agricultural pumps and cold-chain infrastructure, which would improve agricultural production and connect farming to commercial markets. Universal access to clean cooking in Uganda can avoid around 50 000 premature deaths from indoor air pollution per year by 2030, and save households two hours per day in collecting firewood – with the greatest benefits accruing to women and children. It also reduces the country's net greenhouse gas emissions by up to 17 Mt CO_2-eq by 2030, with potential to fund multiple projects via carbon credits. Efforts to reach universal access by 2030 contribute to the creation of 170 000 clean energy jobs for Ugandans, an important stepping stone into greater formal employment and higher wages.

Uganda's economic development depends on rising use of modern energy

Achieving universal access is a critical first step, but Uganda's growth and development also depends on rising use of modern energy. In the ETP, electricity consumption grows faster than any other source of energy at 14% annually, bringing Uganda from almost 80 kWh per capita today to around

1 750 kWh per capita in 2050, reaching above levels in Egypt today. Oil demand grows threefold, reaching almost 125 kb/d by 2050, driven by rapidly rising freight and passenger transport.

Rising living standards mean more appliances, more travel, and more commercial activity, making efficiency measures vital to keep energy demand growth in check. In buildings, energy performance standards, including on imported equipment, help to rein in growing energy consumption. Improved urban design and public transit help alleviate some demand for private vehicles, but these still grow almost sevenfold by 2050. Plans to implement more stringent age limits for second-hand vehicle imports and strong electric vehicle plans mean electric two- and three-wheelers outsell oil-powered counterparts by 2035 and electric cars in 2037. This helps oil demand peak around 2040, aided by planned increases in biofuel blending. Heavy freight, aviation, and inland shipping still rely primarily on oil out to 2050.

Industrial growth drives the largest increase in energy demand, especially within mining, cement and steel sectors. Light industry remains the largest driver of economic growth, but significant efficiency improvements and switching to modern fuels means these industries use three-quarters less energy per unit of economic output by 2050. Energy-intensive industries contribute to a steep increase in demand for high-temperature heat from fossil fuels. Coal imports have ticked up in recent years to support the cement and steel industries, but natural gas helps curb this growth in the ETP, relying on imports from Tanzania and small amounts coming from Uganda's oil fields. In particular, future expansions of primary steel increasingly rely on natural gas-based production routes that can be switched to low-emissions hydrogen in the future.

Electricity is at the heart of meeting rising demand in a cost-effective and sustainable manner

The power sector becomes the backbone of Uganda's energy systems, with all growth met by low-emissions sources. Electricity rises to become the single largest source of energy consumed by 2040, growing to reach 56% of total final consumption by 2050**.** The grid today is already 99% renewable, with only a small amount of oil-based generation used in critical situations. Low-emissions sources of energy maintain this share all the way through to 2050, even while generation grows nearly forty-fold. Solar power is the leading source of low-cost generation, with country-wide solar resources better than global leaders, such as Spain. Hydro and geothermal resources together meet over one-quarter of generation by 2050 and, along with battery storage, play an important role in integrating solar and wind. Uganda has plans to develop nuclear power and is in Phase 2 of the IAEA's Milestone Approach, with plans to bring on the first facility in the early 2030s.

A strengthened, interconnected grid is essential to Uganda's vision to become a regional energy supplier. The country has existing or planned interconnections with all of its neighbours in the East African Power Pool. Reinforcing and better utilising these links helps lower costs, improve reliability and security, and enhance resilience against climate change and physical disruption. It also plays a key role in integrating rising shares of variable renewables, which reach around 45% by 2050, similar to levels seen in Uruguay. Uganda would need to accelerate domestic end-use electrification efforts and greatly expand electricity exports to realise prior ambitions of installing 52 GW of generating capacity by 2040. These efforts could include earlier adoption of carbon capture, utilisation and storage (CCUS) and electrolytic hydrogen.

Leveraging emerging major extractive industries for growth

Uganda's oil production and new refinery help meet growing domestic and regional demand in the ETP. Production of crude oil peaks around 230 kb/d by the end of this decade – 0.2% of global oil supply today. Even with Uganda's efforts to peak domestic oil consumption in 2040, demand in the Greater Horn of Africa region remains higher than the region's production. The planned Hoima refinery would reduce the need to import refined products and its output covers Uganda's domestic demand, although meeting regional needs without importing would imply further refining expansion. In the ETP, best efforts are made to mitigate emissions from Uganda's oil and gas operations. This includes a target for methane emissions intensity per barrel that is half of today's global averages and powering oil and gas operations with low-emissions sources of electricity. Revenues from oil and gas can be reinvested in renewables and other clean energy infrastructure needed in the ETP.

The country's critical mineral deposits present a meaningful economic opportunity and would help secure global clean energy supply chains. Uganda has identified deposits of graphite, rare earths, copper and cobalt, all at varying stages of development. Uganda is pursuing plans to develop processing and beneficiation of these minerals domestically, with estimated potential production of 100 kt/y for graphite and 3 000 t/y of mixed rare earth elements by 2030. These operations could be important anchor buyers for utilities and mini-grid developers, which could reduce the use of expensive diesel generation common in remote mining operations today.

The Energy Transition Plan lays the groundwork for Uganda's net zero ambitions

In the ETP, Uganda meets its Nationally Determined Contribution (NDC) to the Paris Agreement in 2030 and peaks energy-sector emissions around 2040. Energy-related greenhouse gas emissions reach just above 20 Mt CO_2-eq by 2030, in the range of Uganda's mitigation targets specified in its conditional

NDC, and peak at around 23 Mt CO_2-eq in 2040. In a scenario where Uganda did not take further action, energy-sector emissions would reach 30 Mt CO_2-eq in 2030 and would not be on course to peak even in 2050. Efforts on mitigating methane from oil operations and biomass use are essential to meeting this target. Continued efforts on efficiency and electrification via a largely decarbonised electricity sector contribute the most to the 2040 peak in energy-sector emissions.

Through the development of the ETP, Uganda has set a target to reach net zero emissions in the energy sector by 2065. Continued electrification delivers around 40% of the energy sector emissions reductions needed to reach net zero after Uganda peaks its emissions in 2040. The rest comes from switching to low-emissions fuels in heavy industry, aviation and road freight, as well as introducing CCUS. Global progress on commercialising such technologies and lowering their costs would support Uganda's adoption of these technologies, along with international climate financing and carbon credits.

Implementation requires greater domestic and international partnerships

Annual energy investment needs to increase to USD 8 billion by the end of this decade, with USD 850 million required annually by 2030 to reach universal access. Realising this sharp increase in investment requires concerted efforts to involve the private sector. Over the last decade, development finance institutions financed about 80% of Uganda's power investments, much of this through concessional funding, compared to a mere 10% from the private sector. Innovative financing models and additional concessional finance can help, alongside greater involvement from domestic institutions, including pension funds. Diversifying funding sources is critical to scale investment, better balance risks, reduce public financial strain and maintain affordable energy services.

Reinforcing Uganda's public institutions and the operating environment for the private sector is vital to realise the ETP. It is using the ETP as the basis for its new Integrated Energy Resource Master Plan. Delivering this requires greater investment in institutions, human capital, regulatory quality, and technological capacities. Uganda seeks to expand public-private partnerships to meet these goals. It also requires deeper regional co-operation and international partnerships. It is important to note that the ETP is a high-level strategy, not a blueprint, and like all plans, must be revisited periodically based on experience with implementation as well as broader technology advancements and market trends. Still, the ETP sets clear targets for domestic institutions and the international community to rally behind and represents a meaningful commitment by Uganda on climate ambition which other African countries can follow on their road toward greater sustainable energy development and prosperity.

Chapter 1: Setting the scene

1.1 Introduction

Uganda is one of the fastest growing economies in the world and has ambitious plans and goals for economic development. The country aims to become a modern and prosperous country, undergoing an economic transformation in the coming decades that will rely on building a stronger industrial engine to improve growth and living conditions for its citizens. Fulfilling these ambitions requires an unprecedented mobilisation of support to modernise and reinforce Uganda's institutions, engage citizens and business, and build new infrastructure for which these transformations will rely on.

Expanding and modernising Uganda's energy system is at the core of achieving these objectives, whether it be giving electricity to homes, schools and hospitals; supplying burgeoning industries with power and fuel; or enabling the transport of people and goods across the country and beyond. This energy must be affordable, reliable and secure if the country is to cultivate new industries and attract foreign investors. The transformation of the energy sector must also be sustainable to meet Uganda's climate commitments. Fortunately, the country is blessed with vast domestic renewable energy resources, in addition to its oil deposits. Harnessing a diverse mix of energy resources in a sustainable manner can help to improve the country's energy security, supporting Uganda's 2040 Vision. It would also enable Uganda to become an important energy keystone in the East Africa region, meeting rising demand for energy products and services in neighbouring countries. Moreover, it could help Uganda establish itself as a role model for climate conscious development in Africa, as well as an example for seizing opportunities and efficiently maximising resources for a clean energy future.

Realising the energy systems needed to deliver on Uganda's vision for economic transformation requires rigorous and detailed planning. This is why the Ministry of Energy and Mineral Development (MEMD) initiated work on an Energy Transition Plan (ETP), which would provide a strategic vision for its energy systems from now to 2050 in line with the country's objectives for economic development and raising living standards for all Ugandans. Developed in partnership with the International Energy Agency (IEA), the roadmap is based on best-in-class energy-system modelling to chart a realistic yet ambitious energy strategy. The ETP relies heavily on the IEA's comprehensive data and expert analysis on energy access of the African region. It also uses the IEA's Sustainable Africa Scenario as a reference point for its development.

The ETP recognises that Uganda's energy development does not take place in a vacuum. Worldwide, energy systems continue to evolve rapidly with the accelerated

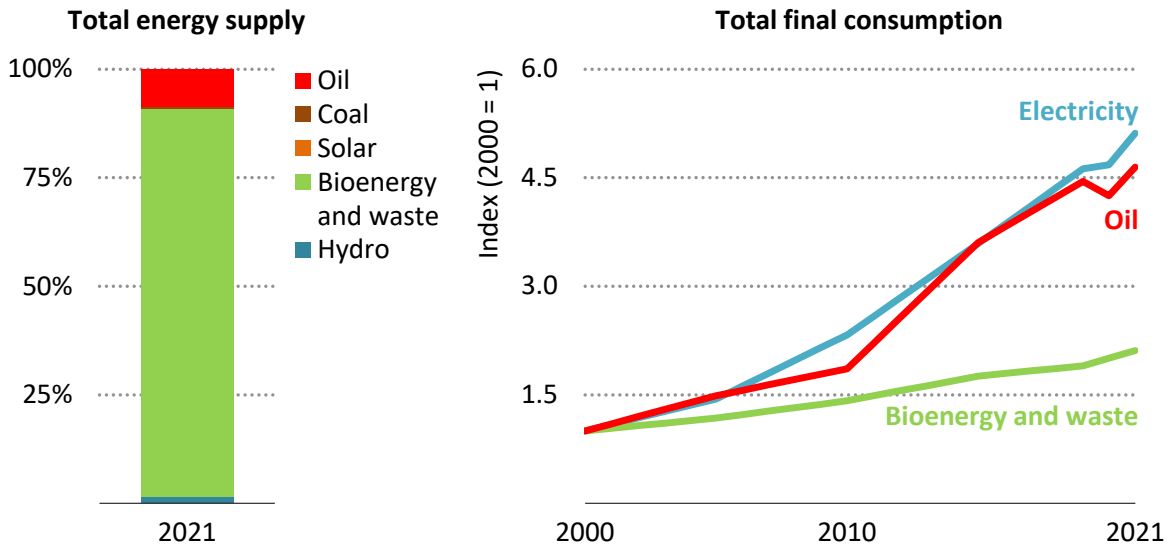
uptake of clean energy technologies in the wake of the global energy crisis, and acknowledges that peak demand for all three fossil fuels – coal, oil, and natural gas – are on the horizon. While these trends vary region by region, and each country has its own starting point, these global trends will shape clean technology costs and availability and inform energy investment as risk appetites change. Additionally, the ETP recognises the increasing importance of climate-related financial flows in Africa's energy sector and prioritises investments that the country could be eligible for from international and domestic financing institutions.

The roadmap takes stock of the challenges facing Uganda's energy sector and aims to remedy these issues in parallel to rapid growth. The IEA carried out an in-depth review of Uganda, which served as the starting point for the ETP, detailing the country's current energy system, policies and regulations in place and critical priorities. These issues were all considered, as were other high-level objectives, in the development of the ETP. This chapter gives a brief overview of the recent evolutions in Uganda's energy sector and the challenges it faces, then lays out the central aims of the ETP which guided the development of the scenario.

1.2 Uganda's energy systems today

Uganda's current energy system has seen a range of modernisation efforts in recent years but remains underdeveloped. Nearly 90% of Uganda's final energy consumption is still met by burning solid bioenergy, largely wood and charcoal. However, the use of modern fuels is ramping up, outpacing both economic and population growth.

Figure 1.1 Overview of Uganda's energy system by fuel and sector, 2000-2021

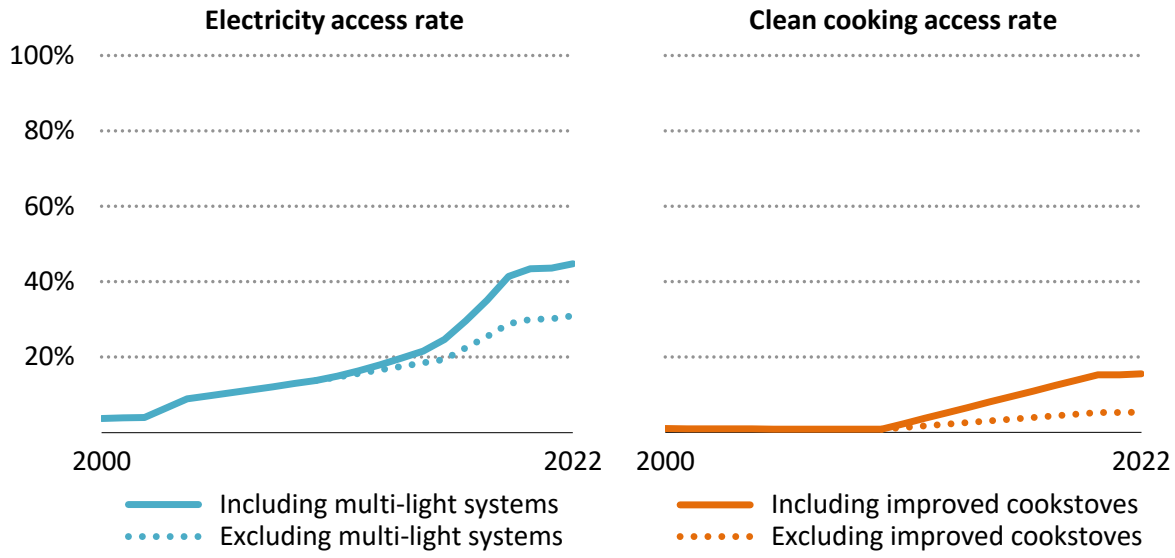


Bioenergy, mostly solid biomass, dominates energy supply and total final consumption, although electricity is starting to gain a foothold. Buildings are the primary demand sector.

From 2000 to 2021, Uganda had gross domestic product (GDP) and population annual growth rates of around 6% and 3%, respectively, both among the highest rates in the world. Over the same time period, the final consumption of modern energy grew by about 10% per year, though mainly in urban and peri-urban areas where new industries are emerging and 220 000 people are moving each year. As a result, over the last two decades the share of oil products has doubled, to just over 10%. Diesel and gasoline use in the transport sector dominates demand, but fuel oil is also consumed for power generation, both for the grid and industrial applications. Electricity still accounted for less than 2% of Uganda's energy demand in 2021, despite electricity consumption growing more than fivefold over the last 20 years.

Progress on electricity access has led to some of these changes, but large gaps remain. Access rates climbed from less than 5% in 2000 to roughly 45% in 2022.

Figure 1.2 Electricity and clean cooking access in Uganda, 2000-2022



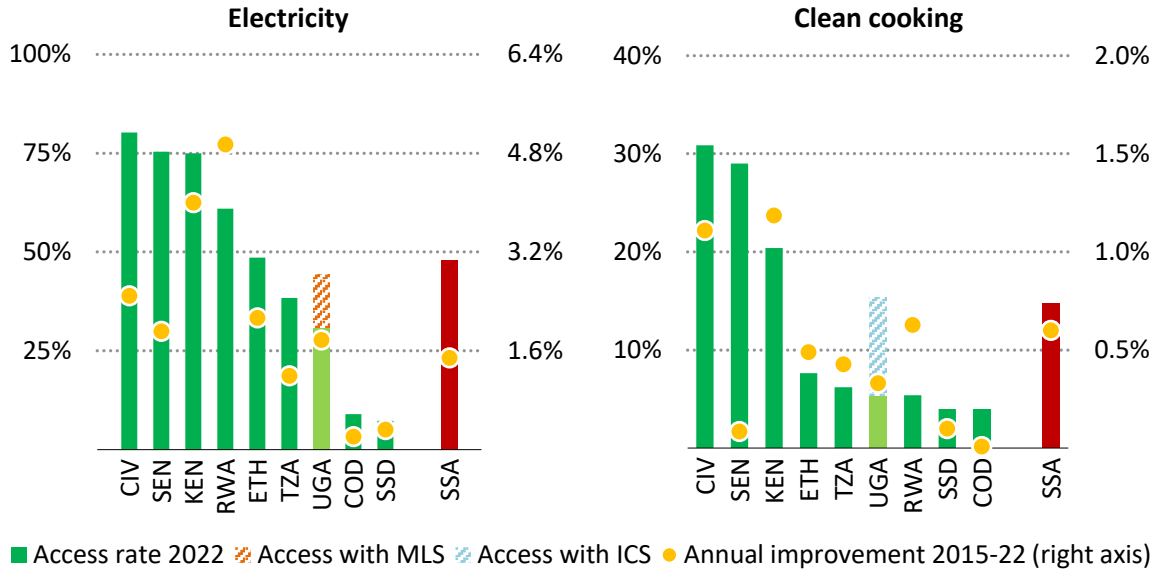
Electricity and clean cooking access rates have improved over the last two decades, but remain low, with many households relying on transitional access solutions.

Notes: The IEA defines access at a basic minimum level of services, which includes more than one light, phone charging and a radio, broadly equivalent to a range of 50-75 kWh per household per year. This definition would typically include solar home systems (SHSs) of 10 Wp and above but would exclude solar lanterns and off-grid solar multi-light systems (MLS). However, MLS are considered in Uganda's reported access rates and are considered within the context of reaching SDG7. Similarly, for clean cooking, access is defined as any stove using clean fuels, including LPG, electric cooking, ethanol, biogas and improved biomass cookstoves of ISO Tier > 3. Official SDG7 indicators exclude all solid biofuels (wood, charcoal, etc.) from access due to gaps in data gathering on improved biomass cookstoves. Uganda's MEMD has data available on improved cookstoves that is used in the clean cooking access rate, however the tiers of these stoves cannot be verified, but are largely from programmes where qualified improved biomass cookstoves (ICS) were being used.

Despite this fast progress, access rates are still below the average in sub-Saharan Africa. Nonetheless, Uganda has seen faster improvements than the sub-Saharan Africa region on electricity access in the last seven years thanks to recent government policies and programmes, such as the Rural Electrification Strategy and Plan and Electricity Connections Policy, that leverage both grid and off-grid solutions. In

particular, the rapid expansion of smaller, solar multi-light systems (MLS) have helped with this acceleration, which provide lighting and sometimes limited phone charging to around 14% of Ugandan homes. Electricity access remains particularly limited in rural areas, where nearly three-quarters of Ugandans live. This also hinders the modernisation of subsistence rural farming, including the adoption of irrigation pumps and other farming equipment.

Figure 1.3 Electricity and clean cooking access rates in Uganda, 2022



Uganda's electricity and clean cooking access rates are below the average for sub-Saharan Africa, but annual improvements in electricity access are higher than the region average.

Notes: For comparison purposes, access rates are shown according to the IEA definitions (for access to electricity this excludes MLS and for historic access to clean cooking this excludes ICS). CIV = Côte d'Ivoire; COD = Democratic Republic of the Congo; ETH = Ethiopia; KEN = Kenya; RWA = Rwanda; SEN = Senegal; SSA = sub-Saharan Africa; SSD = South Sudan; TZA = Tanzania; UGA = Uganda.

Sources: IEA analysis based on data from the IEA SDG7 database (2023) and Uganda Bureau of Statistics.

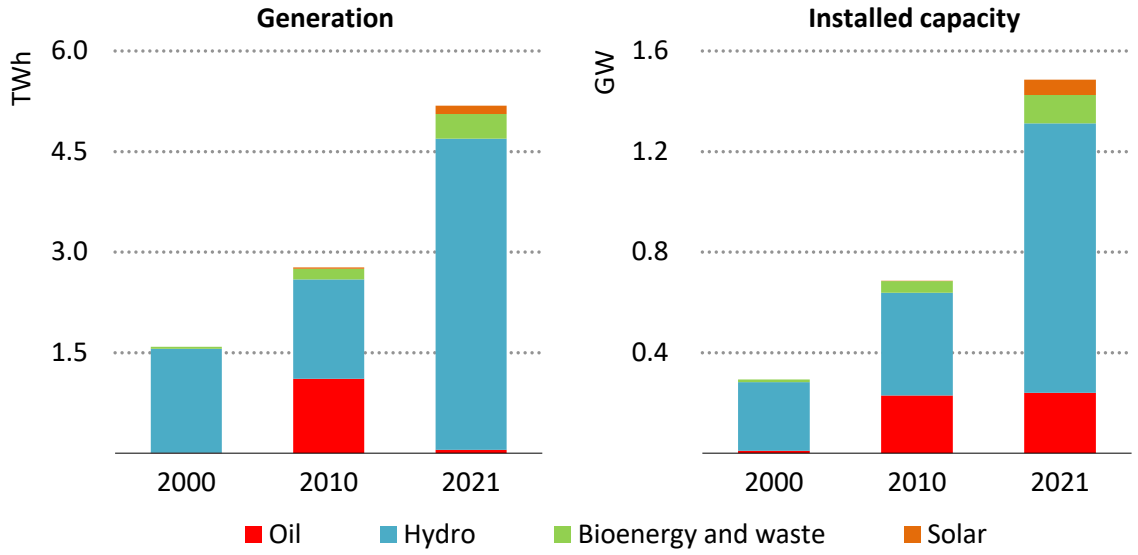
Progress on access to clean cooking has also picked up in response to recent programmes, but still remains around 15%. Only 5% of users rely on liquified petroleum gas (LPG) or electricity, largely in urban centres, while the other 10% have access to improved biomass cookstoves (ICS), which burn biomass more efficiently, delivering some of the health and time-saving benefits of clean cooking. Commercial buildings and industries also rely on solid biomass for most of their energy needs, although some are modernising quickly. Solid biomass satisfies more than 80% of demand in the industry sector, with firewood consumption within the brickmaking segment accounting for the largest share. However, a growing use of agriculture residues such as bagasse – a by-product from the sugar industry – is meeting a rising share of bioenergy used in the industry. In the services sector, solid biomass accounts for nearly 95% of demand, primarily for cooking and water heating in public buildings such as schools and restaurants.

Growing demand for oil is adding to higher import bills, placing new emphasis on managing growth. Oil demand is largely coming from the transport sector. Since 2010, Uganda has experienced a 2.5-fold surge in oil consumption, driven by an increasing number of vehicles on the road. Roughly 95% of the country's freight and passenger transportation occurs by road, with no operating train infrastructure in place, and minimal shipping operations on inland rivers and Lake Victoria. Freight trucking is the major energy consumer in the transport sector, accounting for about 45% of consumption. However, passenger road transport demand is the fastest rising segment, from around 10% in 2010 to nearly one-third in 2021, reflecting a tripling of vehicle stocks over the same period, especially within the two- and three-wheeler segment. Public transport, largely buses and many informal services, make up nearly 20% of transportation energy consumption. The combined energy use of domestic aviation, rail and marine transportation is just above 5%. Uganda still imports all of its finished oil products. However, plans for the country’s first refinery are underway, which will process new oil production coming online in 2025. This will alleviate Uganda’s net import bill and could help meet growing demand in the region for refined products.

There has also been a noticeable uptick in coal consumption in the cement and steel industries in the last five years, with specific requirements for high heat and coal as a coking reagent. Much of this has displaced the use of more expensive heavy fuel oil and solid biomass which faces annual fluctuations in availability. Coal and heavy fuel oil are both imported, contributing to costs. However, future plans to import natural gas from Tanzania will encourage some industries to switch to gas, which would help reduce emissions.

Electricity demand has been steadily growing, putting a strong focus on ramping up the expansion of the country’s power sector. The vast majority of Uganda’s electricity needs are met by low-emissions sources, largely hydroelectric generation. Since 2000, several major hydroelectric dams have come online, which has helped raise total generation capacity from 290 MW to nearly 1 350 MW. Uganda currently generates more electricity than it consumes from its hydropower, and exports around 8% of its total generation to its neighbours. Most of these facilities are run-of-river hydropower plants, except for the 200 MW Kiira plant and the 180 MW Nalubaale plant at the outflow of Lake Victoria. Consequently, output is not always sufficiently available, while surplus electricity output often cannot be used or exported. Oil-powered thermal power plants have been added to help meet the gap in supply. However, additional hydropower capacity and improved dispatch have helped to cut their share in the power generation mix from 40% in 2010 to 1% today. Bagasse and other agricultural wastes are widely used in combined heat and power (CHP) systems at auto production plants in Uganda, accounting for around 7% of electricity supply.

Figure 1.4 Power generation and installed capacity in Uganda, 2000-2021

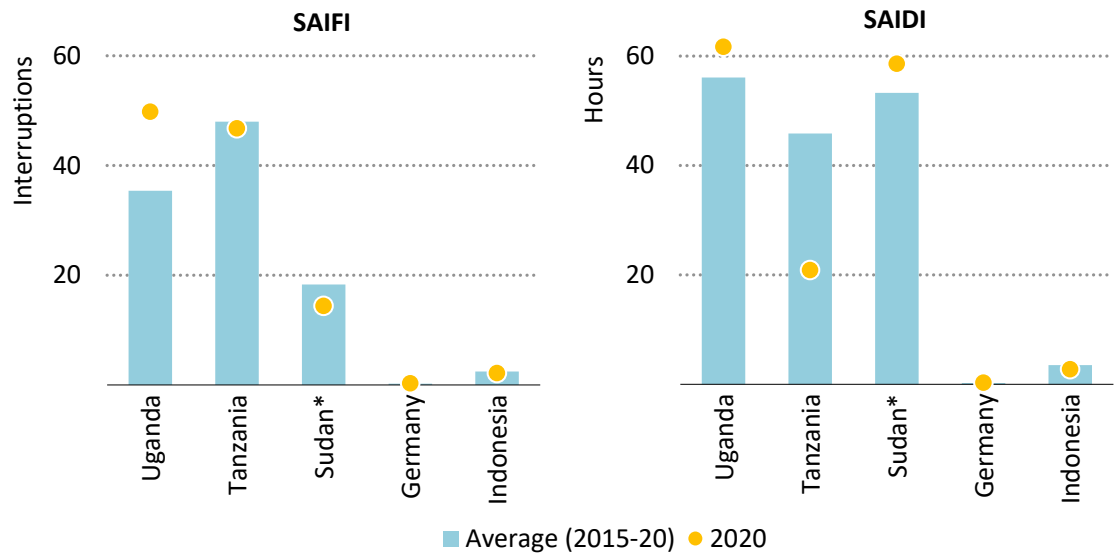


Hydropower has dominated capacity additions in the last decade, enabling a significant reduction in dependence on oil-powered thermal power plants.

Still, low electricity reliability plagues Uganda's energy sector, leading to a high prevalence of diesel generators at critical facilities and in buildings. This is not due to a shortage of generation capacity, but rather a lack of investment in grid infrastructure, low visibility at the grid edge, and challenges with generator dispatch matching demand. In 2020, the average customer experienced over 60 hours of unplanned outages and almost 50 non-momentary interruptions every year, which is above the regional average and well above levels of disruption seen in other emerging economy and developing countries. For example, in Indonesia there are on average 2.8 hours of unplanned outages and around two unplanned interruptions per year. Addressing this reliability barrier will be essential to attract new industries, ensure the power sectors' economic viability and encourage higher reliance on electrification in the future.

Recent progress has been shepherded by a number of new policies to modernise and expand the country's energy infrastructure. In 2002, the government released its first Energy Policy for Uganda, with the goal to "meet the energy needs of Uganda's population for social and economic development in an environmentally sustainable manner" and to modernise the energy system. The policy was revised in 2023 and complements several sub-sectoral policies that were already in place, including the Renewable Energy Policy (2007), the National Oil and Gas Policy (2008, and currently under review), and the Electricity Connections Policy (2018). The ETP takes cues from these policies, considers new ambitions from the Ugandan government, and casts its gaze into the future to 2050. The goal of the ETP is to ameliorate many of the current challenges of the energy system, while also focusing on the affordability, security and sustainability of the sector.

Figure 1.5 System Average Interruption Frequency Index (SAIFI) and Annual System Average Interruption Duration Index (SAIDI) for Uganda and selected other countries, 2015-2020



In recent years, Uganda's electricity grid has had a low reliability compared to other countries in sub-Saharan Africa and the world.

*Sudan = 2019 data (2020 data not available).
Source: IEA analysis based on data from the World Bank.

1.3 Guiding principles of the Energy Transition Plan

A number of different economic and energy goal posts were considered in the development of the ETP. Some of these were pre-existing targets, others new, and in some cases supplant previous ones, reflecting shifting trends and priorities. While many detailed priorities were explored, these have been distilled into five guiding goals that inform the design of the ETP scenario. The five goals are universal access by 2030; modernising and growing the energy systems to support economic growth; improving energy security and affordability; mitigating energy-sector greenhouse gas emissions; and positioning Uganda as a regional energy hub. These goals were reaffirmed in the 2023 National Energy Policy. The following section provides an overview and pathway for these targets, and how they were implemented into the ETP design.

Achieve universal energy access in line with SDG7

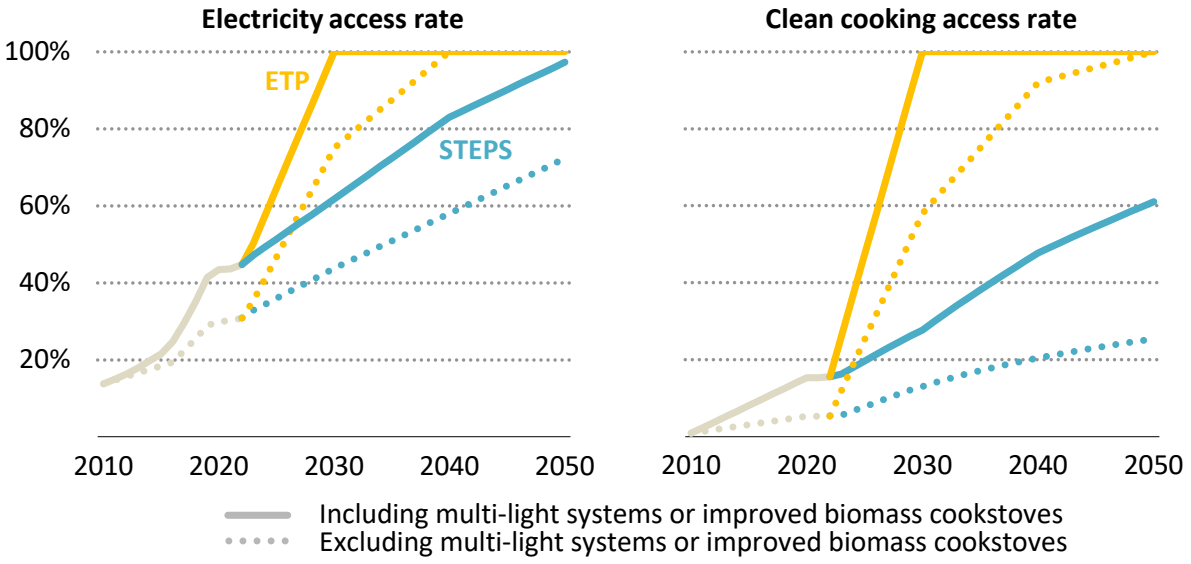
With the ETP, Uganda sets a more ambitious goal for universal energy access, bringing previous targets for electricity and clean cooking access forward by decades. The new ambition is also fully aligned with Sustainable Development Goal 7 (SDG7)

and aims to be realistic while recognising that many users would still only be able to afford low levels of electricity services and would rely on transitional solutions, such as improved biomass cookstoves (ICS), for cooking.

Accordingly, the ETP's first priority is to reach every household with energy access by 2030. More robust connections and modern cooking fuels are prioritised where possible, but smaller, transitional and affordable solutions that can deliver immediate benefits by 2030 are deployed where needed. Beyond 2030, the objective is to continue to provide higher levels of access to facilitate the replacement of transitional solutions so that by 2040 everyone has access to at least the IEA's basic bundle for electricity and to ISO Tier 4 stoves for clean cooking. Chapter 2 details a pathway to universal access for electricity and clean cooking, highlighting a number of considerations and measures needed to achieve these twin goals.

Uganda's policy and financing environment is helping accelerate progress, but remains insufficient to reach this ambition. Under the IEA's Stated Policies Scenario (STEPS), which reflects current policy settings, electricity access rates reach 60% (of which 18% with MLS) and clean cooking access rises to 28% (of which half with ICS) by 2030. Despite these important improvements, 22 million people still have no access to electricity and 42 million to clean cooking by 2030 in the scenario, with household affordability, availability of finance and distribution infrastructure remaining significant barriers to development.

Figure 1.6 Electricity and clean cooking access rates in the Energy Transition Plan and Stated Policies Scenario, 2010-2050



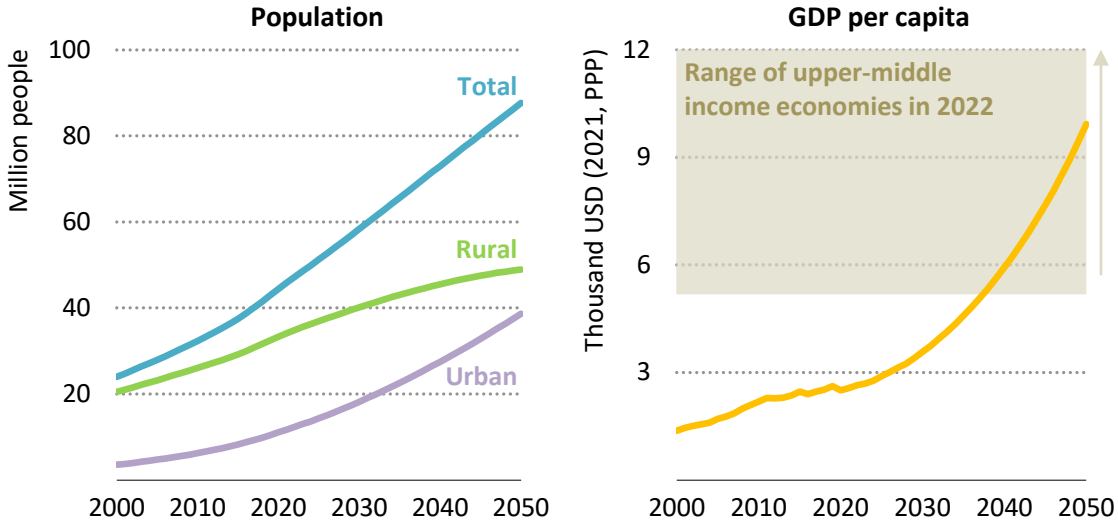
The ETP reaches universal access to at least transitional sources such as MLS by 2030. Efforts continue to provide all households with a basic bundle of electricity services by 2040.

Sources: IEA analysis based on data from the IEA SDG7 database and Uganda Bureau of Statistics.

Modernise the energy system to support economic growth

Uganda's growth is forecast to move apace, underpinning the urgency of the ETP. Population growth trends are projected to continue over the next several decades, almost doubling to 88 million in 2050. Urbanisation will increase the share of towns and cities inhabitants to almost 45% by mid-century, up from around 25% today. Over the same period, economic growth is expect to increase sevenfold, putting Uganda's GDP per capita on track to reach the status of a middle-income economy by 2040. These projections are consistent with the International Monetary Fund's (IMF) near-term projections, and broadly seen as realistic assumptions for the country's growth. Also underpinning this expansion is a shift in the composition of Uganda's economy, increasingly moving to heavy-industry, manufacturing and the services sectors, and away from agriculture.

Figure 1.7 GDP and population growth in Uganda, 2000-2050



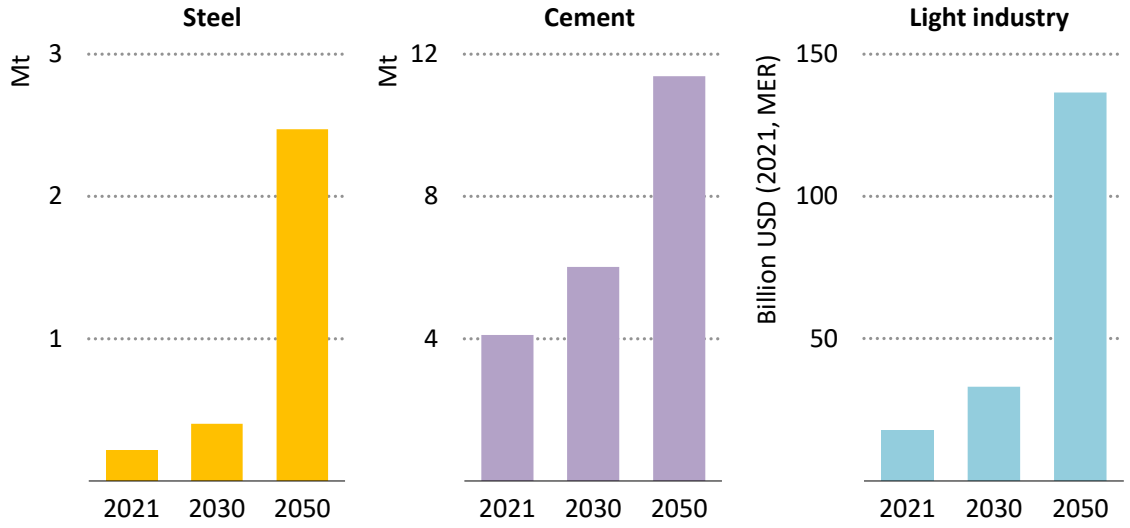
Total GDP and GDP per capita are expected to grow swiftly, positioning Uganda as an upper-middle-income economy by 2040.

Note: PPP = purchasing power parity.
Sources: IEA analysis based on data from the IMF's Datamapper and the World Bank's Databank.

Similarly, economic growth in the coming decades will be accompanied by remarkable increases in industrial production. A construction boom spurred by rising urbanisation rates and new industries will drive steel and cement production to 2030. Yearly production of steel is expected to almost double by 2030 while cement manufacturing is set to grow by more than 30%. Light industry's value-added almost doubles to 2030. The country is also making renewed efforts to use its endowment of critical minerals, with new graphite and rare earth projects in Orom-Cross and Makuutu mines planned to come online in the coming year. At the same time, plans to start up oil production from the Lake Albert Tilenga and Kingfisher oil fields will see the country become an exporter of crude oil in the second half of this decade.

Uganda's energy systems must be developed in lockstep with these emerging industries, with many of them having specific energy requirements. Supporting these industries while providing higher levels of energy services to a growing population is the core driver of energy trends in the ETP.

Figure 1.8 Assumed annual production rates for steel, cement and light industry in the Energy Transition Plan, 2021-2050



Expansion of Uganda's industrial production sees a remarkable increase in products such as steel, cement and critical minerals.

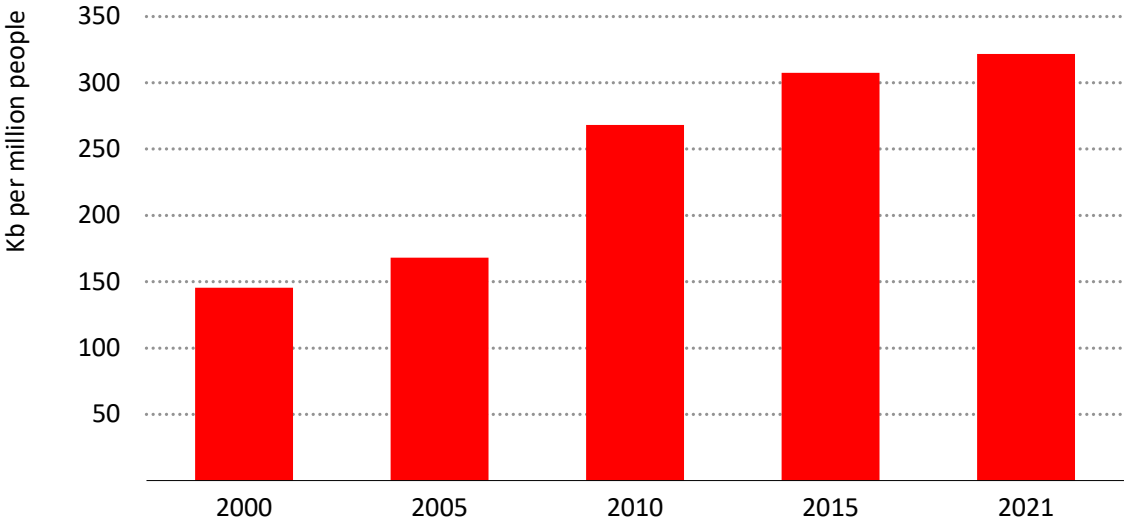
Note: MER = market exchange rate.

Improve energy security and affordability

Improving energy security and affordability are key priorities for the government. All oil products sold today in Uganda are imported. This dependence has increased over the past two decades, with per capita imports rising consistently from 145 thousand barrels (kb) per million people in 2000, to around 320 kb per million people in 2021, with a notable annual rise in LPG (9%) followed by diesel oil (5%) and gasoline (5%). Domestic consumption in 2021 consisted of approximately 18 kb/d each of petrol and diesel, which combined accounted for almost all imported oil products. Smaller quantities of jet fuel, kerosene, and an even smaller amount of LPG (which accounts for around 1% of total product imports) were also consumed.

The ETP allows for a gradual cut in product imports and a switch to using domestic or regionally sourced supplies when possible. Construction of the Hoima refinery has long been a goal of the government, both to add value along the petroleum supply chain and to reduce reliance on imported oil products. Tenders for the refinery project are currently underway. Security of supply is a particular concern of the government since Uganda is landlocked and must rely on imports via Kenya and Tanzania. The ETP also looks to enhance efficiency and electrification to avoid rising import needs, as well as taking steps to diversify its energy mix to limit reliance on any single source of energy.

Figure 1.9 Oil imports per capita in Uganda, 2000-2021



Oil imports per capita have continuously increased over the past two decades, highlighting a rising dependency on oil, gasoline, and other oil products.

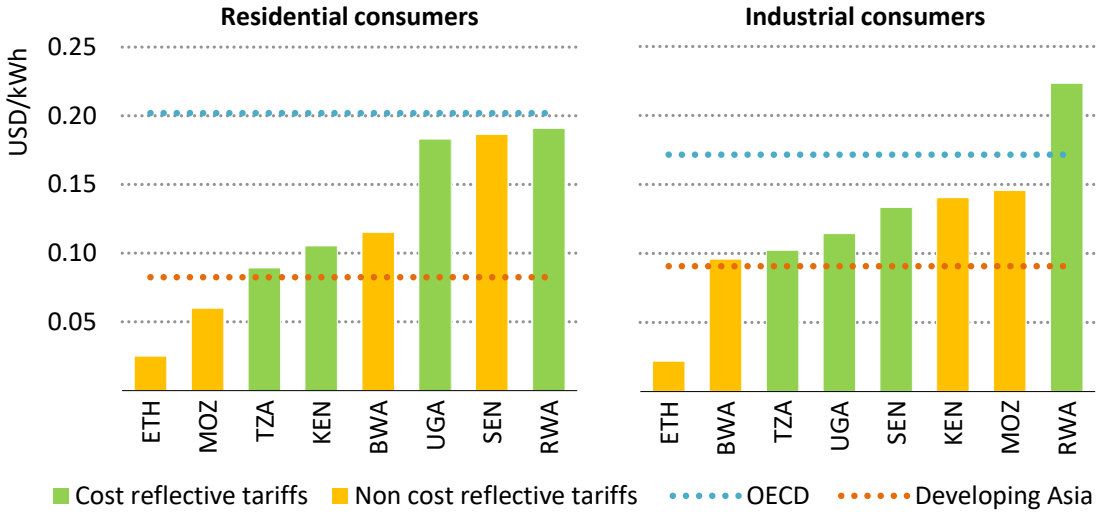
Affordability is another key concern for the ETP. Uganda has some of the highest electricity prices in the East African region, which has had a substantial impact on residential consumers. Uganda does not have fossil fuel subsidies in place today, and has cost-reflective tariffs, which means the prices paid by consumers are the full costs, and that discounted prices are not eventually borne by consumers through other taxes elsewhere. Subsidies also create billowing debt within energy firms. Uganda's no subsidies policy is promising for a sector aiming to grow rapidly in the coming years, and especially as it works to attract potential international partners and investors.

Still, elevated energy use can create headwinds for industries as well as small and medium-sized enterprises (SMEs) given that energy expenses often comprise a significant portion of their operational costs. However, Uganda's industrial electricity prices are largely competitive globally, lower than the advanced economy average and nearing the level seen in developing Asia. Electricity prices are however high for residential consumers, nearing the average for advanced economies, which creates difficulties towards extending electricity access beyond the 15 kWh per month upper limit of the social tariffs due to affordability challenges. The underlying reasons for these elevated prices include significant capital outlays for hydroelectric projects, inefficiencies in the ageing power distribution system, reliance on costly backup diesel generators, and regulatory challenges. Other fuels used, like diesel, gasoline and LPG, also carry relatively high end-user prices, owing in part to increased costs associated with imports and inland transport.

Cost management is a key strategy in the ETP in order to keep prices in check for consumers. The ETP uses a least-cost approach when modelling what fuels consumers choose and which power sector assets are built. Additionally, the ETP considers targeted measures to provide affordability support, particularly to poorer

households. It focusses on reducing or eliminating operational inefficiencies, including generation losses, curtailments, and heavy use of diesel generators, to compensate for low reliability, all of which result in higher effective costs for energy and hinder development.

Figure 1.10 Residential and industrial average electricity prices in Uganda, 2021



Uganda has high residential electricity prices compared to other countries in the region.

Note: BWA = Botswana; ETH = Ethiopia; KEN = Kenya; MOZ = Mozambique; RWA = Rwanda; SEN = Senegal; TZA = Tanzania; UGA = Uganda. OECD = Organisation for Economic Co-operation and Development.

Mitigate emissions from the energy sector

Meeting Uganda's existing climate and energy security goals requires keeping an eye toward managing emissions growth. As a signatory of the Paris Agreement on climate change, Uganda has committed to implement policies to curb emissions growth and meet its Nationally Determined Contribution (NDC). At the same time, the country needs to significantly expand energy access, infrastructure and demand to unlock economic growth development. To balance these two goals, the ETP prioritises approaches which curb emissions growth without negatively impacting development, while creating opportunities for attracting international climate finance.

In 2021, Uganda emitted roughly 115 Mt CO_2-eq of greenhouse gas (GHG) emissions, of which the bulk are from agriculture, forestry, and other land use. Only around 20 Mt CO_2-eq of emissions come from the energy sector, which includes transport, buildings and industry. Uganda's updated NDC, submitted in 2022, outlines that baseline energy sector emissions (combustion and process) for all GHGs could double by 2030. The conditional emissions target, which is dependent on financial support from the international community, is 17.8 Mt CO_2-eq, a decrease of 23% compared to the baseline scenario. Uganda's conditional NDC is met in the ETP, and beyond 2030 further action is pursued to mitigate emissions towards a peak in 2040, leveraging international progress on low-emission technologies. The ETP also recognises the importance of climate action in attracting needed international financial support, and therefore puts it as a top priority.

Position Uganda as a regional energy hub

Finally, Uganda recognises its energy resources and strategic location in the East Africa region means that its energy sector development could support rising demand in neighbouring countries. This includes its build out of its electricity sector, exports of oil products from the refinery, including LPG production for clean cooking, and possibly critical minerals for other countries that have operations and demand for them. Accordingly, steps are taken in the ETP to position Uganda to play a larger role in the region's energy systems, however it remains focused exclusively on meeting domestic demand.

1.4 Scenario descriptions

As the name of the report suggests, the Energy Transition Plan explores a scenario in which energy systems evolve along with the country's growth assumptions and priorities. However, one additional scenario and two alternative cases are also explored as points of comparison throughout the report. Brief descriptions for each scenario follow below, all of which rely on the same underlying population, GDP and industrial drivers. Both cases are a variant of the main ETP scenario, exploring key sensitivities and decision points within the framework.

Energy Transition Plan

The **Energy Transition Plan (ETP)** represents Uganda's proposed pathway to achieve its five key objectives for energy development, described in the preceding section. This scenario is largely aligned with the outcomes of the IEA's Africa Energy Outlook 2022 Sustainable Africa Scenario, which assumes the rest of the globe is on a trajectory consistent with the Announced Pledges Scenario from the World Energy Outlook 2023.

Two cases are explored as variants of the ETP:

The **Regional Energy Hub Case (REHC):** This sensitivity case explores what additional measures Uganda could put in place to support much faster growth in electricity generation capacity, including increasing exports, accelerating domestic electrification efforts, raising industrial output, and adopting climate mitigation measures like carbon capture, utilisation and storage (CCUS) and electrolytic hydrogen, all of which are electricity intensive.

The **No Nuclear Case (NNC):** This case explores an alternative power generation mix and capacity additions to meet electricity demand in the ETP under a scenario where Uganda's approvals and development of its nuclear facilities do not materialise on time.

Stated Policies Scenario

The Stated Policies Scenario (STEPS) reflects Uganda's pathway under today's polices. It builds on all policies with concrete implementation measures captured in the Uganda Energy Policy Review and reflects how energy systems would evolve if no additional policy measures were taken. This scenario is consistent with the IEA's Stated Policies Scenario at the global level in the World Energy Outlook.

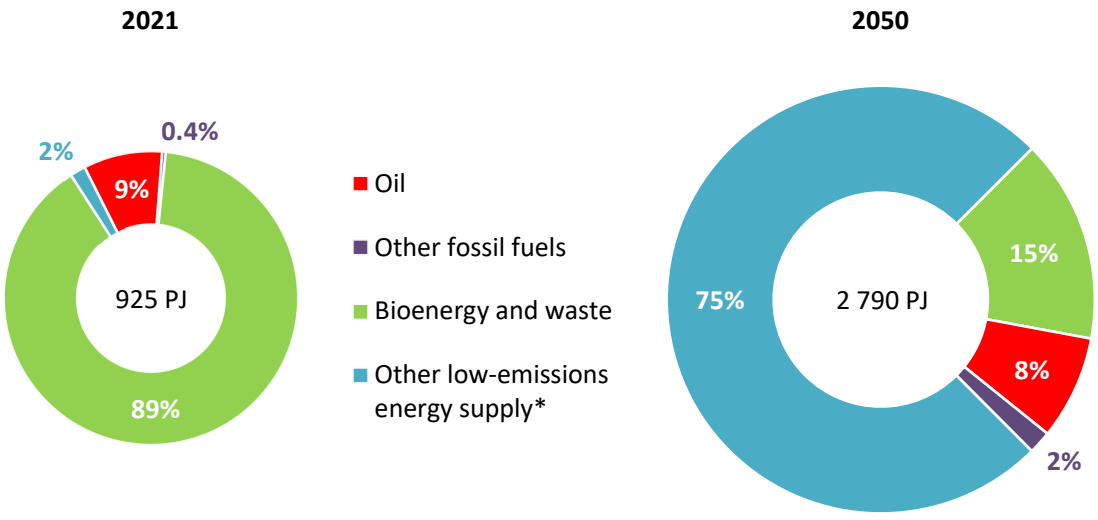
Chapter 2: Uganda's Energy Transition Plan

2.1 Overview

Uganda's expansive development agenda holds the promise that its future energy system will look very different from today, with universal access to electricity and to clean cooking achieved by 2030, a key benchmark in its transition plan. Spurred by economic transformation, industrialisation and modernisation, the nation's primary energy demand increases threefold by 2050, enabling a measurable rise in living standards for all Ugandans and growth of the nation's economy.

Concurrent with this growth is a concerted effort to reduce the use of solid biomass – almost 90% of current final energy consumption – to modern energy. By 2030, transitioning households and the services sector to cleaner forms of cooking and water heating, and the industry sector to more efficient and modern fuels, drastically reduces the use of solid biomass. By 2050, all remaining bioenergy is in the form of liquid biofuels, biogases, recovered solid bio-waste, and sustainably harvested and processed solid biomass.

Figure 2.1 Share of total energy supply by fuel in the Energy Transition Plan, 2021-2050



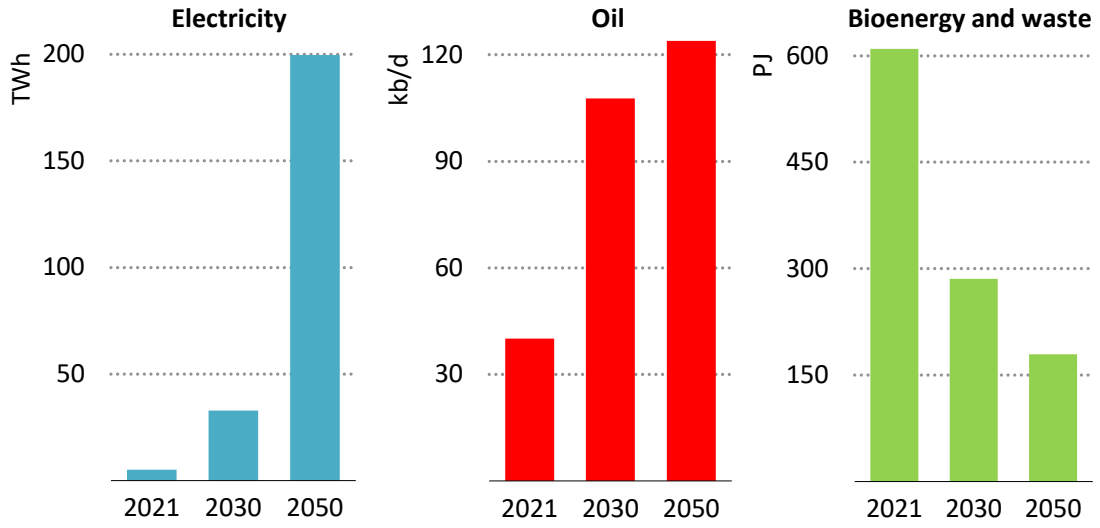
Uganda modernises its energy supply while meeting growing demand, pivoting from bioenergy as the primary source of energy supply to low-emissions power inputs in 2050.

*Includes solar, wind, geothermal, hydro and nuclear.
Note: PJ = petajoules.

Simultaneously converting to modern sources of energy while meeting rising demand implies a steep ramp up in electricity, and to a lesser extent oil. Electricity demand grows faster than any fuel in the Energy Transition Plan (ETP), with generation accelerating from 5 TWh today to 200 TWh in 2050, substituting for biomass use and providing 56% of total final consumption by the end of the period. Oil demand also grows, largely in buildings and in the transport sector, where liquefied petroleum gas (LPG) plays a critical role in achieving universal access to clean cooking. Uganda's domestic oil reserves will help supply this growing demand.

Uganda also harnesses its abundant renewable energy resources – which include solar, geothermal, hydro, modern bioenergy and wind – to supply its domestic electricity system in a low-emissions manner. These rich renewable sources will enable a decoupling of greenhouse gas (GHG) emissions and energy production in line with its climate commitments. Coal, which has seen a recent surge for use in industry and is all imported, is replaced where possible by natural gas, largely from Tanzania. This helps reduce emissions while enabling heavy industries like steel and cement to grow. These two fuels, however, remain a marginal part of the energy mix, making up less than 2% of Uganda's energy demand in 2050.

Figure 2.2 Energy demand by fuel in the Energy Transition Plan, 2021-2050

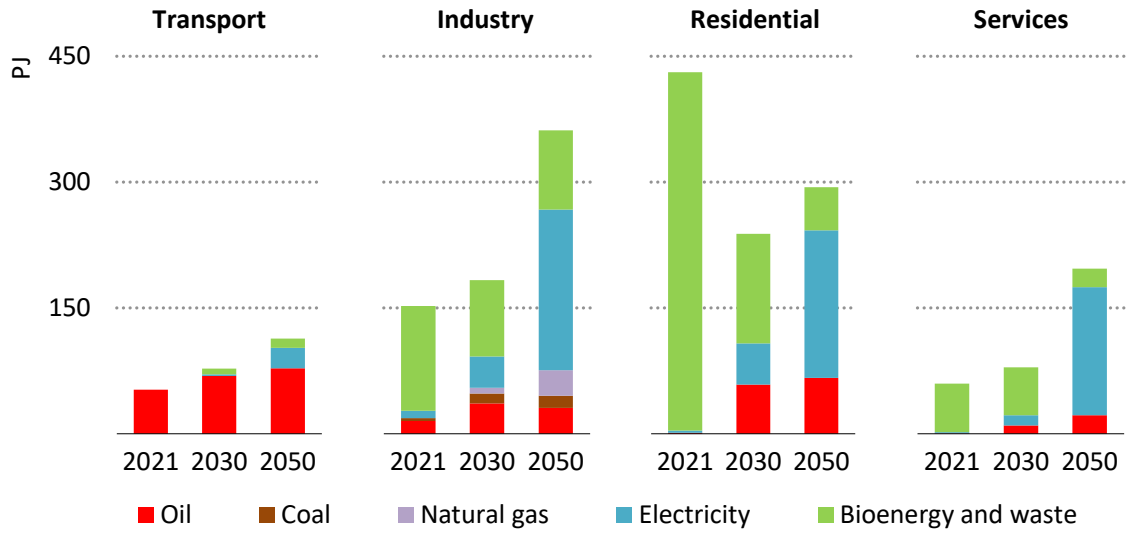


Electrification of all sectors drives electricity supply up 40 times. Demand for LPG and other oil products grows threefold to 2050. Only modern bioenergy is used by 2050.

Across all sectors, the ETP sees rising demand for modern energy. Industry sector demand more than doubles by 2050, accounting for nearly 40% of the country's final energy demand compared with just over 20% in 2021. More than three-quarters of this growth is driven by electrification, predominantly in light industries where electrified end-use technologies are well developed and cost effective.

In addition, several major industries take off in the coming decades, notably steel, cement, oil refining and critical mineral mining. Each industry has unique energy demand profiles, which are reflected in the ETP. Of note is the need for high temperature heat in steel and cement production, which means that fossil fuels are still required for some applications to remain cost competitive. However, overall efforts to prioritise lower-emissions options prevail in the ETP.

Figure 2.3 Total final consumption by sector and by fuel in the Energy Transition Plan, 2021-2050



Total final energy consumption grows in all sectors except residential, led by economic growth, industrialisation and improved living standards.

Clean cooking transforms the composition of energy demand in the residential sector. Behind a pivot away from solid biomass for cooking, modern energy demand rises consistently to 2050 as increases in incomes, living standards, and appliances ownership mean households access higher energy services. The adoption of cleaner stoves and fuels eliminates the use of traditional biomass, typically in the form of wood or charcoal, by 2030. Electricity replaces bioenergy as the major energy source in households by 2040. Oil products, largely LPG for cooking, rounds out the residential demand.

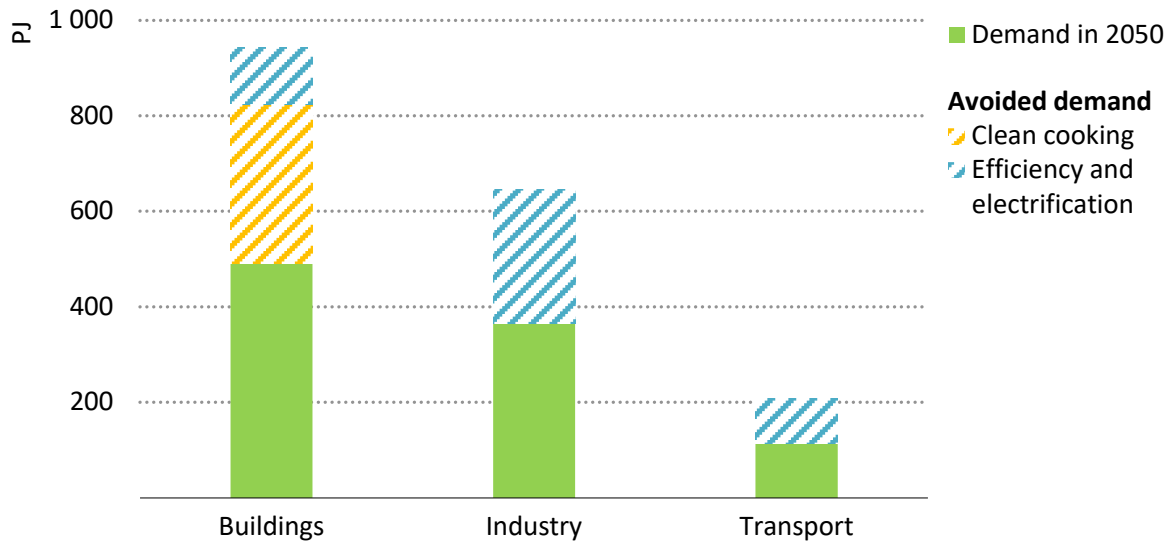
The services sector sees a similar transformation, as commercial floorspace doubles to 2050, in the form of stores, restaurants, offices, hospitals, schools and other buildings. Electricity provides nearly all of the demand growth in this sector; the replacement of biomass in cooking, water heating and other applications with modern fuels, such as LPG, accounts for the remainder.

Transport energy demand doubles by 2050, driven by both increased vehicle ownership and a rise in freight activity. The sector continues to rely predominately on oil products, meeting about 70% of demand in 2050. However, electrification

and biofuel blending start playing an important role, with electricity accounting for 40% of energy demand growth in the transport sector. Road passenger vehicles, including buses, and rail lead the charge on electrification, with these technologies becoming increasingly prominent globally, and with falling costs. Other medium- and heavy-duty vehicles, such as freight trucks, which are more difficult and costly to electrify, continue to rely largely on oil products, but global efforts to make these vehicles more efficient and lower-emissions begin to take effect in the 2040s.

The ETP places a strong emphasis on energy efficiency across all sectors to reduce costs and manage supply-side burdens. The Energy Efficiency and Conservation Bill, which is currently being developed in tandem with the ETP and the Integrated Energy and Resources Master Plan, represents a significant step forward in formalising energy efficiency policymaking, regulation and enforcement. It is expected to catalyse significant reductions in energy consumption across various sectors by instituting mandatory minimum energy performance standards (MEPS) for buildings and appliances, and by promoting clean cooking methods.

Figure 2.4 Avoided and realised total final consumption in the Energy Transition Plan, 2050



Efficiency measures such as minimum energy performance standards for buildings, electrification and other initiatives curb demand growth.

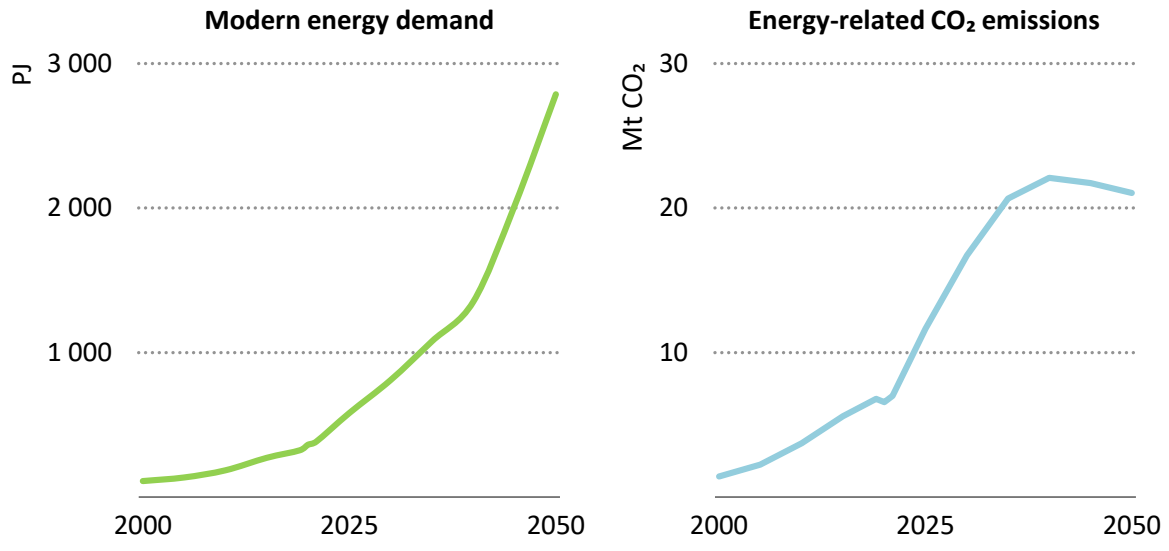
Source: IEA analysis based on data from the Uganda 2023 Energy Policy Review.

In the buildings sector, energy demand would be nearly double in 2050 without the switch away from traditional biomass to efficient cooking technologies, which accounts for three-quarters of the savings, with the remainder coming from appliance standards and other efficiency measures. In the industrial sector, electrification and improved efficiency of manufacturing processes cut energy

consumption by nearly half in 2050, with efficient electric motors, pumps, compressors, and electric process heating making up the largest areas for savings. The rollout of electric vehicles that are two to four times more efficient than current internal combustion engine vehicles, as well as import bans for inefficient vehicles and fuel economy standards, similarly avoid around 45% of demand in 2050.

The ETP balances this economic development with the need to curb the growth of energy-related greenhouse gas emissions to achieve international climate pledges. The rise in energy demand catalysed by the modernisation and expansion of Uganda's economy is initially matched by a steep growth in energy sector CO_2 emissions, which are more than two times higher in 2030 compared to 2021 levels. Improvements in efficiency, electrification and rising shares of renewables mean that economic growth and fossil fuel use eventually decouple, improving the emissions intensity of the energy mix from 2030 to 2050 by an annual average of almost 5%. Accordingly, CO_2 emissions peak around 2040, a key milestone in Uganda's Energy Transition Plan. After peaking, emissions begin to decline gradually, but with additional efforts, Uganda would be able to reach net zero emissions in the energy sector by around 2065, which is a new target emerging from this analysis. This level of ambition is consistent with the vision presented in IEA's Africa Energy Outlook 2022, and can be reinforced by growing clean energy supply chains, falling costs and rising levels of climate financing.

Figure 2.5 Modern energy demand and energy-related CO_2 emissions in the Energy Transition Plan, 2000-2050



Emissions grow less rapidly than modern energy supply, indicating a decoupling between energy use and emissions driven by the rise of clean energy.

Note: Energy-related CO_2 emissions include direct CO_2 emissions from fuel combustion and from industrial processes.

The following sections go into greater detail, sector by sector, on the findings of the ETP, detailing the major drivers and policy measures needed to realise Uganda's vision for energy development.

2.2 Energy access

Uganda has set a clear objective with the ETP to reach universal access to electricity and clean cooking by 2030 in line with SDG7 of ensuring access to affordable, reliable, sustainable and modern energy for all. This requires Uganda to accelerate from relatively low levels of access today – around 45% for electricity and 15% for clean cooking. As detailed earlier, this means the ETP prioritises readily scalable solutions that will be affordable for the wide number of Ugandans.

These solutions, though an initial stepping stone, provide urgently needed improvements to health, gender-equality, productivity, quality of life and GHG emissions reductions, and are rapidly deployed to 2030 to fulfil the SDG7.1 target on energy access. Subsequently, more robust access solutions are conferred to these households as incomes rise and families climb the energy development ladder.

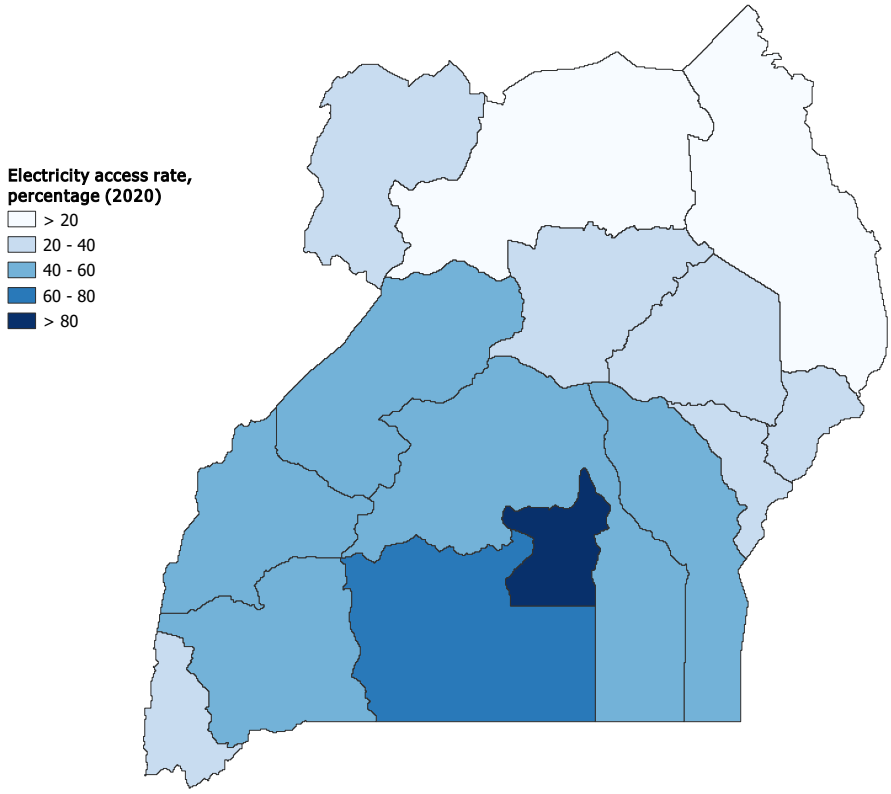
In the last four years the Covid-19 pandemic and the 2022 energy crisis have undermined progress in access to electricity and clean cooking projects, highlighting the urgency for even stronger and faster action.

2.2.1 Access to electricity

Achieving access to electricity provides fundamental services and benefits to households that spans from basic task lighting permitting children and young adults to study to storing food longer in refrigerators and boosting national and local economies by powering small businesses and farming activities.

However, in Uganda today 25 million people or 55% of the population have no access to electricity. Most of the people with access are concentrated in Kampala and in the Central Region where grid infrastructures are the most developed. Around 6 million of those with access do not reach the IEA's basic bundle of minimum level of electricity services. This low level of access is in contrast with the high natural hydro, geothermal and solar resources in the country, and the already existing electrical overcapacity. Currently, around 1.4 GW of electrical capacity is available but cannot be fully used as it is unable to reach the final consumers due to a lack of proper transmission and distribution infrastructures. In the ETP strong efforts to develop the national grid and regional connectors are key to achieve the country's energy ambition.

Figure 2.6 Map of Uganda with electricity access rates by sub-region, 2021



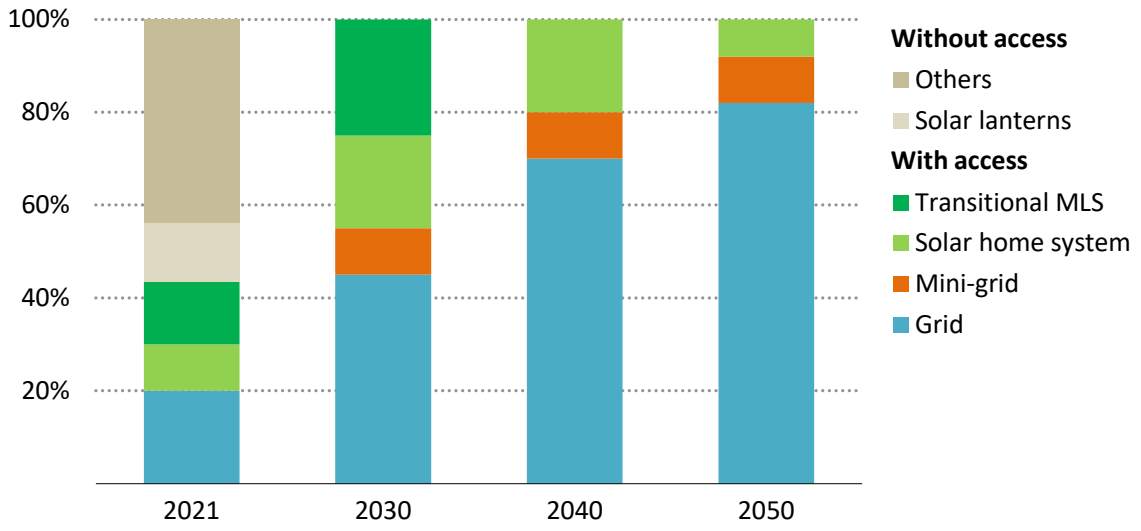
The highest levels of access rates are achieved in the south of the country with Kampala and the Central Region benefitting from relatively high access rates.

Source: IEA analysis based on data from the Uganda Bureau of Statistics.

While most of the population without access can afford basic electricity services if provided with a free grid connection, those in remote areas face challenges accessing the same services with off-grid technologies. However, climbing the ladder to additional essential energy services, for example increased lighting and the use of fans, is unaffordable for almost two-thirds of the population. Affordability concerns limit electricity demand, requiring incentivisation for electrification projects to succeed.

In the ETP, every person in Uganda has access to at least a transitional multi-light system (MLS) by 2030, while the average level of household energy services grows steadily. To achieve this, around 7% of the population needs to gain access each year (of which 1.5% to MLS). The ETP sees a different set of solutions deployed depending on the specific needs and locations of households yet to gain access. The bulk (45%) of those gaining access by 2030 do so via a grid connection due to the relatively high population density in many areas of the country that makes it economically and technically viable to extend and densify the grid. Around 45% of homes benefit from a grid connection in 2030 up from 20% today.

Figure 2.7 Share of population with electricity access by technology in the Energy Transition Plan, 2021-2050



Reaching SDG7 requires a rapid rollout of solar PV access solutions. Over time, households will switch to larger off-grid systems or connect to the grid.

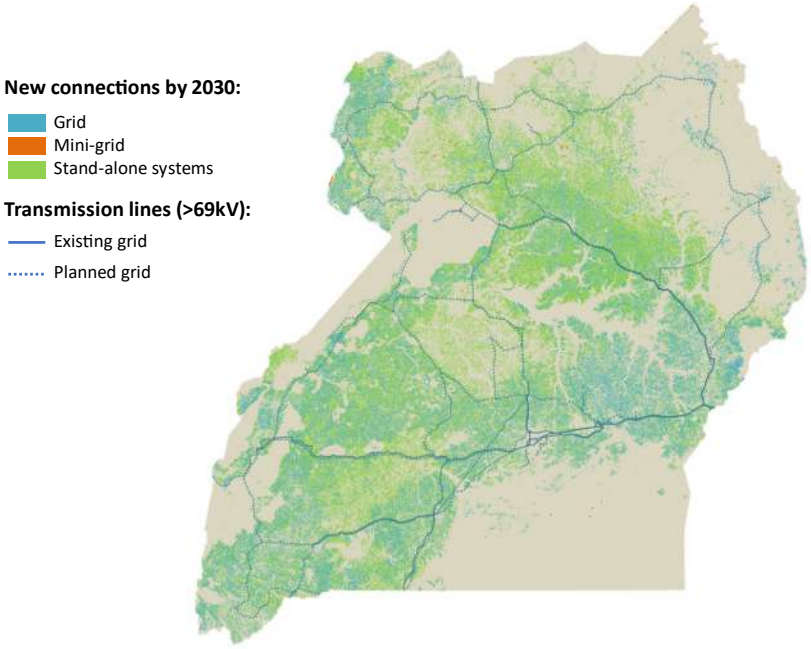
Note: MLS = multi-light systems (off-grid solar).

Sources: IEA analysis based on data from the IEA SDG7 database and Uganda Bureau of Statistics.

In more remote communities, off-grid solar PV systems and mini-grids offer a feasible alternative due to lower cost, faster deployment and easier scalability compared to a traditional grid extension. Mini-grids and solar home systems (SHSs) combined provide first access to more than one-third of the population gaining access. The remaining 20% gain transitional access through MLS, which provides lighting to one-quarter of the country by 2030. Considering the significance of the off-grid component, robust and transparent policies and regulations are essential to encourage the mini-grid developers and SHS distributors involvement in electricity access. Pilot projects and pre-feasibility studies, led by government and international partners, are vital to demonstrate the viability of investments in areas where, due to lower incomes and limited payment capacities, returns on investment might appear challenging.

As people gain first time access, in the ETP the per capita electricity consumption almost triples by 2030, reaching around 230 kWh per year driven by growing appliances ownership and e-cooking access, but also from improved affordability. Beyond 2030, this trend continues and households further climb the ladder with per capita residential demand reaching around 560 kWh per year by 2050, supported by increased access to larger supply infrastructure. By 2050 more than 90% of the population has access, either via the main grid (82%) or a mini-grid (10%), up from 55% in 2030, while the remaining most remote 10% benefit from larger SHSs.

Figure 2.8 Map of Uganda with households gaining access to 2030 by technology in the Energy Transition Plan



Larger settlements not too far from existing main grids are most often connected to them, while stand-alone systems provide the bulk of access in low-demand remote communities.

In the ETP, many off-grid systems, especially mini-grids, are gradually integrated to the main grid, contributing to improving its overall reliability. However, this needs to be accompanied by strong and transparent policies on standardised grid codes and clear government guidelines on grid expansion to ensure the protection of private investments as well as support the proper upfront design of mini-grids for future integration.

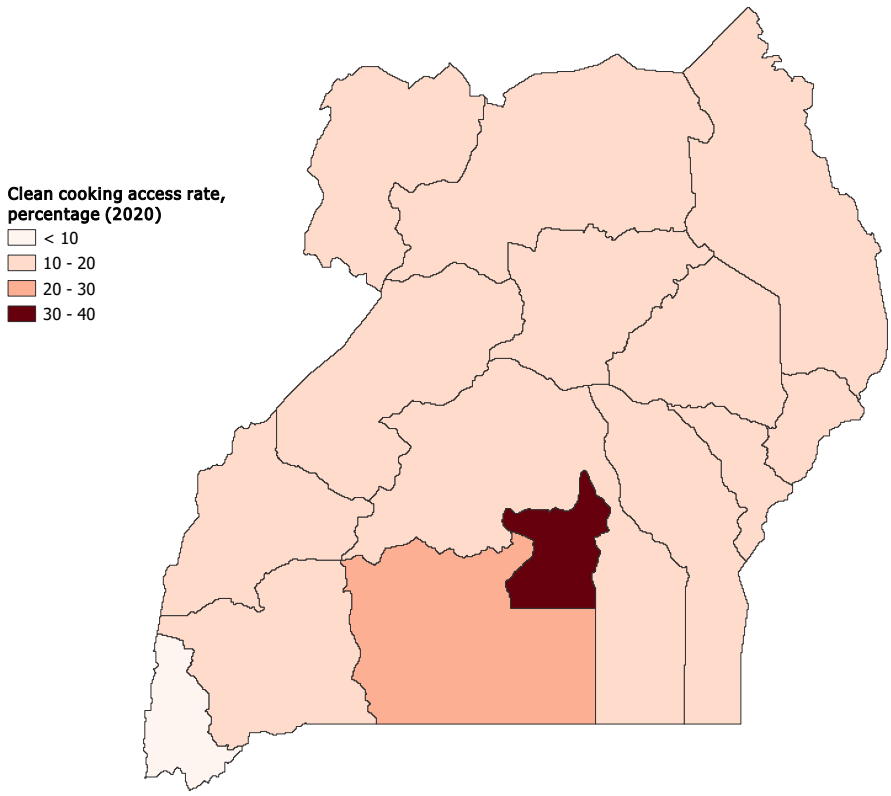
2.2.2 Access to clean cooking

Transitioning to clean cooking technologies, such as improved biomass cookstoves and electric stoves, can significantly improve health issues and reduce premature deaths by limiting exposure to harmful indoor smoke, which disproportionally impact women and children. It also lessens the time and effort spent on collecting traditional fuels, decreases the risk of violence against women during the collection process, and contributes to environmental conservation by reducing GHG emissions, limiting deforestation and protecting ecosystems. To ensure the uptake of improved and modern cooking solutions, targeted policies that address economic and sociocultural barriers to clean cooking are necessary.

However, today only 15% of Uganda's population has access to cleaner cooking technologies. Around 95% of the population primarily cook with solid biomass such as wood, charcoal or other vegetal and animal residues, with only one in ten of those using improved biomass cookstoves, while the remainder still relies on

traditional, harmful and inefficient stoves (e.g. three-stone cooking fires). Just over 5% of the population uses modern clean fuels such as LPG, electricity – mostly concentrated in the urban areas of Kampala and the Central Region – or biogas from biodigesters for cooking. In this report, the analysis of clean cooking primarily focuses on the residential sector but the lack of clean cooking is also a significant problem in the services sector, particularly schools, hotels, restaurants and hospitals, which are heavy consumers of solid biomass. Shifting to cleaner cooking solutions in the services sector, besides reducing solid biomass demand and lowering the cost of fuel for these institutions, can also serve to act as demonstration units to show the benefits of clean cooking at the community level (e.g. for mothers of students in a school that switched to improved or modern cooking stoves).

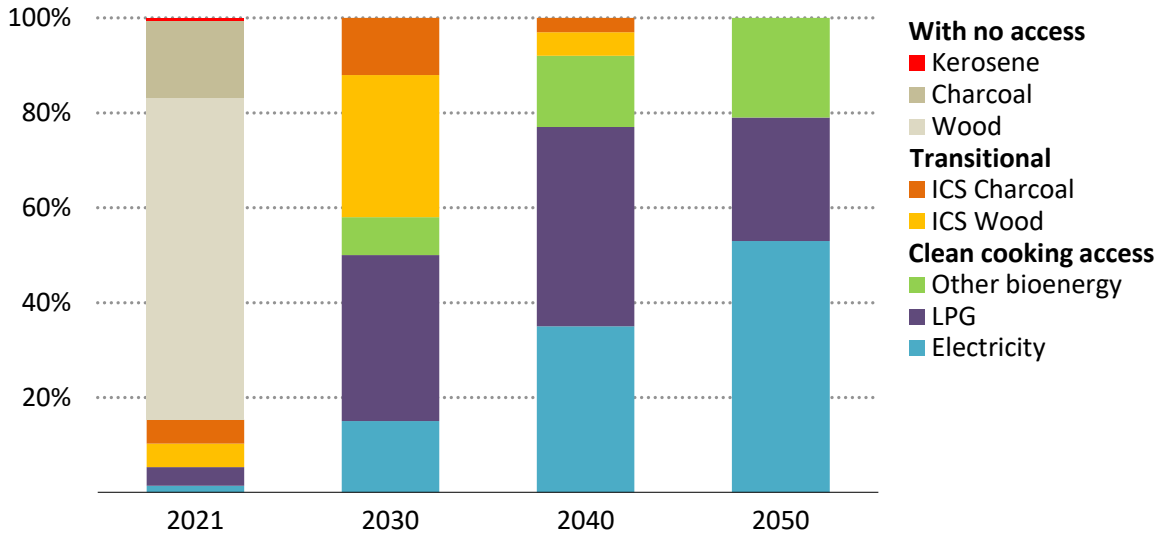
Figure 2.9 Map of Uganda with clean cooking access rates by sub-region, 2021



Besides Kampala and the Central Region, most areas have access rates below 15% and this is including all improved biomass cookstoves.

Affordability concerns are very important for clean cooking access, especially since around 90% of the population cooking with firewood (three-quarters of the country) do not have to pay for it. Less than 30% of the population lacking access to clean cooking can afford to cook using LPG, and only 10% can manage with an electric resistance hotplate. However, approximately 30% could afford cooking with electricity if a more efficient induction stove is used, mainly thanks to the availability of a clean cooking electricity tariff.

Figure 2.10 Share of households by cooking technology in the Energy Transition Plan, 2021-2050



Universal clean cooking access by 2030 will initially depend on improved cookstoves and LPG, shifting towards electric cooking by 2050 to achieve 100% modern cooking.

Notes: ICS = improved biomass cookstove. Other bioenergy include biogas, bio-LPG and bio-ethanol.
Sources: IEA analysis based on data from the IEA SDG7 database and Uganda Bureau of Statistics.

In the ETP, by 2030 every household has access to cleaner cooking stoves. More than 10% of the population switches from the traditional use of biomass to cleaner technologies every year between today and 2030. Almost 40% of those gaining access by 2030 do so via ICS, which represent an efficient and quick-to-deploy transitional solution not requiring a fuel switch and so are particularly relevant in rural areas where both affordability and fuel accessibility issues present the main obstacles in the near term.

More than one-third gain access via LPG stoves, which will be increasingly domestically supplied as the development of the Tilenga and Kingfisher oil fields advances in 2025. LPG infrastructures such as refilling and storage units are also built to ensure a secure supply of LPG also to some remote areas by 2030. On top of representing a modern and healthy cooking solution, LPG, though a fossil fuel, contributes to reductions in GHG emissions when people switch away from traditional biomass stoves.

Electricity is the main cooking choice for more than 15% of those gaining access by 2030. Electric cooking represents a key opportunity to build on synergies with access to electricity efforts by increasing demand and improving profitability of projects. However, primarily relying on electricity for cooking requires a strong and reliable supply of electricity, which is currently, and in the short-term, limiting higher uptake. Existing e-cooking electricity tariffs in Uganda encourage wealthier

household to increase use for cooking. However, in the ETP targeted, more affordable electricity tariffs for cooking allows use by poorer households. Electric cooking in the ETP also plays an important secondary role in households primarily cooking with other fuels, for example in the use of kettles, microwaves or electric pressure cookers, which are very efficient for slow cooking staple food.

The remaining 10% gain access through biogas and bio-ethanol. Biodigesters represent an important avenue for rural farming households, while in the ETP the already developed sugar industry plays an important role for supplying bio-ethanol. In Kenya, recent success of the bio-ethanol cooking model in urban areas highlights the potential for the fuel to play a major role in access to clean cooking efforts in Uganda too.

Beyond 2030, improved cookstoves gradually disappear: by 2040 all remaining ICS are of ISO Tier 4 and above, and by 2050 every household in the country cooks with a modern fuel or stove. More than half of the population is cooking with electricity by 2050. The reliance on fossil LPG declines, with only about one-quarter of the population using it by 2050, down from 40% in 2040. By mid-century, bio-LPG plays an important role to further decarbonise cooking still benefiting from the investment in LPG infrastructures done in the previous decades.

To reach the ETP goals, clean cooking progress needs to drastically accelerate, with investments sharply increasing. Achieving clean cooking will avoid around 7 Mt CO_2-eq each year by 2030 on a net basis, which excludes deforestation and black carbon emissions. If the unsustainable solid biomass harvesting is accounted for this rises to 17 Mt CO_2-eq. Climate finance, and especially carbon markets which are already funding clean cooking projects, also play a key role in the ETP scenario. However, clear and reliable national regulations mirroring international standards will be fundamental for clean cooking companies to access this finance.

Box 2.1 How feasible is reaching universal access by 2030 in Uganda?

Access to electricity

Uganda's recent progress in access to electricity is above the regional average but an acceleration is still required to align to the ETP pathway in 2030. The required speed of improvements in electricity access has already been achieved in other countries in Africa and Asia, so the needed faster pace is not unprecedented.

To achieve the ETP goals by 2030, 5.5% of the population needs to gain access each year to at least a basic level of energy services via a grid, mini-grid or solar home system connection. These levels of improvements have already been

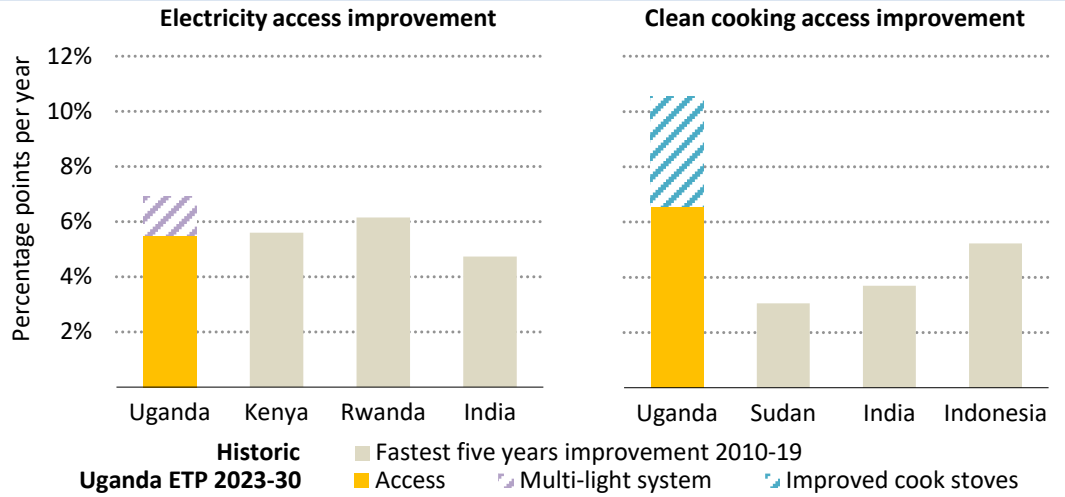
reached in other countries in the region, such as Kenya and Rwanda, and in other developing economies in Asia in the recent past. To close the gap, an additional 1.4% of the population needs to gain transitional access to multi-light systems each year by 2030.

Access to clean cooking

For Uganda, around 6.5% of the population needs to gain access each year to modern cooking fuels and stoves to achieve the ETP goal by 2030. This rate of improvement is unprecedented in the African continent, but a similar level was reached in Indonesia during the last decade through the deployment of LPG programmes combined with end-use incentives.

The success in Indonesia was also driven by strong policy and public funding heavily incentivising LPG, which attracted significant private and state-backed capital. Replicating the same acceleration model in Uganda would require a high share of international development and climate financing, as well as regional co-ordination to develop the fuel delivery infrastructure, supply chains and a strong local distribution capacity. However, maintaining this rate of improvements over a long period, especially when relying on steep incentives, will be challenging and too demanding on the government budget. This is why the ETP relies on a diversified portfolio of modern cooking solutions such as e-cooking, biogas and bioethanol. An additional 4% of the population gain access each year with ICS in the ETP by 2030. ICS can be deployed relatively fast and are more readily adopted by rural households if the correct policy and business environment is created.

Historic annual improvement in electricity and clean cooking access rates in selected countries and in Uganda in the Energy Transition Plan

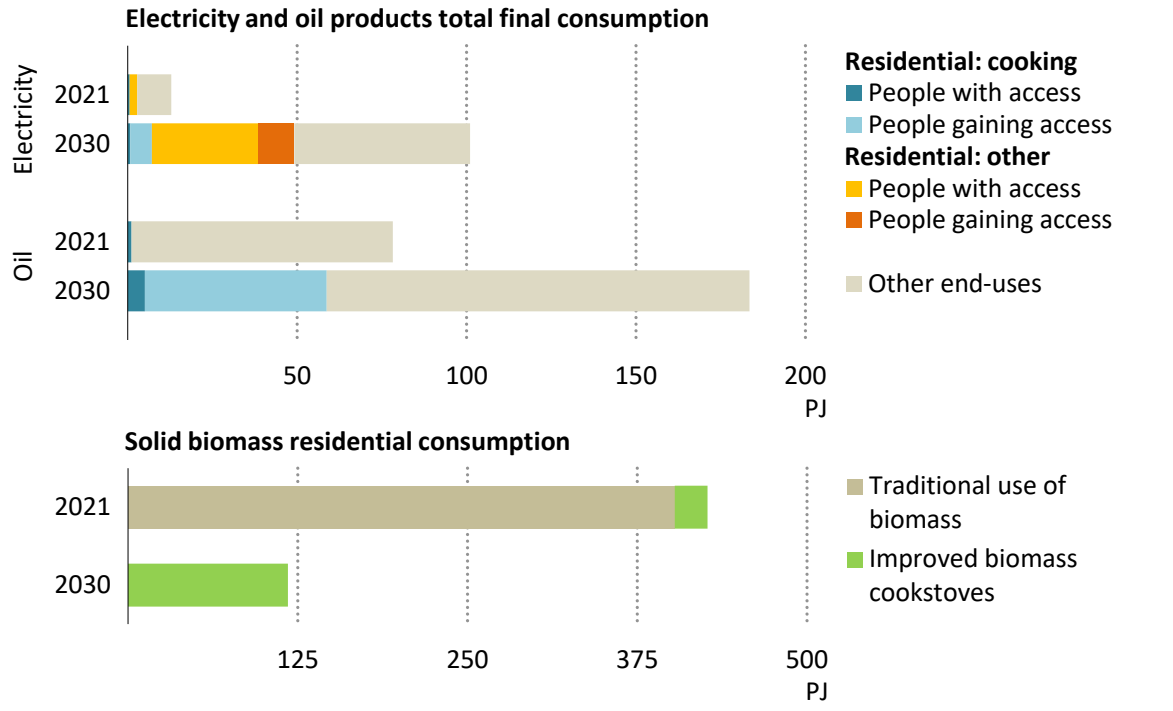


The level of effort needed to meet electricity access goals has already been achieved in the region, while for clean cooking it is unprecedented.

2.2.3 Energy supply implications of universal access

Despite the ambitious electricity access targets, demand from the population gaining access to electricity is not the primary driver of the increase in electricity consumption in the ETP by 2030 due to the low levels of demand at first. Conversely, people switching to LPG cooking leads to a surge in oil demand which accounts for more than half of the increase in total oil final consumption by 2030.

Figure 2.11 Final consumption by selected fuel and use in the Energy Transition Plan, 2021-2030



Increase in electricity demand from people gaining access is 16% of the total in 2030. LPG demand, driven by clean cooking efforts, rises by more than 50 times during the decade.

For those already with access today, electricity demand increases due to economic development and rising household income, which provide the ability to acquire additional appliances and pay for higher energy services. On the other hand, although those gaining access create new electricity demand, this is limited at first by low per capita consumption levels. Electricity demand by households gaining access to electricity and electric cooking represents around 10% and 6%, respectively, of total final electricity consumption by 2030.

Oil demand from those who currently already have access to clean cooking rises only marginally, mainly due to the low number of people with access to LPG today. The high number of households shifting away from traditional fuels to LPG, however, means that by 2030, the residential sector accounts for over 30% of oil total final consumption. LPG use increases by more than 50 times by 2030, requiring exceptionally fast development of supply and distribution infrastructures.

Uganda's production from the Lake Albert oil projects supply much of the increase in LPG demand by 2030. This will depend on the specific mix of propane and butane, as a relatively high share of butane in the blend is required for use in hot climates.

In the ETP, charcoal and firewood demand decrease by two and a half to four times, respectively, by 2030 following the adoption of more efficient ICS and to the shift to modern cooking fuels. This will have also important benefits on GHG emissions and deforestation, especially if combined with regulations on charcoal production efficiency. Annually, Uganda loses around 72 000 hectares of forest – equivalent to approximately 100 000 football pitches – due to charcoal and firewood uses. The shift to clean cooking by 2030 may reduce charcoal-related jobs significantly, necessitating careful management for affected communities. Policy makers are crucial for guiding a just transition, supporting new training for unskilled workers and reskilling for long-term employment, possibly within the clean cooking sector. Equally, prioritising women in reskilling and training programmes is critical to significantly improve their participation in the formal workforce and ensure a just transition. Promoting women in the formal workforce also reduces their exposure to dangerous cooking smoke levels at home that, combined with backbreaking work of gathering wood, would improve their health and reduce early death rates.

2.3 Buildings and agriculture

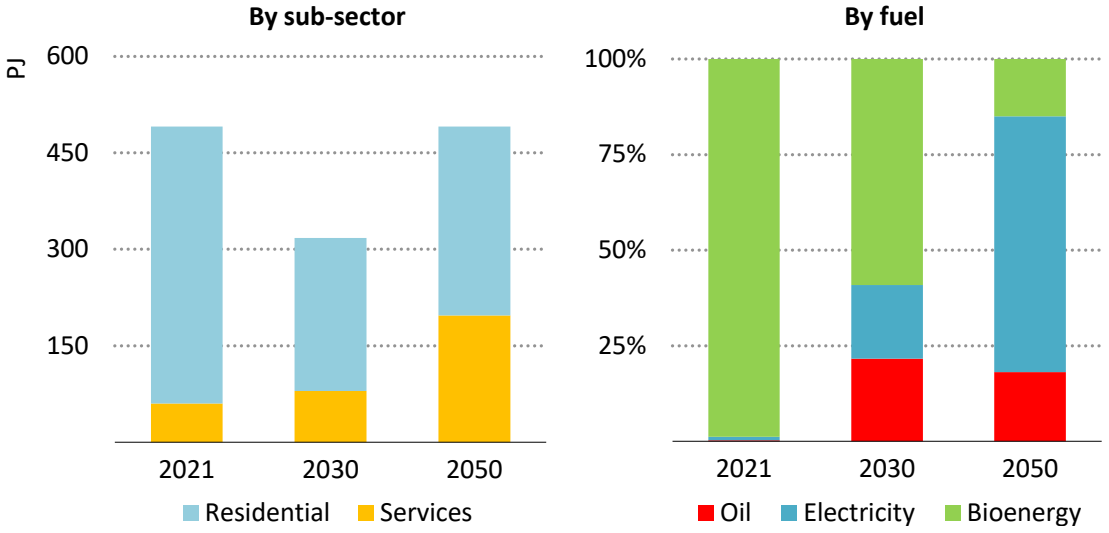
Africa is witnessing a unique and rapid increase in household numbers, a trend that extends across the continent, including Uganda. This demographic shift, coupled with the push for universal access and economic growth, plays a pivotal role in escalating demand within the buildings sector. Furthermore, the evolving energy landscape is marked by the emergence of more commercial buildings and rising living standards. In the ETP, electricity demand in buildings is almost 15 times higher in 2030 than today, and grows another fivefold by 2050.

By 2030, all Ugandan households, businesses and public institutions gain access to electricity, further underpinning economic development. The share of the services sector in buildings energy demand expands from just over 10% to around 25% by the end of the decade, and includes floorspace for commercial activities doubling by 2050 as the retail and technology sector expand. Key drivers for increased energy consumption in the services sector include the expansion of space cooling and other appliance use in offices, hospitals, and other public or commercial buildings, as well as a growing cold chain infrastructure to improve food production and storage.

Buildings in Uganda inherently have lower energy consumption per floor area, owing to the country's moderate climate. Space cooling needs in Uganda are lower than in other parts of Africa thanks to a relatively mild climate throughout the

year. Space heating needs are also limited during colder months. Consequently, building envelope improvements are less of an imperative than in other regions, though the buildings stock becomes more energy efficient over time as a large part of the existing buildings is replaced in the coming decades.

Figure 2.12 Building sector final energy consumption by fuel and sub-sector in the Energy Transition Plan, 2021-2050



Electricity use in buildings is set to increase almost eighty-fold by 2050, fuelling Uganda's transition to a modern, service-oriented economy.

In the residential sector, consumption of modern energy services per capita remains significantly higher in urban areas, in particular among households that have already climbed up the energy ladder today. Ownership of refrigerators, fans, TVs and other electric appliances expands rapidly, as incomes and living standards rise. Water heating needs are also increasingly met by electric solutions, further explaining the skyrocketing electricity demand in homes.

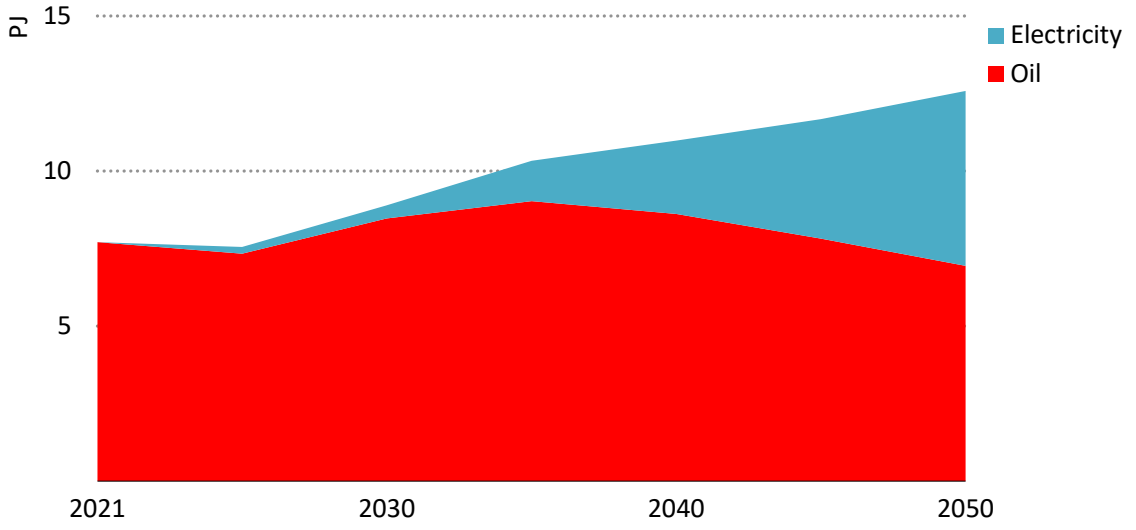
Efficiency improvements in the buildings sector go beyond the transition to more modern and efficient fuels. This is key to keep energy use in check as all Ugandans gain access to electricity and progressively use more energy services. The recently adopted National Energy Policy and the forthcoming Energy Efficiency and Conservation Bill aim to introduce minimum energy performance standards (MEPS), building energy codes and other regulations and requirements such as mandatory energy audits. Ensuring compliance with these regulations is key to guarantee that efficiency improvements materialise. This task is especially challenging due to the significant presence of second-hand markets for appliances, which serves as a particular barrier to achieving further efficiency gains. This challenge becomes even more pronounced with the rapid proliferation of appliance and air conditioner ownership in developing economies.

MEPS for major appliances such as refrigerators, air conditioners and lighting are the main lever, cutting energy demand in buildings by nearly 10% by 2050. In countries with long-established efficiency standards, such policies have helped reduce energy consumption of refrigerators by half in just over 20 years, while other appliances have seen similar improvements. Efficiency standards also help reduce energy bills for consumers by limiting the electricity consumption of appliances over their lifetime. These savings can easily be unlocked as data from other African markets illustrate that more efficient refrigerators, fans or air conditioners are often available at the same, or only slightly higher, upfront cost than less efficient models.

Uganda's emerging energy efficiency framework also offers a unique opportunity to integrate digital technologies across the sector. For example, enabling real-time communication with end-use devices can help reduce peak demand and facilitate the integration of variable renewable energy sources.

In agriculture, which represents one-quarter of Uganda's gross domestic product (GDP), energy demand today stems from irrigation pumps and agricultural processing equipment. Efficient electric pumps, often in combination with solar PV solutions, are key to replace diesel generators over time. The accelerated roll-out of mechanised agricultural processing equipment initially drives up oil demand in the sector, though electrification enables a gradual transition to cleaner alternatives. Growing cold chain infrastructure also accounts for rising electricity use in agriculture, enabling increased productivity and higher volumes of produce to reach urban markets.

Figure 2.13 Agriculture sector final energy consumption by fuel in the Energy Transition Plan, 2021-2050



By 2050, electricity is set to account for 45% of energy demand in agriculture, thanks to a shift towards more sustainable solutions such as efficient electric pumps for irrigation.

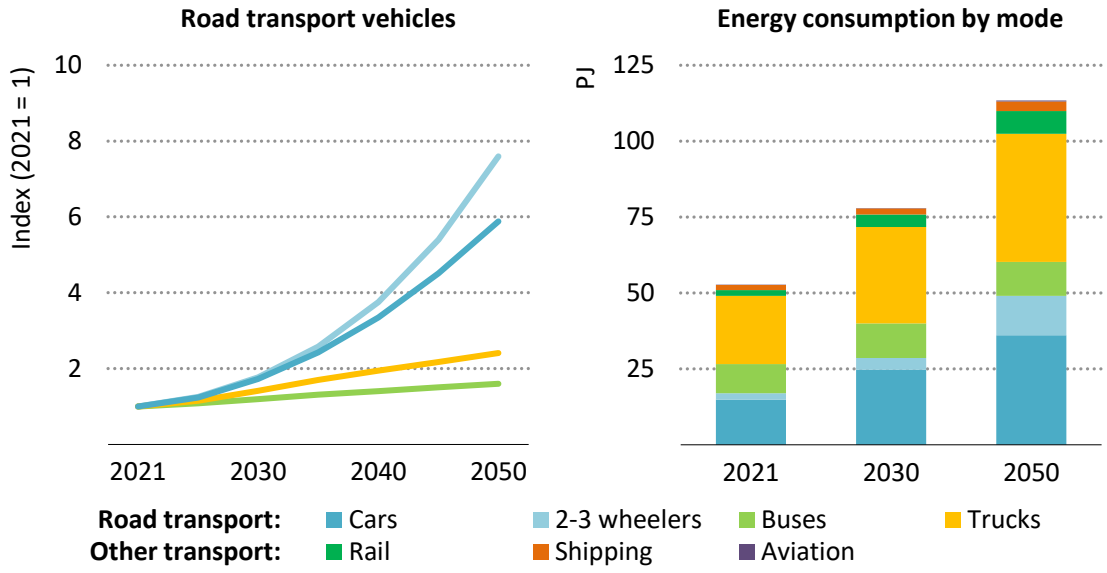
2.4 Transport

Uganda's transport sector is growing rapidly, as expanding road infrastructure and a rapid rise in vehicles use allows greater travel of people and goods across the country. The number of vehicles on the road has already doubled since 2010. This increase is primarily due to a rise in passenger cars and two- and three-wheelers, which account for two-thirds of the growth, while the number of trucks has tripled in the same interval. Despite these developments, passenger car ownership per capita in Uganda remains more than ten times below the average level in emerging market and developing economies.

In the ETP, the number of vehicles on the road continues to rise, however improved urban design and mass transit throttle growth. Buses on the road increase by around 20% by 2030, as urban bus travel is increasingly formalised. In parallel, new rail lines start to serve core travel corridors for passengers and goods. Nonetheless, car stocks increase by more than 70% by 2030 and nearly sixfold by 2050. Two- and three-wheeler vehicles see an even faster rise over this period, largely concentrated in urban areas and among more price-sensitive consumer segments. By 2050, the fleet of trucks on the road more than doubles compared with today's levels.

As a result, transport energy demand is set to grow by 50% to 2030, and eventually doubles by 2050 to over 100 PJ. Road vehicles continue to account for around 90% of energy consumption in the transport sector.

Figure 2.14 Road transport vehicles and transport sector final energy consumption by mode in the Energy Transition Plan, 2021 to 2050

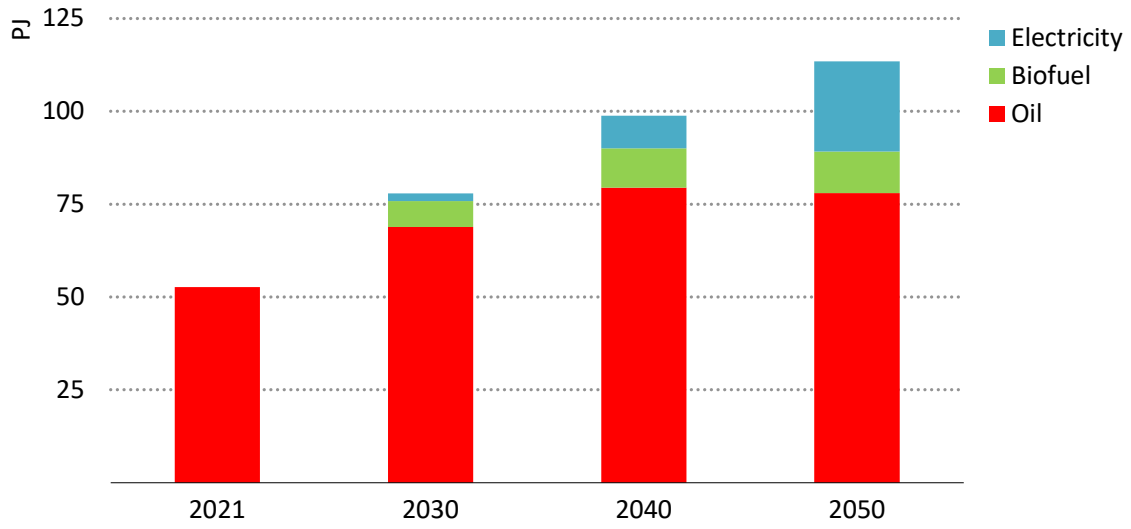


By 2050, vehicles on the road are set to increase more than fivefold, while efficiency and electrification helps hold transport energy consumption to a doubling over the same period.

Efficiency improvements and rising electrification among road vehicles temper energy demand growth in the ETP. The average energy consumption of the passenger car stock is cut by more than half by 2050, reflecting more efficient internal combustion engine (ICE) vehicle fleets and a higher share of electric vehicles (EVs) that are on average two to three times more efficient than their ICE counterparts.

One key efficiency measure in the transport sector is a tightening of age limits for imported second-hand vehicles from 15 to 8 years. This is reinforced with stronger fuel economy standards that ratchet up over time. Improved consumer information, including standardised labelling on fuel efficiency and estimated total cost of ownership, helps Ugandans make more informed choices when buying vehicles, especially first-time buyers. Improved urban planning and better quality roads also improve fuel efficiency and reduce congestion.

Figure 2.15 Energy demand in transport by fuel in the Energy Transition Plan, 2021-2050



Oil demand peaks in the mid-2040s as electrification and biofuels make inroads.

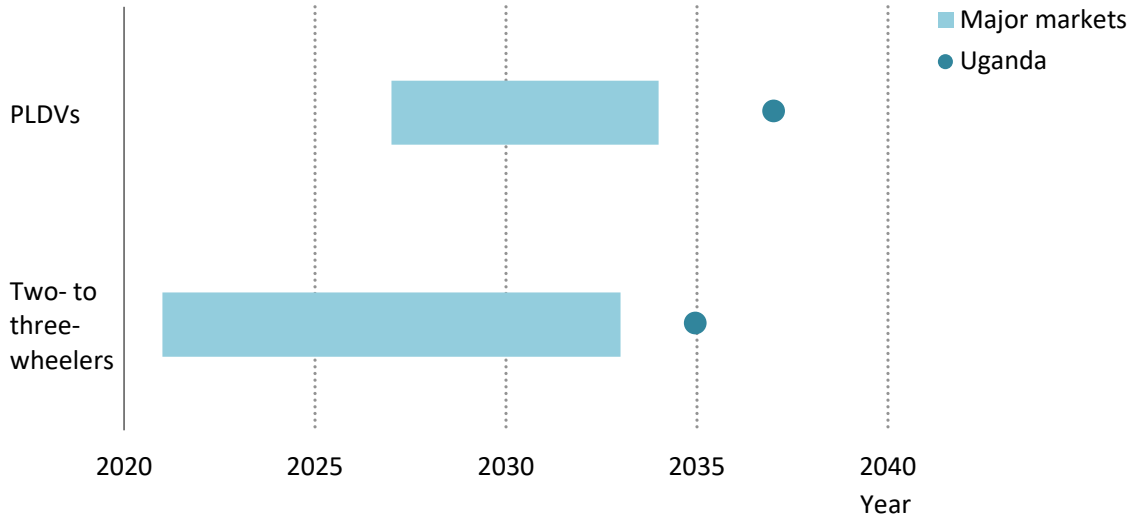
Oil products meet nearly all of transport energy needs today, the entirety of which is imported. Oil continues to provide the majority of demand in 2050, however biofuel blending curbs growth in the near-term, while vehicle electrification makes large inroads starting in 2030. Together these trends result in a peak in oil demand in the transport sector in the mid-2040s. Biofuels reach around 10% of liquid fuels by 2030, a share expected to remain stable through 2050.

The share of electricity in the transport sector rises rapidly, from just 3% in 2030 to over 20% in 2050, driven by a rising share of electric vehicles. The implementation of age limits on second-hand vehicles leads to a higher number of imported electric vehicles, in line with increased availability from major car markets

that post higher turnover rates of EVs. Accordingly, sales of EVs are set to overtake ICE cars sales in Uganda before the mid-2030s, a delay compared with major markets like Europe, Japan, People's Republic of China (hereafter, "China"), and the United States. This means that by 2050, more than two-thirds of passenger cars on the road in Uganda are electric. Sales of electric two- and three-wheelers overtake sales of their ICE counterparts early, around 2035. Still, electrification in heavy transport sectors remains low by 2050, mirroring global trends and underscoring the necessity of establishing charging infrastructure. An expansion of EV charging infrastructure and strengthening of the distribution grid supports this level of EV uptake in the ETP. Improving power sector reliability must go hand-in-hand to encourage greater vehicle electrification.

The soon to be released National E-Mobility Strategy reinforces the ETP goals, providing significant tax exemptions for EV components, and establishing a special energy tariff for both public and commercial charging points. The strategy also envisions the local production of electric vehicles, batteries, and other components which is crucial for revitalising industrial production and supporting local communities.

Figure 2.16 Year EV sales surpass ICE vehicle sales, by segment and regions



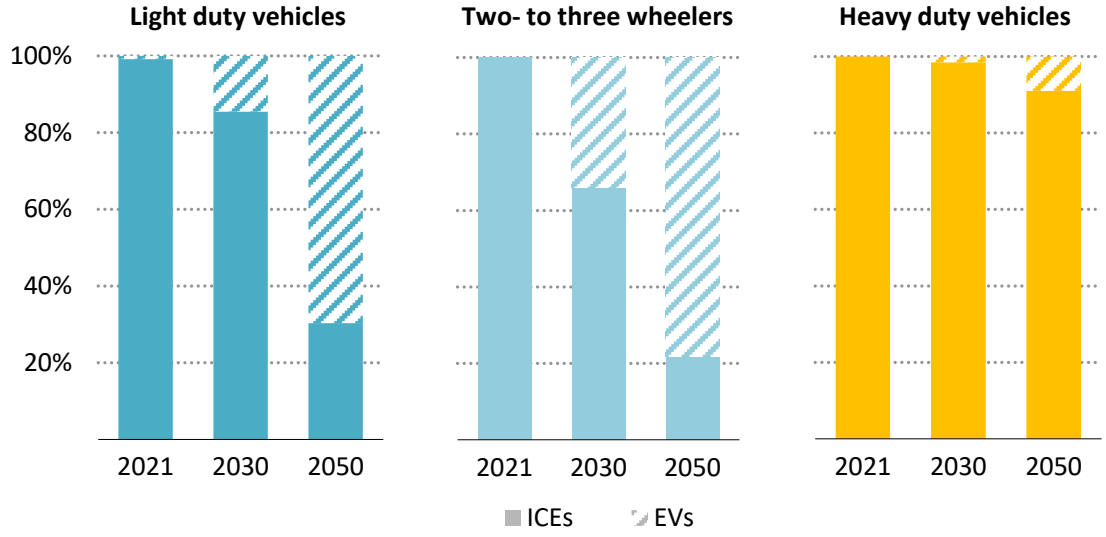
As more advanced markets increase sales of new EV sales and higher turnover rates, Uganda sees a shift to second-hand EV sales by the end of next decade.

Notes: EV = electric vehicle; ICE = internal combustion engine vehicle; PLDVs = passenger light-duty vehicles. Major markets include Europe, Japan, China and the United States.

Progress is slower in other road transport segments that are more challenging to electrify. Only around 10% of the heavy-duty vehicle fleet will be electrified by 2050. Instead, biofuels meet an increasing share of fuel in heavy-duty freight and aviation demand. Airport infrastructure is also upgraded to improve domestic and

regional connectivity. In shipping, energy use doubles over the same period, as the country expands the use of inland barges to transport goods more efficiently across its waterways. By 2050, energy consumption for aviation is over 16 times higher than today but remains dependent on oil products. Rail transport infrastructure and end use is also set to expand, with energy demand projected to grow fivefold by 2050, of which a rising share is met by electricity. These segments, however, represent only a small portion of transport energy demand, consuming around 10% of energy in the transport sector between 2030 and 2050.

Figure 2.17 Road vehicle share of electric models by type in the Energy Transition Plan, 2021-2050



Passenger cars and two- and three-wheelers electrify rapidly, but challenges remain for heavier vehicles for long-distance transport.

Note: ICE = internal combustion engine vehicles, EVs = electric vehicles, Heavy duty vehicles = road buses, medium and heavy freight trucks.

2.5 Industry

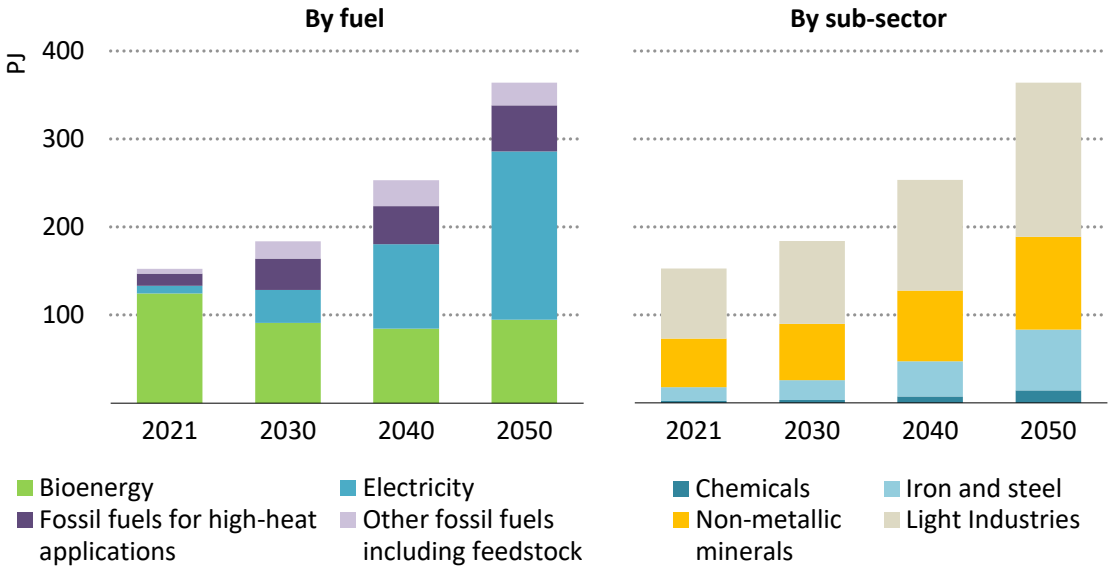
Industry currently accounts for nearly 30% of the country's GDP and around a fifth of energy demand and energy-sector CO_2 emissions. Around half of today's industrial energy consumption is in light industries, which comprises food production, machinery, textiles, timber, as well as construction and mining. Cement and other non-metallic minerals make up over one-third and steel around 10% of the sector's energy demand. However, cement and steel production are rapidly expanding, and several other energy-intensive industries are set to come online in the coming decade such as mining extraction and mineral processing.

Accordingly, industry is the main driver of Uganda's energy demand growth in the ETP as consumption increases 2.5-fold by 2050, when the sector is set to account

for over one-third of total final consumption. Light industries maintain a dominating role, but steel and non-metallic minerals production, including cement, are the main source of growth, accounting for one-quarter each of this increase. By 2030, steel demand per capita doubles to levels currently observed in India, which has a GDP per capita twice as high as Uganda's.

During this period, improving energy efficiency and modernising industrial energy systems play a major role in the ETP. The net economic output per unit of energy in industry is nearly four times higher in 2050 than today, highlighting the sector's role as a key engine of economic growth in Uganda. These efficiency gains are driven by a shift to modern fuels and technologies, including the roll-out of more efficient heaters, pumps, and compressors. The share of bioenergy in the fuel mix falls from 80% to just over 25% in the same period, as supply sources diversify, with increased demand for higher temperature heat and the need to release pressure on biomass supply.

Figure 2.18 Industry energy demand by fuel and sub-sector in the Energy Transition Plan, 2021-2050



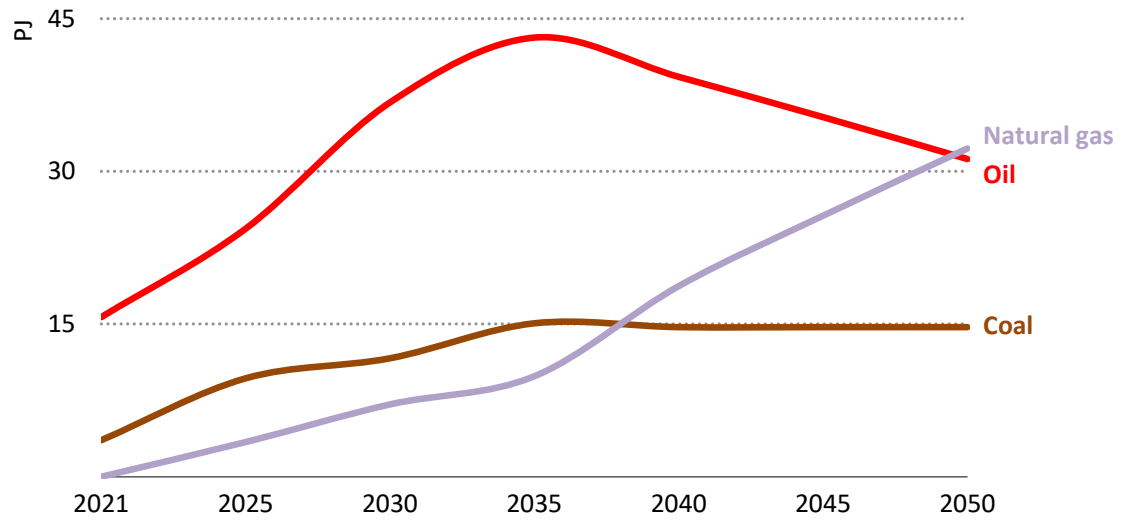
Industry energy demand rises two-and-a-half times by 2050, driven by expanding energy-intensive industries and continued growth in light industries met by increased electrification.

Electricity is the fastest growing fuel in industry in the ETP. Its share in the fuel mix rises from just over 5% in 2021 to around 50% in 2050, with electrification taking hold after 2030. The growing uptake of heat pumps and electric heaters for low-temperature heat applications in light industries increasingly replaces bioenergy, on top of additional demand from further motorisation and digitalisation.

In the medium term, fossil fuel use expands as well, especially in heavy industries. By 2030, its share in the overall industry fuel mix more than doubles to 30%.

Afterwards, stronger efforts to develop alternative industrial processes that can use low-emissions fuel substitutes begin to erode fossil fuel's share. The use of oil in industry peaks by 2035, increasingly replaced by natural gas. Coal plateaus around 2035 as well, largely owing to changes in the type of new crude steel facilities that are built after this decade. Natural gas consumption increases, and declining oil and coal use help reduce the emissions intensity of fuels supplying high-temperature heat in industry. Natural gas growth increases through 2050 in industry, overtaking oil consumption. This reflects the growing role of natural gas as a transition fuel for non-metallic minerals as well as iron and steel production.

Figure 2.19 Fossil fuel consumption in industry in the Energy Transition Plan, 2021-2050



Natural gas helps first curb the use of coal, and then oil in industry, largely in the steel and cement sectors.

2.5.1 Light industries

Light industry comprises a wide array of non-energy-intensive sectors, such as food production, textiles, construction, timber, machinery, and mining. All of these sub-sectors are set to expand in tandem with economic growth and increasing consumer demand.

Light industries continue to account for around half of industrial energy demand through 2050, but the fuel mix sees a rapid transformation. The share of electricity rises from 2% today to nearly 80% in 2050 in the ETP. By then, nearly three-quarters of electricity demand in industry is concentrated in these sub-sectors as many of these industries increase mechanisation and reduce the share of manual work. A rising level of electric heating displacing biomass also is a driving factor. Many of these measures are cost-competitive today. While bioenergy use in light industries accounts for around 60% of bioenergy consumption in industry today, this share falls to around 20% by 2050.

2.5.2 Heavy industries

Cement and steel production are the leading energy-intensive industries that expand in the ETP, driven by a ramp up in construction activities for buildings and infrastructure and the exploitation of Uganda's vast iron ore reserves. By 2030, cement production grows 1.5-fold, while steel production exceeds 6 million tonnes in 2050, a twelve-fold increase from today's levels. These industries require high-temperature heat and therefore continue to rely mostly on fossil fuels. In addition, Uganda's chemicals sector, including for fertilisers, also emerges as a key driver of economic growth. Mining activities also rise in the ETP, with mineral processing having strong potential to play a role as well.

Iron and steel

Today, Uganda produces around half a million tonnes of finished steel products per year. Until recently, Uganda's capacity for producing liquid steel was limited to melting scrap supplemented by imported steel billets with electric arc furnaces (EAF). Today's production of finished steel products and goods is also partly enabled through imports of semi-finished steel products.

To expand liquid steel production and reduce import dependence, Uganda has recently installed two direct reduced iron (DRI) facilities – one at Iganga operated by Tembo Ltd., and the other in Masese by Abyssinia Iron and Steel Ltd. These facilities are based on a rotary kiln-coal DRI process, which uses coal for its ability to supply high-temperature heat. One benefit of this process is that it does not require coking coal, but it is among the highest emissions steel making processes in operation globally today.

According to our analysis, several new coal DRI facilities for primary steel production are operating or under development, and accordingly the steel sector's emissions intensity is initially set to rise. However, after 2030, no new coal DRI facilities are built in the ETP. Instead, new DRI facilities rely on natural gas but are built such that low-emissions hydrogen can be substituted for natural gas in the future without additional retrofits. This approach and timing are consistent with the IEA's Net Zero Emissions by 2050 scenario. Even just by using natural gas DRI to meet the additional demand growth for crude steel from 2030-2050, the ETP saves around 1.1 Mt CO_2 by 2050, compared to a scenario where coal DRI is used instead. In the longer term, switching to low-emissions hydrogen could facilitate almost a complete decarbonisation of the sector, alongside a greater use of EAF as scrap availability increases in Uganda.

Cement and other non-metallic minerals

Uganda's cement industry largely relies on integrated cement mills encompassing all stages of production. The most energy intensive step is in cement kilns, which

requires high-temperature heat. Bioenergy currently accounts for more than 50% of consumption in the industry and is the leading fuel in the sector. This is higher than global averages or even levels in the rest of sub-Saharan Africa, which are closer to 30%. In the wider non-metallic minerals sector, bioenergy accounts for around 90% of total energy consumption, with values reaching almost 100% in some sub-sectors like brickmaking. However, fossil fuels, notably in the form of heavy fuel oil (HFO), diesel, petcoke, and coal, are also used, and have been on the rise as biomass has struggled to meet growing demand, due in part to seasonal variations in availability. By 2030, fossil fuels provide around 30% of energy demand, however coal and HFO shares are greatly reduced, displaced by natural gas. Changes in the cement-making process and improved biomass supply chains lead the decline in the share of fossil fuels to 15% by 2050.

Some of Uganda's main cement producers already have targets to increase the share of bioenergy in their processes by 2030, with the largest supplier announcing an aim to meet 85% of kiln fuel with modern solid biomass in the coming decades. Bioenergy use is also set to rise in other facilities and applications, reaching around 70% of total energy consumption by 2050. This requires a careful handling of the seasonality of agricultural residues, especially as the country urbanises. In parallel, efficiency improvements of processes moderate the growth in energy demand over time.

Fully decarbonising cement requires installing carbon capture, utilisation and storage (CCUS) technologies, as CO_2 emitted from the production of cement represent a major source of emissions from industry. In the case of Uganda, process emissions account for around 50% of the sector's total CO_2 emissions today. Given the high share of bioenergy, installing CCUS could even make the sector a carbon sink, since capturing CO_2 from sustainably harvested bioenergy generates net-negative emissions.

In addition to curbing emissions from cement production, reducing the share of clinker used in cement, adopting more novel aggregate mixes in concrete, and dematerialisation – not overusing cement in construction – are both major levers to help limit demand for cement in the first place. Uganda should aim for an average clinker to cement ratio of 60%, recognising that some structural applications require a higher ratio, and others, lower.

Refining, chemicals, and fertilisers

Uganda's new oil production and refining operations will create a very immediate jump in energy demand when they come online. Some of this energy will be electric, as is the case with heating pipes, pumps and compressors, and some refining operations. However, some refinery operations will rely on burning various by-products to power the refining processes in auxiliary units. Accompanying

chemical production sectors are also being developed alongside the refinery, many of which make use of the chemical by-products. The chemical operations will also rely on natural gas from Tanzania, with a notable uptick in the production of fertiliser that plays an important role securing the agricultural sector. In total, the sector's energy consumption reaches 14 PJ in 2050 – around 4% of industrial energy demand at that point. In IEA's energy balances, (see Annex A, Table A.1), refining is counted separately in the "other energy sector", but for the purposes of the report are discussed here. The supply of oil products coming from the refinery are discussed below Section 2.7, Energy supply.

Extractive industries: mining and critical minerals

Uganda's extractive industries are set to expand in the ETP too, with rising energy demand mainly met by electricity, and relying on grid connections or micro-grids that will limit the use of diesel generators commonly used today. Trucks and other vehicles at mines continue to be fuelled by diesel, although electric or fuel cell vehicles could play a role in the future.

Uganda currently has mining operations focused on the extraction of cobalt, gold, iron ore, tungsten, steel, and tin. It does not produce critical minerals for the energy transition. Plans exist for the exploitation of discovered resources in the coming years, and continued exploration in parallel.

Table 2.1 Current and planned mining projects

Mineral	Location	Status
Copper	Kasese, Kotido, Bushenyi, Mbarara Districts	Planned revamping and reviving of mining operations
Cobalt	Kasese	Planned revamping and reviving of mining operations
Lithium	Kabale, Ntungamo, Mukono, Mubende Districts	Exploration ongoing
Lead	Kitomi forest, Isingiro District	Re-evaluation of deposit
Nickel	Ntungamo, Isingiro, Lamwo, Arua Districts	Exploration ongoing
Manganese	Isandara Hill, Western Uganda	Exploration to take place
Rare earths	Makuutu deposit, Eastern Uganda	Exploration ongoing
Tin	Ntungamo, Isingiro Districts, Mbarara District	Exploration and feasibility study
Graphite	Orom-Cross	Development
Iron ore	Muko, Kabale, Kisoro, Mbarara, Hoima Tororo, Moroto Districts	Five existing mining leases granted for development of iron ore resources

Source: Mineral Reserves and Potential of Uganda and Status of Exploration and Development.

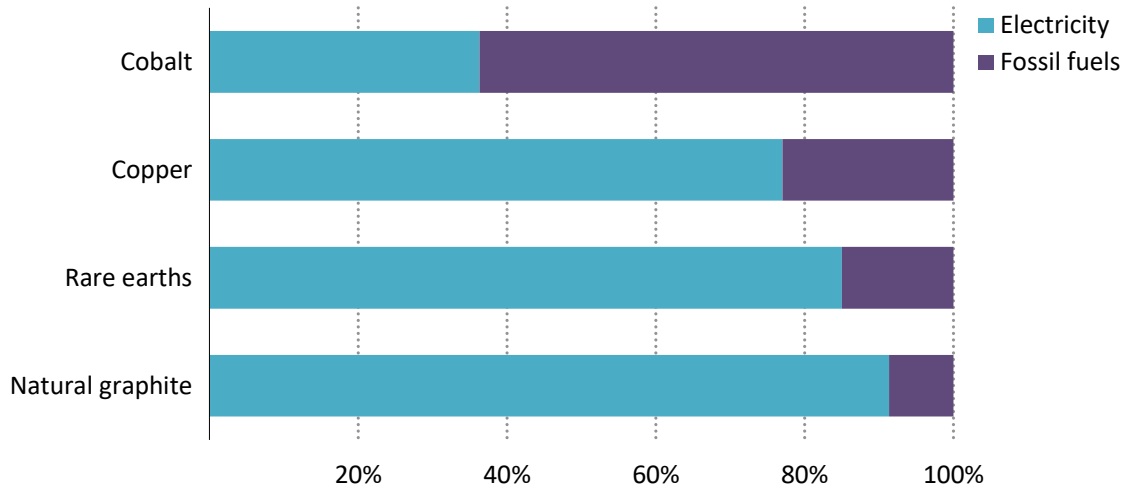
The Orom-Cross Graphite Project is forecast to yield around 100 kt of graphite per year on average from 2025. Electricity typically accounts for 90% of energy consumption for graphite production, with fossil fuels covering the remainder.[1]

The Makuutu rare earth mining project in eastern Uganda is planned to start production towards the end of 2024. The deposit contains clays rich in rare earth minerals, with a basket equivalent to other major deposits found in large mines in China. The mines will produce about 80 kt of mixed rare earth carbonate products.

In addition, there are reserves of copper and cobalt in the Kasese District. Existing mining operations could be revamped and revitalised to yield an initial yearly production of 40-80 kt of copper and 8-14 kt of cobalt. Extracting Uganda's iron ore resources, estimated at around 500 Mt, is key to supply the new DRI facilities for primary steel production.

Overall, energy demand from mining activities at Orom-Cross and the Makuutu projects is expected to amount to around 8 PJ –1.4% of total final consumption in 2030. Fuels for mining trucks will be particularly important for rare earth minerals and cobalt, while electrification will power the development of existing copper reserves. Including mineral processing and beneficiation activities – an ambition Uganda has with the pending passage of a law restricting the export of raw materials – would drastically increase energy consumption given these steps are typically two to nine times more energy-intensive than the mining operations.

Figure 2.20 Share of fuel demand per tonne of mined minerals



Energy demand per tonne of mineral produced would be primarily from electricity in both graphite and rare earth production.

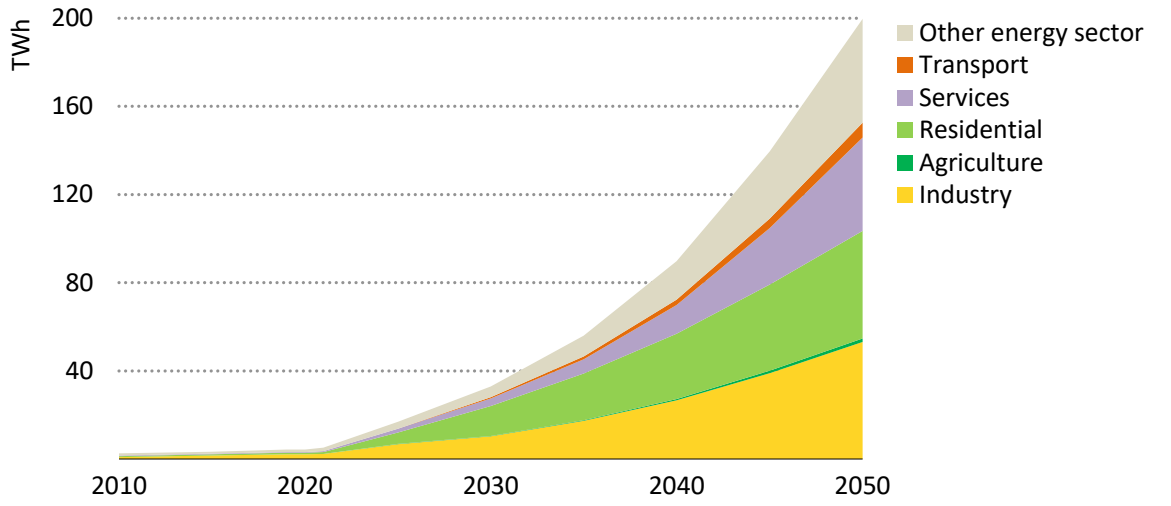
Source: IEA analysis based on data from the GREET Database.

[1] IEA analysis based on GREET Database.

2.6 Power

In the ETP, electricity becomes the backbone of the country's energy system. Electricity demand grows across all sectors, and by 2050, Uganda requires about 40 times more electricity than it does today, reaching around 200 TWh. Growth is fuelled by robust industrial activity, increased levels of electricity access, rising living standards, population growth and higher shares of end-use electrification. Of the end use sectors, industry accounts for the most growth and remains the largest electricity consumer in 2050. Residential buildings are the second-largest end use sector in 2050, followed by the services sector. Electrification in all end-use sectors reaches 56% by 2050, up from just 2% currently. Electricity is the largest single energy source in 2040.

Figure 2.21 Electricity demand by sector in the Energy Transition Plan, 2010-2050

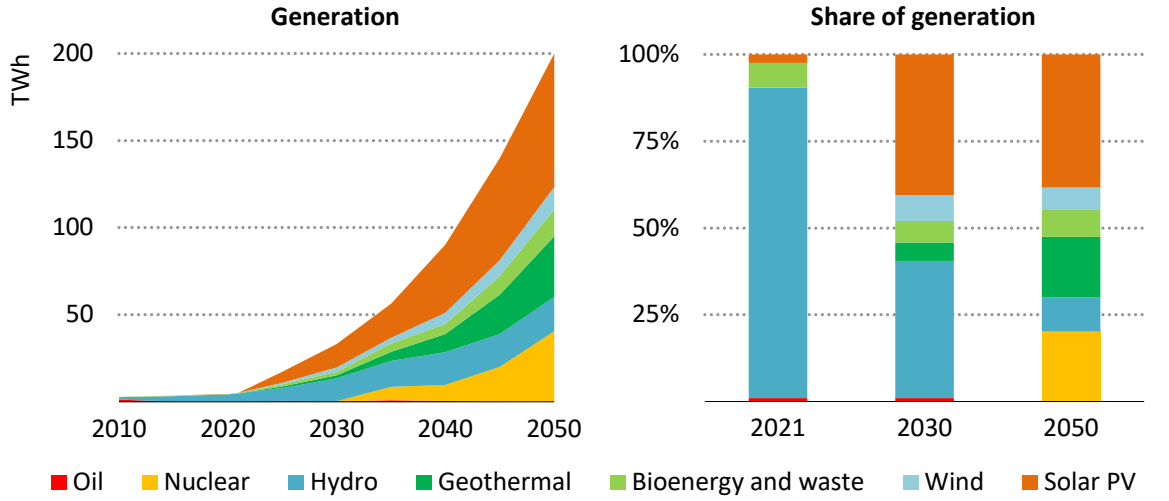


Fuelled by industry and rising levels of electricity consumption in buildings, electricity consumption grows around forty-fold by 2050.

Electricity demand is overwhelmingly met by low-emissions sources in the ETP. Uganda's electricity generation mix is already 99% low-carbon, with 90% from hydropower generation. The remaining non-renewable generation is oil-based – largely a stopgap measure to shore up reliability and cover demand when hydropower may not be available. The ETP aims to diversify Uganda's generation mix to avoid relying too heavily on any single power source. While oil-based generation does expand in the near-term, it is used sparingly to manage costs, and as grid operations and reliability improves, its use declines further. In 2035, the country's electricity low-carbon generation mix is more diversified. Renewable projects represent a least cost and secure generation option for Uganda, particularly solar PV, geothermal and hydropower.

Solar PV is the central technology used to expand electricity supply in the ETP. Although Uganda has less solar insolation than other parts of Africa, its solar resource profile remains better than many major solar markets today, with an average practical potential of 4.46 kWh/kWp/day, on par or above leading solar generation locations like Spain (4.41 kWh/kWp/day), China (3.88 kWh/kWp/day) and Germany (2.96 kWh/kWp/day). From 2021 to 2030, solar PV provides many of the new capacity additions due to its short project lead times and its modular nature. Accordingly, solar PV capacity expands from 0.06 GW today to 7.5 GW in 2030, and almost 45 GW by 2050. This means that by 2050, solar PV generates almost 40% of Uganda's electricity in the ETP. In 2050, around two-thirds of the solar PV installed is distributed, most of it is grid-connected, as stand-alone systems are increasingly absorbed by the grid over the course of the ETP.

Figure 2.22 Electricity generation by technology in the Energy Transition Plan, 2010-2050



The Energy Transition Plan pursues a balanced power mix, leveraging Uganda's plentiful renewables.

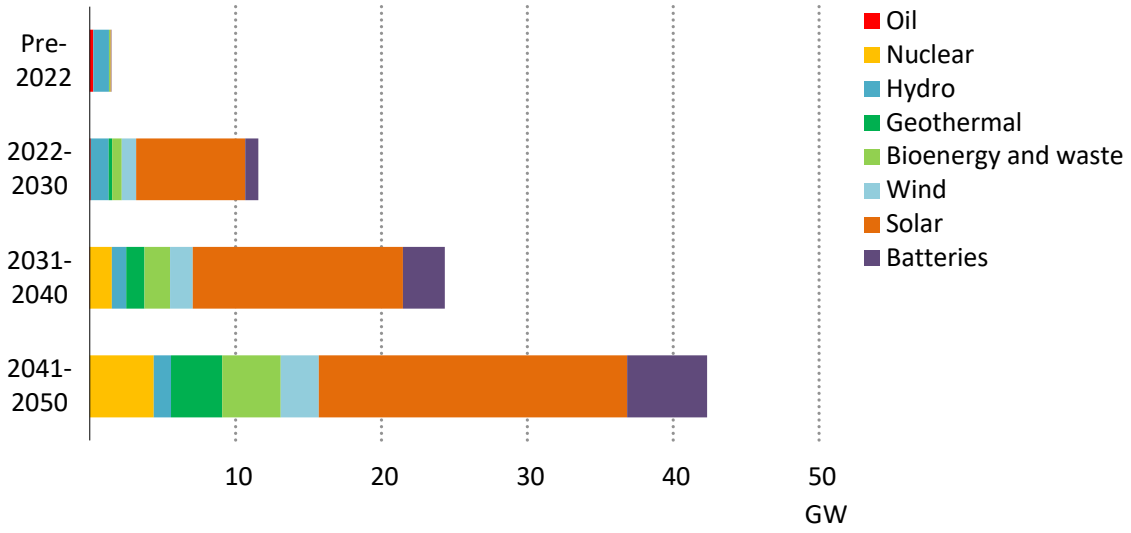
The potential of geothermal power is substantial and offers considerable flexibility, acting both as dispatchable, responsive capacity as well as base-load power when needed. The country's Western Region, specifically in the Uganda Rift System, offers significant opportunities for development of geothermal resources, with current government projections for 1.5 GW capacity by 2040, and expectations that much higher volumes could be tapped by using new drilling approaches and surveying additional sites. In the ETP, the long lead times mean that geothermal electricity does not begin to make a foothold in the generation mix until the 2030s, but domestic capacity increases as new projects proliferate, eventually reaching 5 GW in 2050 and generating over one-sixth of Uganda's electricity.

Hydropower is currently the largest source of electricity. With new sites limited and concerns around the impacts of climate change on water flows, capacity

expansions are limited from 1 GW in 2021 to 2.3 GW in 2030 and 4.5 GW in 2050. Wind power also plays a role, albeit smaller given limited resource potential, largely in the northeastern part of the country. Additionally, the country's sugar and agro-industries provide opportunities for using bioenergy as a sustainable source of dispatchable power. Bioenergy, which accounted for 7% of electricity generation in 2021, is currently used in several sugar processing plants to generate power for processing, with the excess electricity sold back to the national grid. In the ETP, Uganda's sugar industry and improvements in the collection and distribution of organic wastes to industrial facilities, such as forestry residues and municipal solid waste, mean that bioenergy and waste is anticipated to continue playing a small but important role in electricity generation.

Uganda's government has also stated its intention to pursue the development of nuclear power plants to improve both energy security and grid stability. It has announced plans to commission two nuclear power plants, the first of which will have a 1 GW capacity and come online in the early 2030s. The country is currently in Phase 2 of the International Atomic Energy Agency's Milestone Approach, meaning that the policy decision to pursue nuclear has already been made and the preparatory work for the contracting and constructing of the nuclear power plant is being undertaken. In the ETP, nuclear power continues to grow after the first plant comes online, reaching nearly 6 GW by 2050, providing 20% of Uganda's electricity. While large-scale reactors are currently the dominant form of nuclear power, technological developments and rising interest in small modular rectors means that these reactors could also play a role.

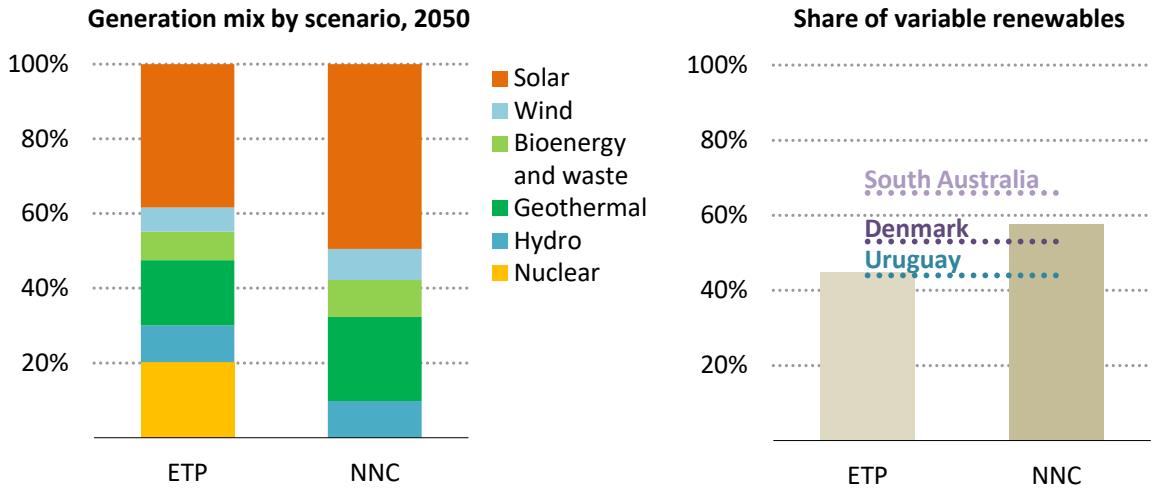
Figure 2.23 Power sector capacity additions by technology in the Energy Transition Plan, 2022-2050



Solar grows rapidly as a least-cost option. Capacity additions of nuclear and geothermal accelerate after 2030, as do batteries, enhancing grid stability and reliability.

Inherent to the development of a new nuclear programme is the uncertainty around suppliers, commission timelines and international approvals. Further, on a levelised cost basis, nuclear energy remains more expensive than other alternatives, notably solar. The firm power delivery and consistent availability of nuclear means it provides reliability value that solar does not on its own but can in concert with other generation sources and batteries. As a result, a No Nuclear Case (NNC), where the planned facilities do not come online in the expected timeline, is explored. This sensitivity case finds that even without nuclear power, Uganda has sufficient domestic renewable resources, including dispatchable renewables, to meet its energy demand. In the NNC, solar replaces over half of the generation gap left by nuclear and increases to 50% of total generation in 2050. Physical limits with hydropower mean that the remaining gap in nuclear generation is spread across geothermal, bioenergy and wind. In this no nuclear sensitivity case, the share of variable renewables increases by 13% compared to the ETP, reaching 58% of generation by 2050. This level is within the ranges seen in other geographies such as Denmark and South Australia. Like these areas, Uganda is also interconnected with other regional electricity networks, which further enhances its energy security.

Figure 2.24 Electricity generation by technology and share of variable renewables in the Energy Transition Plan and No Nuclear Case, 2050



Uganda's share of variable renewables would be within levels seen globally today, even if nuclear projects do not materialise.

Notes: NNC = No Nuclear Case; variable renewables = solar and wind. Uruguay, 2020; South Australia, 2021-2022; Denmark, 2021.

In either the nuclear or no nuclear case, there is an increased focus on developing a suite of flexibility options to contend with rising levels of variable renewables, as well as increasingly peak end-user demand. Dispatchable or semi-dispatchable sources like geothermal, hydro, bioenergy and nuclear already meet most of the

flexibility needs in the ETP, and in total reach almost 55% of generation in 2050. These resources also help reduce reliance on oil-fired thermal power for peaking, however this capacity stays online for emergency situations, and supports different key grid functions like black start capability. After 2030, grid-connected batteries come online, contributing to greater operational flexibility, especially in short timescales, as well as enhancing the resilience of the grid. Battery storage plays a small but important role to 2030 before scaling up to almost 9 GW in 2050 thanks to cost reductions globally. Another very important aspect of flexibility is greater grid interconnectivity to neighbouring regions and enhancing grid operation paradigms. Designing electricity systems and markets to facilitate more fluid electricity exchanges with other countries in the future is critical to ensuring Uganda benefits from initiatives such as the Africa Single Electricity Market and Continental Power System Masterplan.

Box 2.2 The importance of grid infrastructure in powering Uganda's energy transition

Grid infrastructure is a bottleneck in Uganda's existing energy system. Investment in expanding generation infrastructure has not been co-ordinated or linked with spending on transmission and distribution infrastructure. Coupled with a low demand for electricity, some of the country's generation capacity is underused. The inclusion of take-or-pay clauses in purchase power agreements (PPAs) with many generators means that the government still needs to pay for deemed energy even if it cannot be used, heightening the cost of power and contributing to the country's high residential tariff rates.

The government has ceased signing take-or-pay PPAs with deemed energy clauses and signalled plans to invest in developing grid infrastructure. The National Energy Policy for Uganda 2023 outlines a range of policies and strategies for "expanding electricity transmission and distribution grid networks". Prior to this, the national transmission operator, Uganda Electricity Transmission Company Limited (UETCL), published the Grid Development Plan 2018-2040, which forecasted the grid expansions and investments required under different scenarios. The National Electrification Strategy (2021-2030), meanwhile, forms the basis of the grid expansion and connectivity component of the World Bank's Electricity Access Scale-up Project. This project will provide Uganda with nearly USD 360 million for grid expansion and connectivity.

Expansion of grid infrastructure is crucial for supporting Uganda's energy transition. A recent IEA report on Electricity Grids and Secure Energy Transitions concluded that without sufficient investment, grids could become the "weak link" of the energy transition. On the supply side, insufficient transmission infrastructure and connection queues can produce bottlenecks for bringing new renewable assets online. In Uganda new high voltage grid infrastructure can take six to ten

years from planning to completion compared to one to five years for new renewable projects. Timelines for distribution projects are typically much shorter, ranging from a few months to a couple of years depending on the project scale, which enabled the country's distribution network to expand by nearly 40% in the past five years. On the demand side, expanding distribution infrastructure is critical for increasing electricity access and enabling electricity demand to grow in order to support electrified end uses, rising living standards and industrialisation.

Financing presents a key challenge to improving and expanding grid infrastructure. The country's low income levels and relatively high electricity tariffs have combined to limit the number of customers connecting to the existing grids and paying for electricity. In turn, lower government revenues from electricity tariffs have limited the funds available for financing expansions and improvements of grid infrastructure. The high cost of capital and low levels of engagement of private sector actors due to regulatory barriers present further challenges.

With Uganda already facing bottlenecks in energy supply due to infrastructure, electricity grids are also critical for the country's energy transition. As grid connectivity rates increase, funds available for grid expansion should grow and recent reforms will enable greater private sector involvement in the transmission sector. Further actions, namely increasing investment in grid infrastructure, integrating the ETP with long-term planning for distribution and transmission, and leveraging regional integration and digitalisation opportunities, are necessary to power Uganda's energy transition.

Regional Energy Hub Case

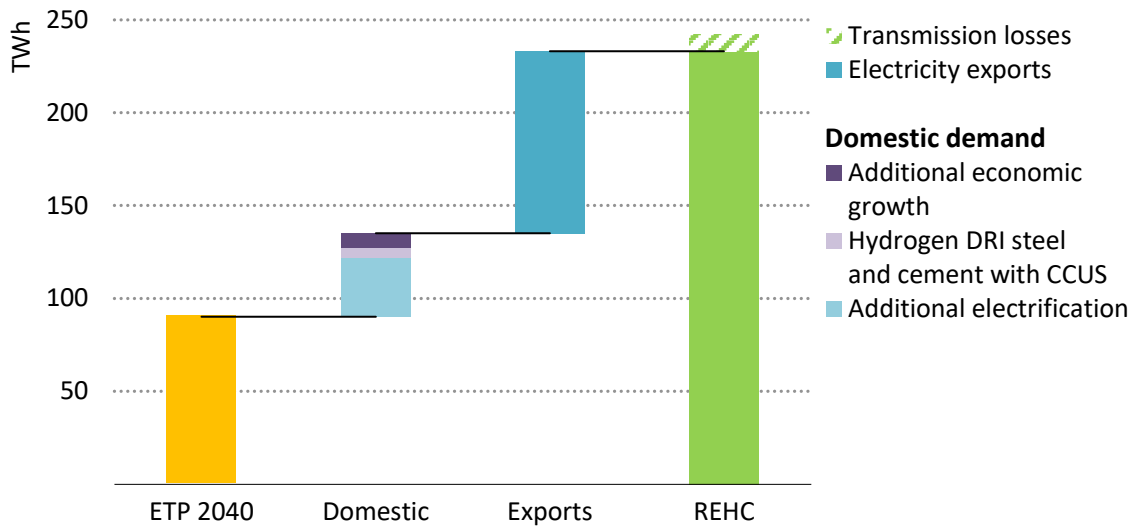
On top of the power sector expansion required to support rising domestic electricity demand, Uganda has ambitions to become a regional supplier of energy. The Energy Policy for Uganda 2023 states that by 2040 the country aims to have around 52 GW of installed capacity, which at healthy levels of utilisation would generate about 240 TWh annually, much higher than the domestic supply of 90 TWh in 2040 in the ETP. In order to use these generating assets economically, Uganda would need to stimulate more demand. The ETP's alternative Regional Energy Hub Case (REHC) explores various levers that can be used to increase electricity use by 2040, including advancing domestic electrification efforts, accelerating the deployment of low-emissions hydrogen production for steel and fertilisers, and CCUS in cement and increasing regional exports. Higher exports of electricity could also generate a marginal increase in economic growth, which in turn could stimulate more domestic energy demand.

The search for cultivating additional electricity demand should first start domestically. There are opportunities to accelerate both vehicle and cooking electrification, while also furthering emissions mitigation efforts. Uganda must

commit to these efforts early if sufficient electricity demand is to materialise by 2040. With additional initiatives, electrification could help raise demand by over 30 TWh by 2040 in the REHC.

Another option would be developing low-emissions hydrogen production and CCUS projects early to stimulate more electricity demand. Post-2030, all crude steel production capacity in the ETP is hydrogen-ready, which would be a clear off-taker for low-emissions electrolytic hydrogen production, as would the refining and fertiliser segments. Additionally, adding CCUS to cement production would represent a net carbon sink, capturing both the process emissions as well as those from sustainably harvested biomass. Such operations would be clear candidates for carbon credits and offsets. Uganda could also increase its cement and crude steel production to meet a higher share of domestic demand for these commodities, with an estimated potential to grow another 20% based on current plans. These efforts together would result in almost 6 TWh of domestic electricity consumption by 2040 in the REHC.

Figure 2.25 Electricity generation in the Energy Transition Plan and Regional Energy Hub Case, 2040



In the Regional Energy Hub Case, Uganda becomes a major regional exporter of electricity and producer of energy-intensive products, unlocking further economic growth.

Notes: REHC = Regional Energy Hub Case. CCUS = carbon capture, utilisation and storage. DRI = direct reduced iron. All steel produced via hydrogen DRI are assumed to use low-emissions electrolytic hydrogen.

Efforts to bolster domestic demand ultimately only close a portion of the gap in the REHC, at which point Uganda would need to look to secure contracts with neighbouring countries to off-take its electricity generation. In 2021, Uganda exported 395 GWh of electricity to Kenya, Tanzania, Democratic Republic of Congo (DRC) and South Sudan, some 8% of its power generation. In the REHC,

Uganda exports almost 100 TWh of electricity to neighbouring countries. This is equivalent to around 40% of total electricity generated, below leading exporters like Paraguay and Bhutan today. Co-ordinating and securing long-term, cross-border contracts poses challenges to this regional plan, which is important to ensure healthy utilisation of power generating assets across the wider East African Power Pool. The additional electricity sales and production of cement and steel also further stimulate economic growth in Uganda, and would contribute to stronger energy demand.

Together, these additional efforts to boost domestic electricity demand alongside exports would help power sector capacity in the REHC reach a healthy range of operation and cost-recovery. If well-co-ordinated, they could also reinforce wider East African plans for extending access, building up key infrastructure, and cultivating new industries. The acceleration of these measures would also result in a further 1.7 Mt of CO_2 abatement in 2040 in the REHC compared to the ETP.

2.7 Energy supply

2.7.1 Oil production

Uganda is scheduled to begin commercial oil production in 2025 from discoveries in the Lake Albert basin, also known as the Albertine Graben. Uganda's recoverable oil resources are estimated at around 1.7 billion barrels, accounting for less than 1% of the total recoverable oil resources in Africa. On the basis of already discovered resources and the anticipated ramp up in production from projects under development, oil production reaches around 250 kb/d by 2030, before declining by around 6% per year on average to 2050. In 2030, the Tilenga project provides over 80% of total production, with the rest coming from the Kingfisher project.

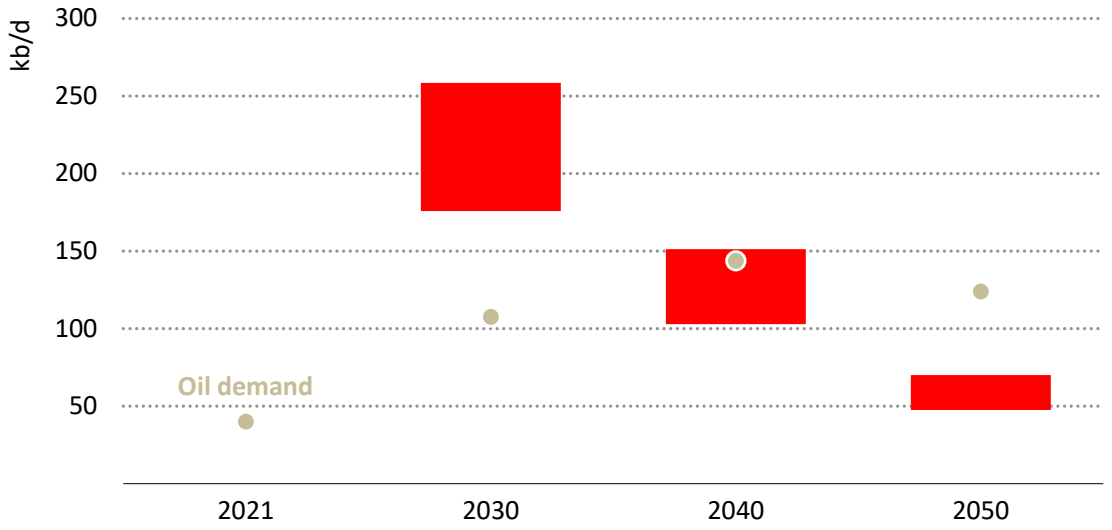
Box 2.3 Oil production in the Albertine Graben

The Albertine Graben is a 500 km long the rift valley in the Western Region of Uganda and neighbouring Democratic Republic of Congo. Oil deposits in the region around Lake Albert were first discovered in 2006, with total oil in place reserves estimated at 6.5 billion barrels, of which 1.7 billion barrels are deemed recoverable. There are additional gas resources associated with this oil production and separate deposits, which together amount to nearly 17 billion cubic meters. The oil deposits in the Albertine Graben are heavy, waxy crudes and tar sands that pose more challenges than lighter crude oils. For example, complex and more expensive energy-intensive extraction methods such as steam injection are

required to produce oil from the reservoir, and pipelines would need to be heated to maintain a viscosity that can be transported.

A consortium of TotalEnergies E&P Uganda B.V., China National Oil Corp, Armour Energy Ltd (AEL), Oranto Petroleum Ltd (OPL), Tullow Uganda Operations Pty (TUOP) and Uganda National Oil Company (UNOC) have been awarded the production contract. These three main upstream investors are also developing a crude oil pipeline in partnership with the Tanzania Petroleum Development Corp, with exports to international markets via the port of Tanga in Tanzania. A planned refinery at Hoima has capacity to provide both domestic and regional markets with oil products. The Tilenga and Kingfisher oilfield sites as well as the East African Crude Oil Pipeline have been criticised for their impacts on the environment and local livelihoods. As a result, these projects have faced difficulty securing financing, which has delayed the development schedule.

Figure 2.26 Crude oil production range and oil demand in Uganda, 2021-2050



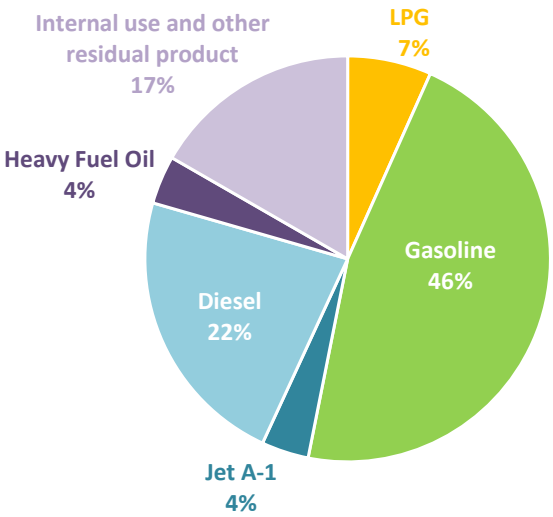
Uganda's oil production is set to reach around 250 kb/d in 2030 before gradually falling below 70 kb/d in 2050.

Note: Ranges reflect a number of production projections assuming a 2025 start date for projects. The top end of the range corresponds to production levels in the Stated Policies Scenario (STEPS).

The proposed Hoima oil refinery would allow Uganda to refine some of this production domestically to meet growing demand for oil products. The 60 kb/d refinery would produce around 40 kb/d of gasoline and diesel, which would be just above Uganda's peak demand for these fuels at around 35 kb/d in 2040 in the ETP. However, demand for refined oil products continues to grow in neighbouring regions that depend on fuel deliveries through Uganda. Transport oil demand in

the rest of East Africa is approximately 180 kb/d today, around eight times higher than in Uganda, and would be able to absorb surplus refining output, as East Africa currently has no operating refineries.

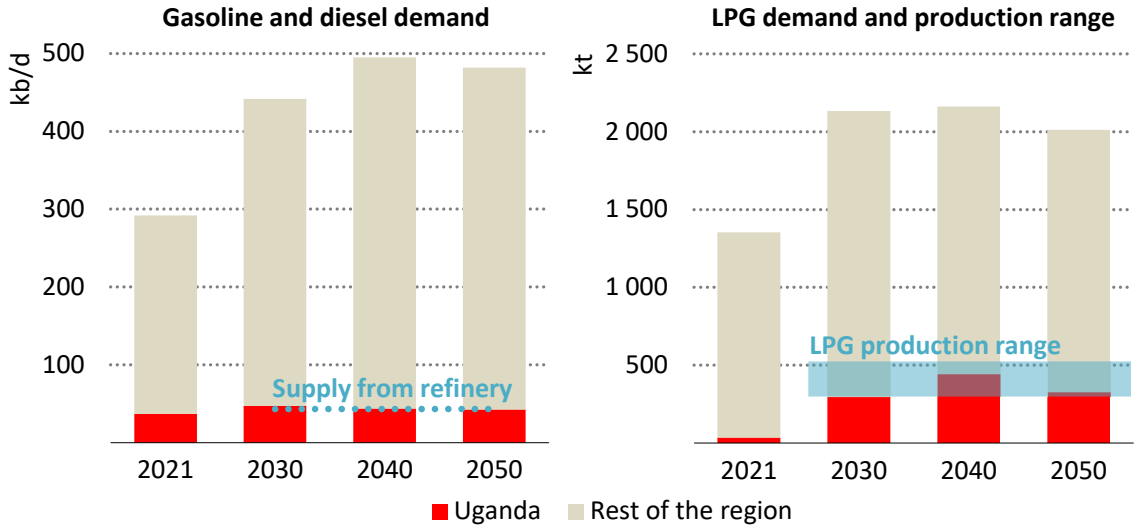
Figure 2.27 Composition of Hoima oil refinery production



Transport fuels account for around three-quarters of the production from the planned refinery in Hoima.

Source: IEA based on data from the Ugandan government on projected production at the Hoima oil refinery.

Figure 2.28 Gasoline, diesel and LPG demand in the Energy Transition Plan, 2021-2050



Planned refining capacity would be sufficient to meet Uganda's transport oil demand in the ETP. Similarly, LPG production could cover most, if not all, of the country's demand.

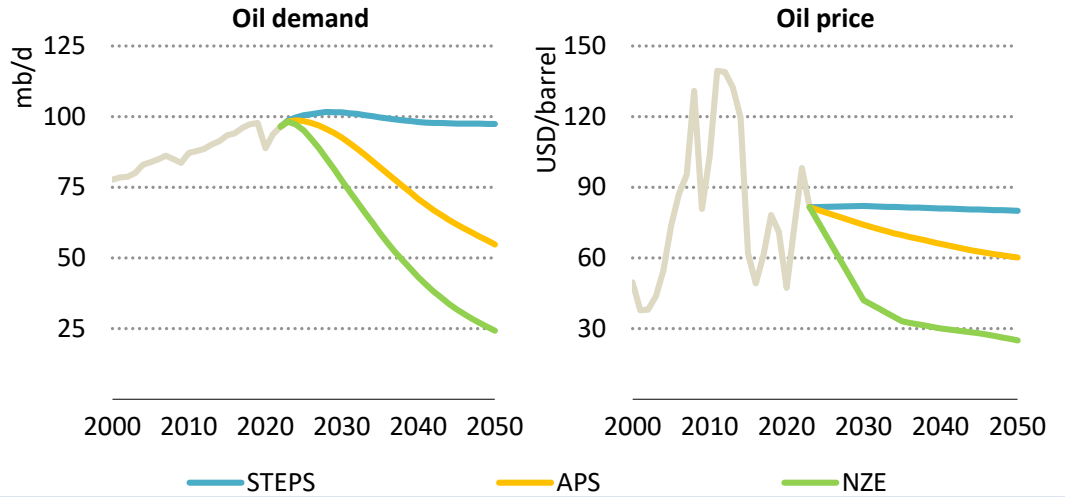
Notes: Rest of the region = Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan and Sudan. Gasoline and diesel demand projections in the rest of the region are based on the IEA's Sustainable Africa Scenario.

Butane and propane gasses, the constituent gasses of LPG, would also be produced from Uganda's oil fields, and would be a by-product of the refining process. Current refining splits today plus expected recovery from Kingfisher and Tilenga oil fields would produce an estimated 300-500 kt per year of LPG. The upper range would cover expected LPG demand in the ETP. Depending on the composition of the gasses produced, Uganda may still need to import propane and butane to ensure a blend that can be safely used in LPG cannisters across the range of climate conditions in the country.

Box 2.4 An evolving global outlook for oil

In the World Energy Outlook 2023, the IEA's Stated Policies Scenario (STEPS) now, for the first time, sees a peak in the demand for all three major fossil fuels – coal, oil, and gas – by the end of this decade at the global level. In this scenario, oil demand peaks just above 100 mb/d before gradually declining, with rising consumption in emerging market and developing economies offsetting declines in advanced economies and China. As demand weakens, global oil prices are set to stay well below historic highs as the clean energy transition continues to accelerate. Oil prices in the STEPS are expected to remain around USD 80/bbl through 2050.

Global oil demand and crude price by scenario, 2000-2050



Under today's policies, oil demand peaks this decade, with accelerated climate action poised to reduce demand faster. Prices, accordingly, are set to stay below historic levels.

Note: STEPS = Stated Policies Scenario, APS = Announced Pledges Scenario, NZE = Net Zero Emissions by 2050 Scenario.

However, the world has set more ambitious targets for curbing emissions than outlined in the STEPS. As countries take additional measures to align with these targets, oil demand and prices are set to fall even further. In the Announced

Pledges Scenario (APS), which reflects all national climate pledges being met on time and in full, oil prices average a lower USD 75/bbl by 2030 with demand estimated at around 90 mb/d in 2030, before declining to 55 mb/d by the middle of this century. Demand and prices are projected at even lower levels in Net Zero Emissions by 2050 Scenario (NZE Scenario).

These changing trends could significantly impact oil and gas producers profit returns. If oil prices evolve as expected in the NZE Scenario, developing new resources may not generate substantial returns or fiscal income from oil and gas sales. Speed to market, strong environmental performance, low-cost, and low-emissions intensity production all benefit new producers. More details on measures producers can take to reduce methane emissions are discussed in section 2.8.2.

2.7.2 Modern bioenergy

Bioenergy plays a major role in the country's energy sector and will continue to in the future, but at much lower levels by 2030. At the same time, the composition of bioenergy sources will change, moving away from largely foraged solid biomass to more modern sources, notably liquid biofuels, biogas, and modern solid biomass. The types of bioenergy used varies across buildings, transport and industry, as do the technologies used to produce, process and use this bioenergy.

Overall, bioenergy final consumption decreases by half to 2030, mainly driven by the rapid shift from the traditional use of solid biomass to modern fuels and more efficient stoves. After that initial push on cleaner cooking, demand for solid biomass in cooking decreases, but modern bioenergy continues to grow in the power sector and to a lesser extent the transport sector.

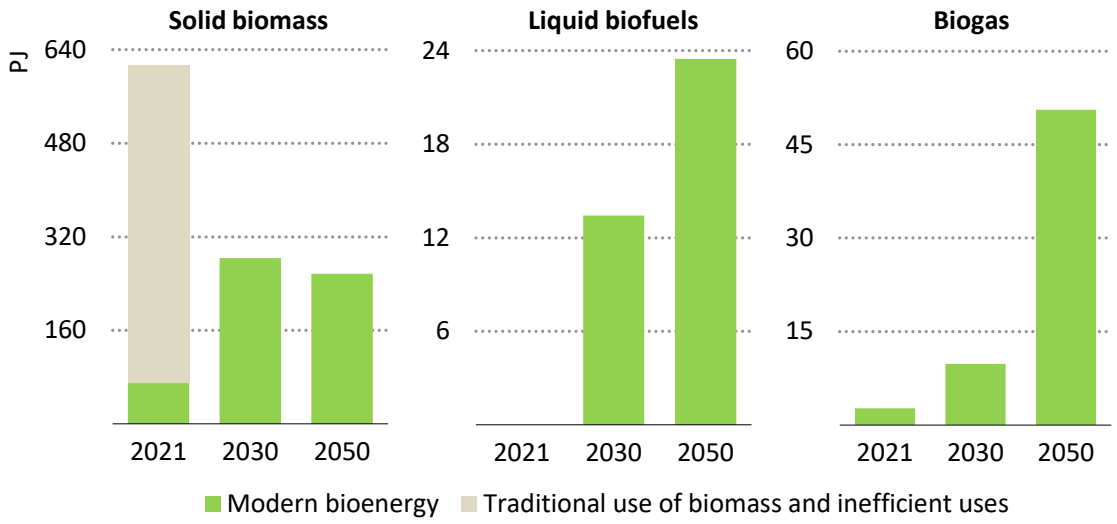
Around 480 PJ of solid biomass is currently used for cooking and water heating in the residential and the services sectors. Most of this is in the form of firewood, with charcoal providing around 20% of demand, largely in urban areas. Solid biomass burned in industry accounts for 125 PJ and another 7 PJ are used to produce more than 7% of the country's electricity demand today, mainly in auto production plants running on bagasse and other agriculture wastes.

Firewood is by far the largest source of solid biomass today. Two-thirds of residential firewood is collected by users directly from the forests or green areas, while another quarter rely on their own plantations. A high share of the solid biomass is unsustainably produced, putting pressure on forests, especially in the case of charcoal, which is mostly produced illegally in traditional and inefficient kilns. Production hot spots are gradually moving further away from urban areas where charcoal consumption is the highest, increasing transport costs. In the ETP,

charcoal production is steadily more regulated, eliminating unsustainable operations by 2030. Reductions in demand for charcoal in the ETP are steep and impact the many informal workers producing, transporting, and selling it today. Particular attention will need to be paid on how to manage the negative impacts on the labour force, with programmes that can help connect these workers to new jobs in access provision.

Modern solid biomass demand grows in power generation and the industry. In power generation, most of this is in the form of wood waste, processed biomass in the form of wood briquettes, and agriculture residues such as bagasse. Demand for these grow threefold to 2030, although attention needs to be paid to ensure security of supply at low-cost to meet subsequent growth after that point, with a particular eye towards seasonal variations in their production. By 2050, solid biomass used in the power sector represents around 55% of total solid biomass demand, followed by the industry and the services sector, with very little use remaining in residential.

Figure 2.29 Bioenergy demand by type in the Energy Transition Plan, 2021-2050



The modernisation of fuel use in Uganda decreases biomass demand in buildings, but demand rises in the power, transport and industry sectors.

Notes: Traditional use of biomass is used for cooking and water heating in the residential and services sectors. Inefficient uses refers to the inefficient use of solid biomass in industry for heat raising purposes. This graph includes only energy uses in final consumption and the power sector and excludes uses in the energy sector for transformation and own use (e.g. charcoal production).

Liquid biofuels consumption today is negligible, with only a small amount of bioethanol used for cooking. By 2030 liquid biofuels supply grows to 13 PJ, driven by biofuel blending requirements increasing for transport fuels and an expansion of bio-ethanol use in the residential sector. Growth continues to 2050, as the demand for liquid biofuels reaches 23 PJ, although the rapid uptake of electric

vehicles limits demand growth coming from transport. Uganda plans to produce most of its biofuels domestically, relying mostly on local feedstocks – largely sugar – but this would be supplemented with imports from the region. The ETP focuses on increasing the sustainability of biofuel harvesting practices, maximising the use of agricultural residues and waste, especially from the thriving sugar industry.

Biogas production, mainly in small biodigesters to satisfy cooking and water heating needs, is limited to just 3 PJ today. However, small biodigesters continue to be increasingly deployed in the ETP to support goals on universal clean cooking access. Demand, including for bio-LPG, rises almost 20 times, to more than 50 PJ by 2050. The increased use of biogas from recovered landfill and sewage waste in power generation and industry also contributes to stronger growth, representing around 20% of biogas demand by 2050.

2.8 Emissions

Mitigating energy-sector emissions is a cornerstone of the Energy Transition Plan. Uganda's ETP outlines the importance of GHG emissions reductions linked to a greater access to clean cooking, but also the opportunities for a faster shift toward clean energy and a more sustainable growth beyond 2030. The ETP is guided by the current Nationally Determined Contribution (NDC), but then continues to pursue other cost-effective mitigation levers to contribute to the collective effort of reducing global greenhouse gas emissions.

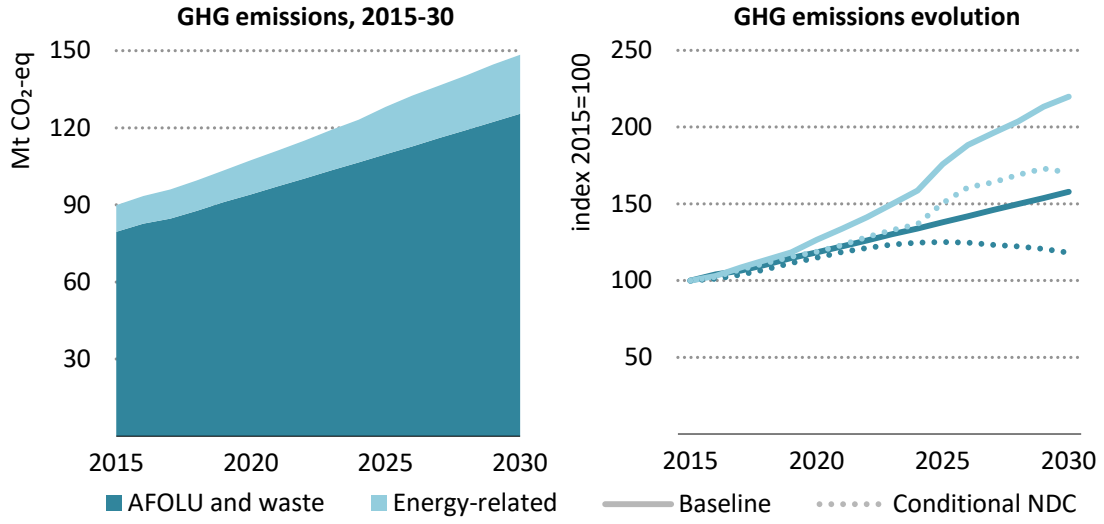
2.8.1 Uganda's emissions and current targets

Today, energy represents only a small portion of Uganda's emissions but is set to steadily grow. The country emitted roughly 115 Mt CO_2-eq of GHG emissions in 2021. The energy sector currently accounts for about 15% of the greenhouse gas (GHG) emissions, with the vast majority from the agriculture, forestry and other land-use (AFOLU) and waste sectors. Energy-related CO_2 emissions rose steadily over the past two decades, reaching 7 Mt CO_2 in 2021. Transport and industry sectors are the main drivers of the growth in emissions, accounting for about 55% and 35% of 2021 CO_2 emissions respectively. Oil products are the largest source of energy combustion emissions today, although the recent increase in coal use in industry has contributed substantially to a faster rise since 2015. Energy-sector methane and nitrous oxide emissions are largely associated with traditional use of biomass for cooking, and have risen alongside the growth in households without access to clean cooking to 13 Mt CO_2-eq in 2021.

Energy sector emissions are set to increase substantially in the decade, but Uganda has pledged efforts to manage this growth by 2030. According to its updated Nationally Determined Contribution (NDC), submitted in September 2022, Uganda committed to unconditionally reduce its economy-wide emissions

by 5.9% compared to its baseline scenario in 2030, which would imply total emissions at 140 Mt CO_2-eq by the end of the decade. Conditional to international finance, capacity-building and technology transfer support, Uganda aims to raise its mitigation target to 24.7% compared to its baseline scenario, or 112 Mt CO_2-eq by 2030. These targets are for economy-wide emissions of CO_2, CH_4, and N_2O, and suggests that 80% of the emissions reductions needed to hit the target come from the AFOLU and waste sectors. This means energy-related emissions are expected to reach around 18 Mt CO_2-eq in 2030 in the conditional NDC[2].

Figure 2.30 GHG emissions profile and evolution by sector in Uganda's Nationally Determined Contribution, 2015-2030



Although AFOLU and waste are the main contributors of GHG emissions, energy-related emissions are set to double by 2030 compared to 2015 without new mitigation measures.

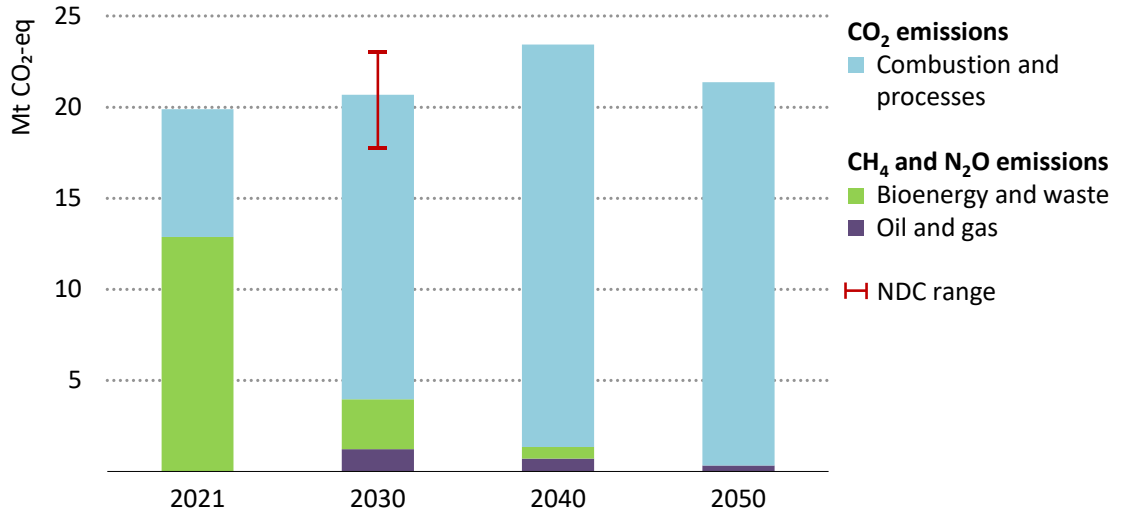
Source: IEA based on data from the Updated First Nationally Determined Contribution (2022).

2.8.2 Energy sector emissions

The ETP delivers on Uganda's conditional NDC, while including a higher provision of energy services than originally intended. In the ETP, energy-related GHG emissions reach just above 20 Mt CO_2-eq by 2030, in the range of Uganda's NDC mitigation target. The NDC itself sets much lower levels of electricity access than the ETP, which contributed to higher near-term emissions, but stronger efforts on clean cooking helped reduce methane and N_2O emissions from burning biomass. Clean cooking's reductions of methane and nitrous oxide more than offset the methane emissions increase from Uganda's oil industries coming online this decade. CO_2 emissions reach almost 16 Mt by 2030, while methane and N_2O decline to 4 Mt CO_2-eq in 2030 from 13 Mt CO_2-eq today.

[2] IEA's definition of energy-related emissions is wider than the IPCC classification, and includes energy and manufacturing industries (1.A), transport (1.B) and industrial processes (2.).

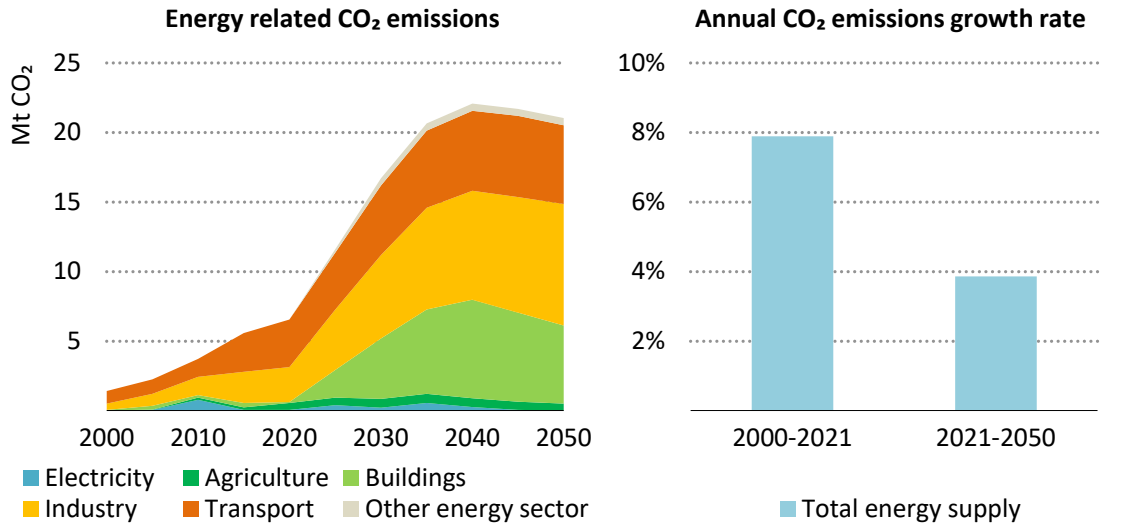
Figure 2.31 Energy-related GHG emissions in the Energy Transition Plan, 2021-2050



Energy-related GHG emissions are mostly driven by fuel combustion and processes, with limited flaring methane emissions. Traditional biomass use is eventually phased out by 2050.

After the NDC is achieved, CO_2 energy-related emissions continue to rise in the ETP, peaking at 22 Mt CO_2 in 2040. Increasing electrification in transport and residential buildings, coupled with a fully decarbonised electricity grid, enable emissions to peak and set the stage for a plateau and decline in the 2040s. Overall, the ETP sees emissions growth rate halved between 2021 and 2050, compared to the past two decades, reaching a 4% annual increase.

Figure 2.32 Energy sector combustion and process emissions and annual growth rates in the Energy Transition Plan, 2000-2050

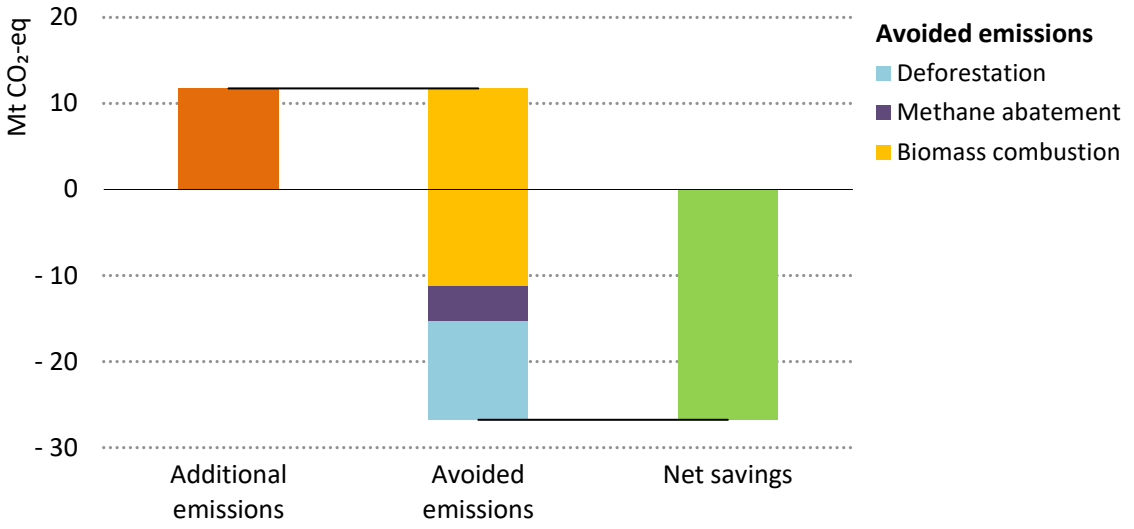


The Energy Transition Plan sees emissions increase to a slower rate than the past two decades, peaking in 2040 and decline towards 2050.

Note: Estimates do not include traditional use of biomass.

Methane becomes an increasingly important focus for Uganda in meeting its greenhouse gas emissions targets by 2030, as its oil production comes online in the coming years in the ETP. The IEA's Global Methane Tracker identifies best practices for both policies and regulations to mitigate the risk of fugitive emissions. This includes notably zero non-emergency flaring and venting, leak detection, repair mandates and technology standards. Best practices are outlined in the ETP to address fugitive methane emissions from these projects. The Tilenga oil project, set to start up in 2025 and projected to produce around 190 kb/d at its peak, is expected to emit about 13 Mt CO_2-eq over the whole lifetime. This project faces lower risks of fugitive emissions, both due to the type of waxy crude oil produced, which is commonly associated to lower emissions, and no routine flaring and methane emissions. The emission intensity of the project is expected to reach on average 13 kt CO_2-eq/mboe, below the world average of about 40 kt/mboe in 2022, and well below other oil fields in the region (81 kt/mboe in Nigeria, 98 kt/mboe in Algeria). Overall, IEA's estimates for methane emissions reached on average 0.9Mt CO_2-eq every year in Uganda, and up to -1.2 Mt CO_2-eq at its peak.

Figure 2.33 Change in major energy-related sources of methane and N_2O emissions in the Energy Transition Plan, 2021-2030



Universal access to clean cooking initially increases fossil fuel demand, but it ultimately leads to significant emissions savings through reduced combustion and deforestation.

Traditional use of biomass also represents an important driver in GHG emissions, and is a key element to mitigate missions for the country. In 20 years, biomass-related emissions increased by 75%, reaching 25 Mt CO_2-eq in 2021. Methane emissions, associated with the combustion of the fuel, and indirect emissions related to deforestation are the main sources for this increase. Achieving universal clean cooking access by 2030, as set in the ETP, results in a net reduction in emissions to 3 Mt CO_2-eq. Even those households relying on improved biomass

cookstoves in 2030 emit far less methane due to reduced use of biomass per meal cooked. With the ETP's target of 100% modern cooking solutions by 2050, bioenergy methane emissions fall substantially over the same period. In addition to the reductions in direct methane emissions, the shift away from harvested biomass reduces strains on deforestation, particularly from the charcoal industry in the Northern Region. An estimated 60% of the 120 000 hectares of forests are cleared each year as result of harvesting for firewood and charcoal.

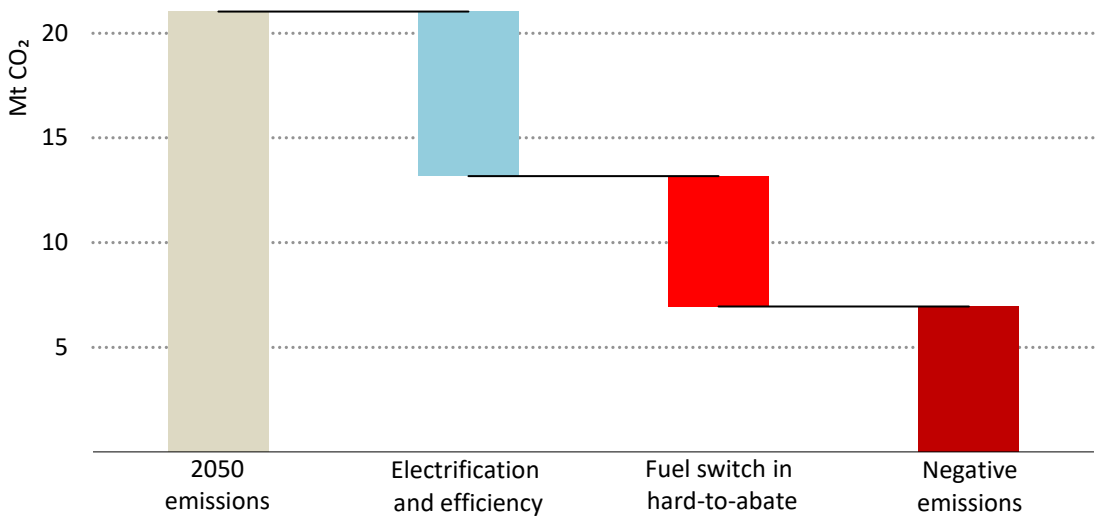
2.8.3 The road to net zero emissions

After peaking in 2040, energy-related emissions will continue to decline, putting Uganda in range for reaching net zero emissions in the energy sector in the following decades. In the ETP, Uganda's energy-related emissions would fall from peak levels in 2040 to around 21 Mt CO_2 in 2050. To successfully achieve net zero emissions, additional actions are necessary beyond maintaining the pre-2050 policies in the ETP. Electricity meets 70% of additional growth post-2050 in the ETP, relying on Uganda's fully decarbonised power supply. The continued uptake of electric light-duty vehicles would yield a reduction of 2.7 Mt CO_2 in emissions by 2065. Continued shifting to electric clean cooking reduces emissions by another 4.8 Mt, along with continued efficiency measures and electrifying the services sector.

Additional efforts address remaining hard-to-abate sectors. Global advancements in research and development are contributing to new technologies and falling costs to address emissions in industry, heavy trucking, shipping and aviation, which can enable some of these evolutions in Uganda. The introduction of low-emissions hydrogen-based steelmaking could help cut emissions by 5 Mt CO_2, and existing natural gas-based DRI facilities built after 2030 are already built to run on hydrogen. Ramping up production of low-emissions hydrogen also supports use in fertiliser production, the petrochemical sector, and ammonia in shipping, among other applications. In cement, CCUS technologies help address process emissions and residual fossil fuel use, reducing emissions by approximately 3 Mt CO_2. In Uganda's cement sector, the high share of sustainable biomass used means that CCUS would be a carbon sink by capturing emissions from burning biomass as well, or so-call bioenergy energy with CCS (BECCS). Heavy trucking also sees rising shares of electrification, and some use of fuel-cell vehicles.

Negative emission technologies like BECCS or direct air capture, are required to reduce the remaining emissions. This approach allows for net zero in the energy sector without strong reliance on reforestation initiatives. Uganda's AFOLU emissions account for about 85% of emission today, and would need to be a key pillar for a broader economy-wide emissions reduction goal. Combined, these two negative emissions sources are used to offset almost 4 Mt CO_2 in the ETP.

Figure 2.34 Drivers of emission reductions in the energy sector after 2050



After peaking emissions in the 2040s, energy sector emissions are well-positioned to contract further, enabling Uganda to reach energy-sector net zero CO_2 emissions by 2065.

These measures could be realistically deployed in the span of 10-15 years and started even earlier than 2050. Accordingly, Uganda's ETP targets net zero emission in 2065 aligned with the end-year of the broader African Union's Agenda 2063. By doing so, Uganda would join the ranks of fifteen other sub-Saharan African nations, including Nigeria and South Africa, which have announced net zero emissions targets by 2050 or later. Having such ambitions could help unlock international support for a number of these deeper decarbonising measures, like low-emissions hydrogen-based steel, CCUS and direct air capture, which could benefit from carbon credits, climate finance and joint venture projects. Operating these projects would increase electricity demand by an estimated just over 30 TWh, and if developed earlier than 2050, could contribute to Uganda's vision in the Regional Energy Hub Case to develop its power generating capacity more rapidly.

Overall, such ambitions make Uganda a leader in decarbonising efforts. It also clearly signals the country's intentions to develop its energy sector in a sustainable, but realistic manner. This level of ambition is broadly consistent with decarbonisation trends in IEA's Sustainable Africa Scenario, with Uganda leveraging its diverse renewable energy resources to be a regional leader.

Table 2.2 Announced net zero emission pledges in sub-Saharan Africa

	Share of sub-Saharan Africa			Pledges
	Population	GDP	CO_2 emissions	
Cabo Verde	0.0%	0.1%	0.1%	Climate neutral by 2050
Côte d'Ivoire	2.3%	3.3%	1.7%	Climate neutral by 2030
Gabon	0.2%	0.7%	0.3%	Climate negative (achieved)
Gambia	0.2%	0.1%	0.1%	Climate neutral by 2050
Ghana	2.7%	4.1%	3.0%	Carbon neutral by 2060
Liberia	0.4%	0.2%	0.1%	Climate neutral by 2050
Malawi	1.7%	0.7%	0.3%	Carbon neutral by 2050
Mauritania	0.4%	0.6%	0.6%	Carbon neutral by 2030
Mauritius	0.1%	0.6%	0.6%	Carbon neutral by 2070
Namibia	0.2%	0.5%	0.5%	Climate neutral by 2050
Nigeria	18.1%	23.9%	14.4%	Climate neutral by 2050-70
Rwanda	1.1%	0.7%	0.2%	Carbon neutral by 2050
São Tomé and Príncipe	0.0%	0.0%	0.0%	Climate negative (achieved)
Seychelles	0.0%	0.1%	0.1%	Climate neutral by 2050
South Africa	5.0%	18.0%	55.6%	Climate neutral by 2050
Total	**32%**	**53%**	**78%**	

Chapter 3: Realising the Energy Transition Plan

3.1 Introduction

Achieving Uganda's Energy Transition Plan (ETP) requires a robust and comprehensive implementation strategy to mobilise the needed investment. The ETP calls for a steep increase in annual investment in the energy sector, reaching around USD 8 billion annually by the second half of the decade, with around USD 7.2 billion of this going to clean or access related investments. The high levels of investment remain constant after 2030, as demand for energy-related projects, both to maintain and further expand energy infrastructure, continues apace to meet the country's ambitious economic and social objectives. Over the next three decades, Uganda would require nearly USD 325 billion in the ETP, underscoring the need for building a sustainable investment model.

Accordingly, Uganda must work diligently, along with international partners, to identify and plan for necessary financing. To this end, it will be essential to implement a number of supporting, enabling measures that help de-risk investments and ensure the projects can be delivered in a timely, cost-effective manner, and that investors see sustainable and reliable returns on their financing. While the detailed, more rigorous plans needed to realise the ETP will be fleshed out in the forthcoming Integrated Energy Resource Master Plan, this chapter explores at a high level some of the measures Uganda can put in place to help secure this investment.

3.2 Investment

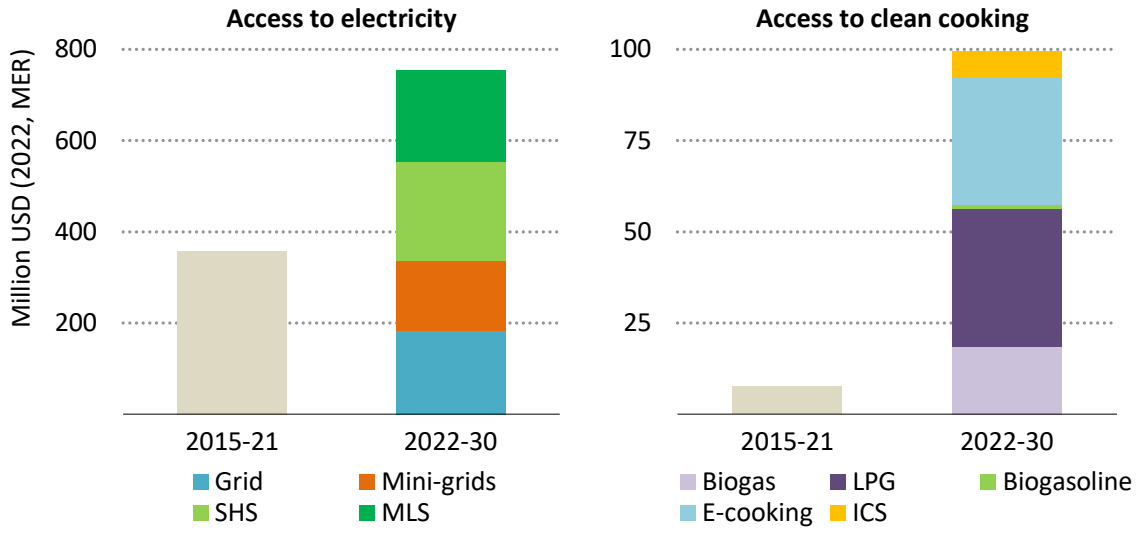
In the ETP, Uganda will need to attract investment for a wide array of energy and related plans, ranging from power generation and electricity access, to supporting consumer spending on efficient stoves, appliances and electric cars, among many other initiatives. The country will need to prioritise and commit to significant annual investments of around USD 850 million per year if it is to achieve universal access to electricity and clean cooking by 2030, in line with UN Sustainable Development Goal 7 (SDG7). Almost 90% of the funding is for electricity provision.

Historical investments in electricity access and clean cooking remain well below the required levels. Spending on electricity access will need to more than double, while clean cooking should increase thirteen-fold to reach the annual investment levels required in the ETP.

For electricity access, an estimated 25% of the required investments target grid infrastructure extensions and improvements, while off-grid solar home systems (SHSs) and multi-light systems (MLS) each account for nearly 30%, with mini-grids making up the rest. After 2030, there is still significant spending on improving electricity access, particularly to transition remote communities to mini-grids or grid connections as demand increases.

Clean cooking annual investments would need to reach USD 100 million in the ETP from now to 2030. Roughly one-third goes to e-cooking and another one-third to develop infrastructure for LPG, including refilling and storage units and cylinders. Biogas and bioethanol from local resources, such as agricultural waste and outputs from the sugar industry, account for around one-quarter of the annual investments in clean cooking solutions. Spending on improved biomass cookstoves are estimated at just USD 7 million (7%) per year. Attracting investment for clean cooking can be facilitated through the use of carbon markets, which provide an important revenue stream to these type of projects, rendering them more bankable for investors and affordable for end users.

Figure 3.1 Annual investments for electricity and cleaning cooking access in the Energy Transition Plan, 2015-2030



Achieving universal energy access will require investments of USD 850 million per year to 2030, of which nearly 90% targets electricity access and the remainder for clean cooking.

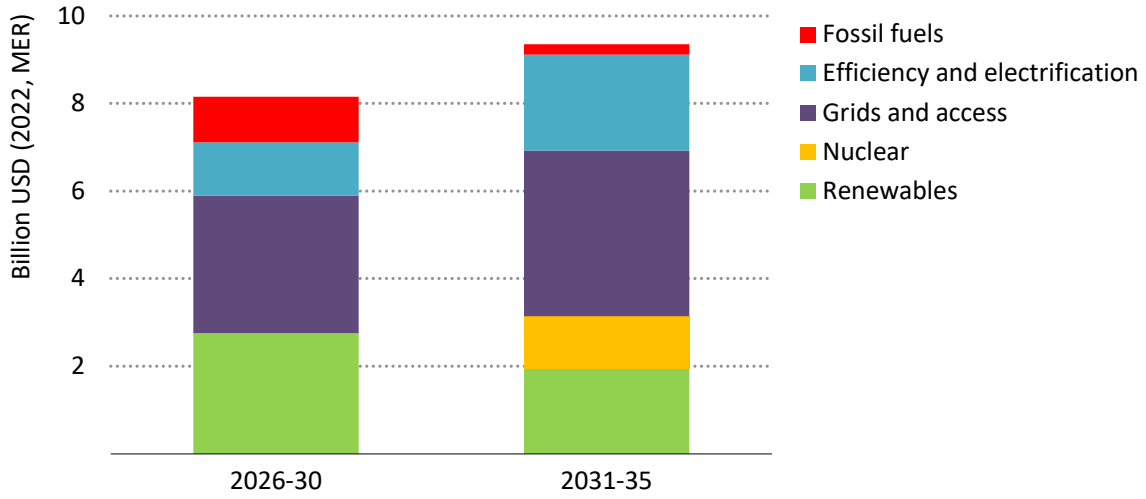
Note: E-cooking = electric cooking; ICS = improved biomass cookstove; LPG = liquefied petroleum gas; MER = market exchange rate; MLS = multi-light system; SHS = solar home system.

Power generation investment rises to around USD 2.8 billion per year from 2026 to 2030 in the ETP. Solar generation accounts for over 30% of the total clean energy yearly investment by 2030. However, post-2030, spending diversifies, and the share of investment for solar generation declines to 5% as Uganda's first

nuclear facility comes online. Concurrently, other renewable energy sources, such as geothermal, hydro, bioenergy and wind power, each consistently account for less than 7% of investment in 2030. In the short-term, oil-powered generation, both centralised and distributed diesel gensets, continue to be added to maintain grid stability and meet consumer requirements for greater reliability, and are expected to come in at around USD 80 million annually. A concerted focus on improving reliability in the near-term could help reduce this total.

This timeline reflects Uganda's current engagement in the preparatory phases under the International Atomic Energy Agency's (IAEA) Milestone Approach for the country's first nuclear plant. Following 2030, the investment in nuclear energy ramps up, with an allocation of a cumulative USD 6 billion from 2030 to 2040, and a further increase of USD 18 billion in the subsequent decade. This escalation in investment is in line with Uganda's ambitious plan to expand its nuclear capacity to 5.9 GW by 2050, with the goal to supply 20% of the nation's electricity. This capacity expansion not only reflects Uganda's focus on improving energy security and grid reliability, but also indicates a potential shift towards incorporating advanced nuclear technologies like small modular reactors in the future.

Figure 3.2 Average annual clean energy capital investments in the Energy Transition Plan, 2026-2035



Uganda must increase annual clean energy investments to around USD 7.2 billion by 2030, spread across electricity access, power generation, grid enhancements and end-use measures like access to clean cooking.

Notes: "Access and grids" includes battery storage. MER = market exchange rate.

Approximately USD 2.1 billion each year is allocated to extending, refurbishing, and upgrading electricity transmission and distribution grids. Around 40% of this total is high-voltage grid expansion and enhancements, which also contribute to cost savings by reducing losses and curtailment. The remaining 60% is in

distribution grids, where extending access and upgrading connection strength are the major investment drivers. After 2030, an increasing share of distribution system upgrades go to building out electric vehicle charging networks. Battery storage investments remain small this decade, mostly concentrated in off-grid systems, however in the early 2030s spending steadily climbs to around USD 300 million, which particularly helps minimise the use of oil-powered generation.

Investment in oil production and refining in the second half of the decade is concentrated in refining, with the Hoima facility being constructed during that time. Sustaining investments for oil production are also necessary after initial oil production slated in 2025. Total annual investments average around USD 1 billion from 2026-2030 for oil and gas supply, refining and processing. This falls substantially after the Hoima oil refinery is completed.

Investments on the demand-side also see a significant uptick in spending from current levels. Around USD 1.2 billion of investments a year are required for energy efficiency measures and the electrification of end uses. This financing spans energy efficiency retrofits of public buildings, developing electrified public transport, and industrial energy efficiency modernisation, among other measures.

Box 3.1 Capital investment needs in the alternative pathways under the Energy Transition Plan

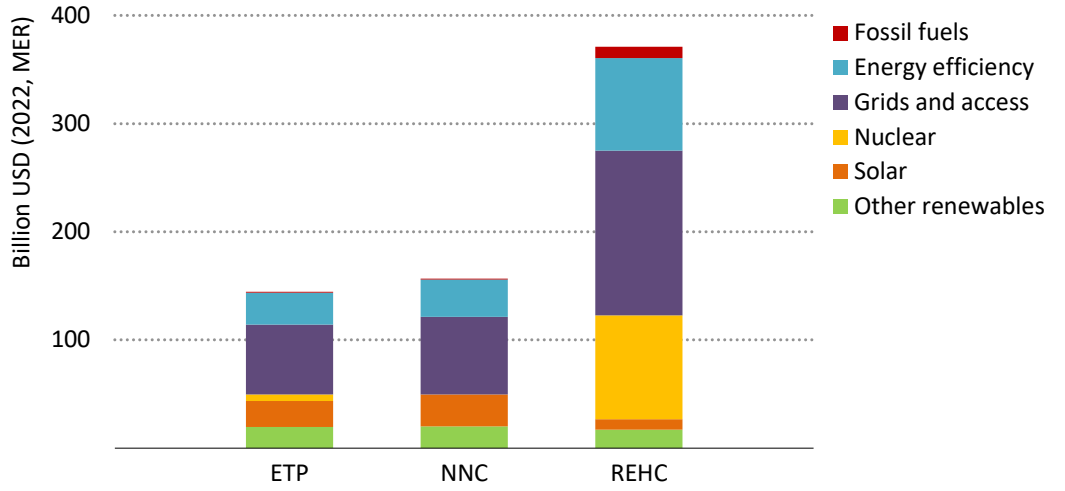
The two alternative scenarios explored in the ETP, the No Nuclear Case and the Regional Energy Hub Case, imply different investment profiles to 2040, particularly in the power sector.

The Regional Energy Hub Case (REHC) focuses on the additional measures required to achieve much faster expansion of mostly nuclear power generation capacity needed to support ambitions to raise exports of electricity to neighbouring countries (see section 2.6). The REHC, where Uganda has 52 GW of capacity in place by 2040, in line with its Vision 2040 development plan, shows that substantial capital investment will be needed to realise this plan, at over double that for the power generation capacity in the ETP to 2040. Most of the increase comes from the nuclear energy investments proposed. Successfully navigating the complexities of international regulatory compliance quickly and providing long-term visibility and assurance to investors will be crucial for this faster investment track to materialise.

Additionally, the REHC requires considerable investments in complementary grid infrastructure and electrification measures, particularly developing cross-border grid transmission, which can be particularly complex to fund due to the large scale

of the projects and the need for political alignment between multiple countries. In the REHC, cumulative grid investments to 2040 are nearly triple those in the ETP. That said, enhancing the grid infrastructure not only benefits Uganda's export ambitions in the REHC, but also improves energy security by strengthening the domestic energy system.

Cumulative capital investments in the power sector in the Energy Transition Plan and alternative cases, 2022-2040



Investment levels do not change substantially by pursuing a generation mix without nuclear in the ETP. However, the REHC requires much higher investment.

Note: REHC = Regional Energy Hub Case; NNC = No Nuclear Case. MER = market exchange rate.

The No Nuclear Case (NNC), conversely, requires a similar level of investment as the ETP. The NNC explores an alternative scenario to the ETP where substantial delays on nuclear procurement and approvals require pursuing an alternative power generation mix and capacity additions to meet electricity demand. It necessitates varied investment strategies to address demand growth, illustrating how a significant increase in investments can meet energy needs without nuclear energy development. This scenario sees slightly higher investment in additional grid-scale storage and grids to integrate a larger share of variable renewables, however the generation investment and costs remain lower. This pathway could also attract greater international support and financing, as there is less regulatory uncertainty on modular renewables like wind and solar and broader public consensus around funding renewable projects.

3.3 Financing

Achieving the investment needs outlined in section 3.2 requires the mobilisation of multiple sources of finance, therefore significant attention needs to be paid to attracting private institutions, especially to the power sector. Securing diverse streams of capital is needed given the investment scale but it also helps spread risks in a more balanced manner across players, reducing pressure on public finances and ensuring that energy services remain affordable for end users. Across sub-Saharan Africa, the private sector accounts for just over half of energy investments by 2030.

Currently in Uganda, the private sector is largely limited to the oil and gas sector in the energy system. Increasing the role of the private sector is key, given the much greater pool of finance available from these providers. This will be particularly true in the power sector where the bulk of investment needs are concentrated. Development finance institutions accounted for around 80% of power financing over the last ten years, whereas the private sector provided just 10% of capital, with the remainder coming from domestic state-owned enterprises. By 2030, the split between finance providers in the ETP moves towards the regional average.

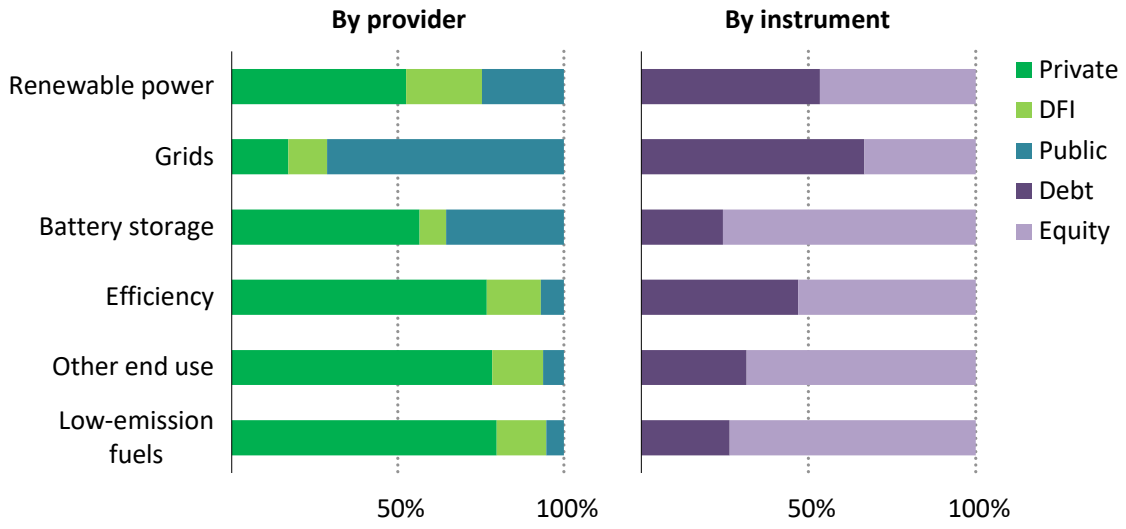
Concessional support needs to be used to mobilise this level of private finance. Across Africa as a whole, the IEA estimates nearly USD 30 billion of concessional finance will be necessary to mobilise a total of USD 90 billion in private finance to energy sector related investments by 2030. This concessional funding is particularly important to target pre-development activities to create a pipeline of bankable projects via the use of technical assistance and capacity building grants or funding feasibility studies and project preparation. Concessional support also plays a significant role in de-risking projects, through instruments such as subordinated debt and equity or guarantees, as well as providing cheap capital for on-lending. Attracting this concessional support occurs alongside strengthened partnerships with donors, and international efforts to review the multilateral development bank approach (via the Bridgetown Initiative) and a renewed global commitment to increase climate finance flows from developed to developing nations, including through negotiated arrangements for climate finance, such as in various Just Energy Transition Partnerships around the world.

Another recent development is the growth of equity financing. Equity providers are willing to take on more risk than debt lenders, making this type of financing particularly important for newer firms or markets that are still in their early stages of development in Uganda. Increasing the availability of equity is also paramount to support the off-grid space, providing seed capital for start-ups and growth equity for the mini-grid sector. Across emerging market and development economies,

equity is generally in shorter supply, particularly since development finance institutions (DFI), which play a dominant role in these markets, are more focused on debt. Ensuring that equity and debt are available at affordable rates will be essential for both achieving the necessary investment levels and for keeping energy prices down given the presence of cost-reflective tariffs.

There is also potential to develop a greater role for domestic financial institutions and pan-African commercial banks. International companies and investors have so far taken the lead in the oil and gas sector, as well as in the power sector, where they accounted for roughly 90% over the last ten years.[3] Domestic capital is particularly important for off-grid projects, where local small and medium-sized enterprises can play a large role if affordable debt is available from commercial banks. Institutional investors, notably the country's growing pension funds, can also provide patient capital for utility-scale projects or grids. Given the relatively low involvement of domestic finance institutions in the country's energy sector today, concessional funding can be used to provide tools such as capacity building, on-lending facilities for commercial banks, and guarantee products for pension funds.

Figure 3.3 Sources of finance for clean energy projects in sub-Saharan Africa (excluding South Africa) in the Sustainable Africa Scenario, 2030



Reaching Uganda's investment needs by 2030 means increasing the role of the private sector, with the support of concessional capital, and a wider availability of equity financing.

Notes: DFI = development finance institutions. The Sustainable Africa Scenario includes universal access to modern energy services by 2030 and the full implementation of all African climate pledges. The scenario is described in more detail in the Africa Energy Outlook 2022, and is broadly consistent with the investment and financing needs of the ETP.

[3] In end-use sectors, domestic finance plays a larger role given the importance of consumer finance and loans from local commercial banks, either to businesses or households.

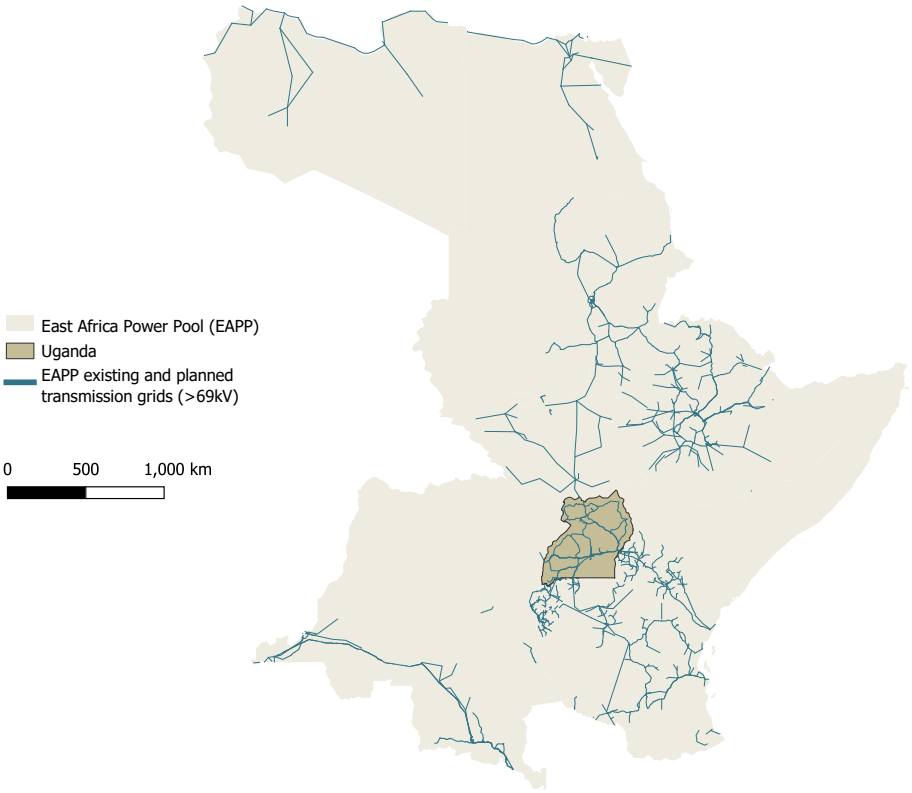
3.4 Key enablers

Attracting international finance to meet Uganda's investment needs requires adequate framework conditions and institutional capacities. The country is well positioned to develop these, building on existing strong institutions, regional partnerships, and a growing young and increasingly skilled workforce. Domestic-led efforts and policy making covering areas such as education, climate resilience and institutional capacities will be essential to send clear signals to markets to attract investment and help cultivate a vibrant domestic energy economy. The sections below describe key policy priorities to strengthen these enablers.

Regional integration

Regional interconnection plans are important for the Energy Transition Plan, especially establishing new and strengthening existing electricity interconnections with neighbouring countries like Kenya, Tanzania, the Democratic Republic of Congo (DRC), Rwanda and South Sudan. Uganda has existing or planned transmission lines to all of these countries.

Figure 3.4 Map of existing and planned transmission lines in Uganda and neighbouring countries, 2022



Uganda is part of the East African Power Pool and has existing or planned transmission interconnections to all neighbouring countries.

Electricity system integration facilitates grid strengthening but could also allow Uganda to export additional electricity supply to neighbouring countries with weaker generation and grid situations. It currently exports 8% of its electricity, and similar volumes or exchanges are maintained in the future in the ETP. In the Regional Energy Hub Case, these grow substantially, reaching just over 40% of Uganda's generation in 2040 (see section 2.6).

This interconnection also improves the integration of variable renewables, which rise quickly in the ETP, reaching 40% by 2050. Stronger interconnections help minimise reliance on energy storage and dispatchable power plants by offering additional flexibility and diversification of supply. Enhanced collaboration with the East Africa Power Pool (EAPP) that co-ordinates cross-border power trade and grid interconnection in the region will be vital to reap the benefits of this integration, especially working toward more day-ahead and real-time exchange and scheduling. Additionally, the African Continental Free Trade Area (AfCFTA), Nile Equatorial Lakes Subsidiary Action Program (NELSAP), and other regional organisations can help facilitate, co-ordinate, and plan future interconnections and exchanges.

Managing affordability

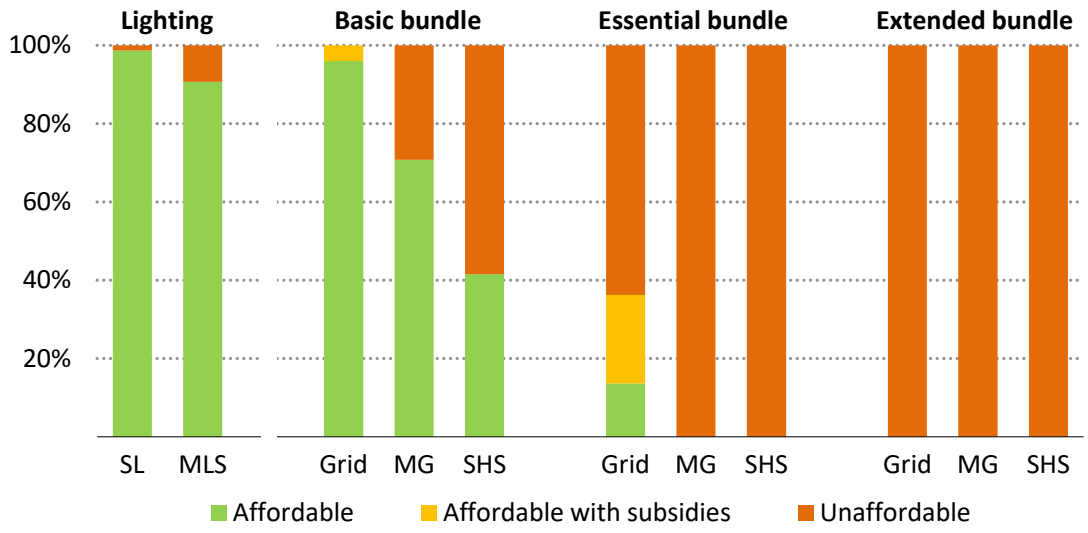
Ensuring that energy is affordable for all end users is essential for businesses and consumers to adopt higher levels of beneficial and productive energy use. This is particularly important for poor households. In 2019, more than 40% of the population was living in extreme poverty and more than 70% was living below the lower-middle-income poverty line – including most of the people without access to electricity. Many Ugandans are engaged in subsistence farming, roughly 60% of the population, where households have limited access to markets and other wage-earning opportunities. Accordingly, these households are unlikely to be able to pay for modern energy sources and would need additional support to switch to using electricity and modern cooking fuels.

In Uganda today, social tariffs in place through utilities would enable all users to afford a basic level of service – notably lighting, radio, and phone charging – if they were provided a free connection. However, for those households where grid connections will not likely reach them by 2030, even this basic level of service would be unaffordable via off-grid systems at today's prices and incentive levels in Uganda. Around 70% of households set to gain access via mini-grids in the ETP could afford a basic level of service. This drops to 40% for solar home systems. However, higher levels of consumption remain out of reach for nearly all those households without access today, regardless if it is a grid or off-grid connection.

These affordability concerns mean that the expected electricity demand from households gaining access would be very limited, negatively affecting electricity

sales and the profitability of new access projects, especially for those targeting rural electrification. This increases investment risks for electrification projects without government support either to the projects or to consumers. Examples of project de-risking mechanisms for access projects includes grants or Results Based Finance (RBF) linked to the number of connections provided. Measures to stimulate household demand and productive uses of electricity could also improve the financial case for access provision. Providing some degree of financial certainty to access projects is important for them to move forward, and then find ways to best capture the long-term benefits of access provision to recoup initial costs. This benefits from integrated planning and co-ordination with other development programmes such as agriculture and transport infrastructure expansion, which help these households increase their access to markets that will enable them to pay in the longer term.

Figure 3.5 Share of households without access that cannot afford electricity by energy service and technology in Uganda, 2022



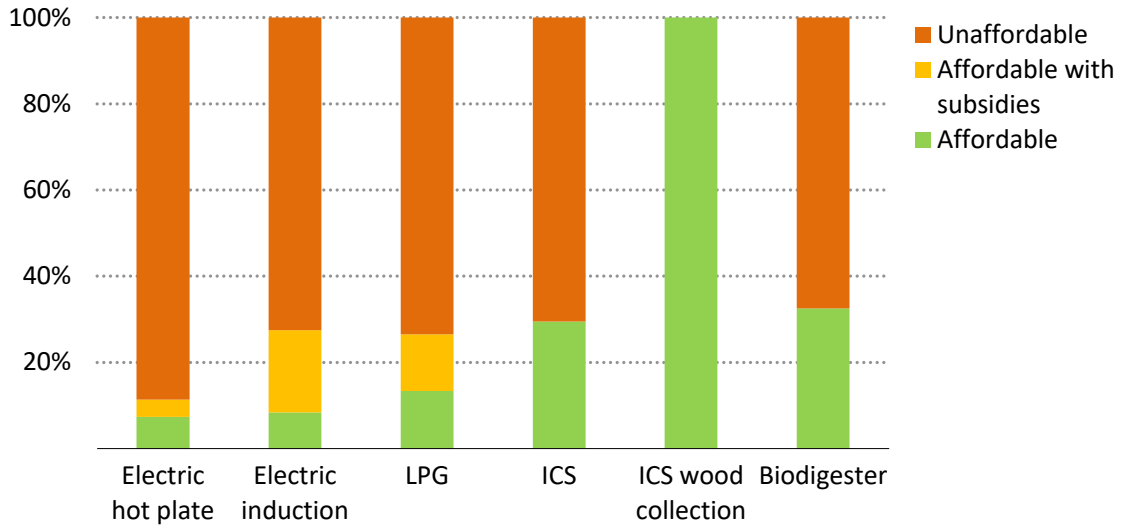
Of the population without access today, only 70% can afford the IEA's basic bundle through a mini-grid and 40% through a solar home system connection.

Notes: MLS = multi-light system; SL = solar lantern; MG = mini-grid; SHS = solar home system. SHS sizes considered increase from the basic (≥ 10 Wp) to the essential (≥ 50 Wp) and extended (≥ 100 Wp) bundles. For further information on the bundles see Guidebook for Improved Electricity Access Statistics (IEA, 2023). In the analysis it is assumed that upfront costs are spread over the infrastructure or product lifetime. The analysis is based on household income data by percentile (World Bank, Poverty and Inequality Platform) and a solution is considered affordable if its cost is lower than or equal to 5% of household income.

Source: IEA analysis based on data from the World Bank.

Similarly, for clean cooking, 70% of households without access today would not be able to afford LPG or electricity for cooking even if a clean cooking stove's upfront costs were covered. While household ability to pay can change overtime, it is an important consideration to ensure the investments in extending access do not go underused, failing to deliver key development benefits.

Figure 3.6 Share of households without access that cannot afford clean cooking by technology and fuel, 2022



70% of the population without access today would not be able to pay for LPG or electric cooking without additional consumption incentives.

Notes: ICS = improved biomass cookstove (ISO Tier > 3); LPG = liquefied petroleum gas. ICS wood collection = improved biomass cookstoves where wood is collected or harvested at no additional cost, as opposed to being purchased. In the analysis it is assumed that upfront costs are spread over the infrastructure or product lifetime. ICS and biogas digesters also receive subsidies, but in the absence of comprehensive information these are excluded from the analysis. The analysis is based on household income data by percentile (World Bank, Poverty and Inequality Platform) and a solution is considered affordable if its cost is lower than or equal to 5% of household income.

Source: IEA based on data from the World Bank.

Uganda should consider pricing and support measures that are targeted to the households most in need while avoiding implementing broad-based energy subsidies, which are inefficient, disproportionately benefit the richer, and are difficult to remove. Today, Uganda's fossil fuel subsidies are limited – an important position to ensure the financial sustainability of the energy sector. In fact, as of the last OECD assessment, Uganda's energy taxes were generating a positive revenue for the government. Energy taxes reinforce efforts to improve efficiency and varying the taxation or fee to the carbon-intensity of the energy consumed helps to strengthen price signals to switch to cleaner forms of energy. Revenues from these fees can be used by governments to target financial support to vulnerable households. For instance, social tariffs can be applied to households just gaining access and still consuming low levels of energy, which then can be covered by higher rates for large consuming households. Special rates can also be applied for users adopting electric cooking or electric mobility to encourage the shift. Similarly in the industry sector, industry-specific or negotiated energy prices can be a tool to support competitiveness while still ensuring electricity generation costs are fully covered.

Managing energy sector costs is also central to keeping energy affordable. The lowest cost energy resources are prioritised in the design of the ETP, while

considering technical and implementation constraints. In particular, attention should be paid to contract structure, balancing healthy returns to attract investors with terms that do not foist extra costs onto end users. For instance, current take-or-pay contracts for electricity generation projects have resulted in paying for electricity not used. Employing market-based mechanisms like auctions can help reduce costs, and increased use of concessional finance would reduce the need to offer overly generous terms to power project developers. Technical capacity building on electricity system dispatch and grid interconnection planning can also reduce risks of underutilising power generation built in the ETP.

Climate and system resilience

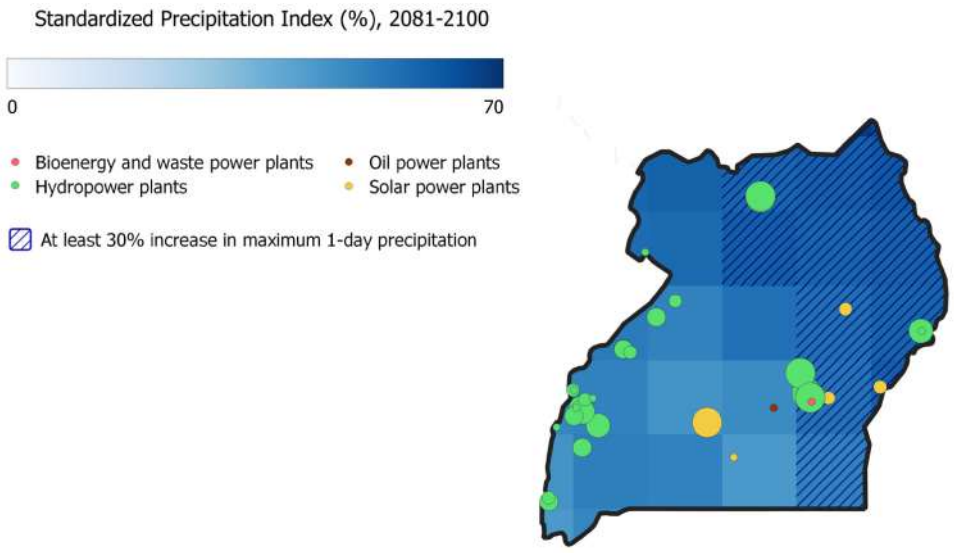
Uganda and other countries in the region have contributed only a small fraction of global greenhouse gas (GHG) emissions, but many sectors in Africa have already suffered significant losses and damages because of climate change.

Among the key risks identified by the Intergovernmental Panel on Climate Change (IPCC) are the loss of biodiversity and food production capacities, increased poverty and critical infrastructure damages. If the rest of the world's emissions pathway follows a similar trend as in the Stated Policies Scenario (STEPS), the mean temperature in Uganda rises by 2.7°C to 3.2°C compared with pre-industrial levels by the end of the century, while maximum precipitation over one day is set to rise by around 25% to 35%.

These developments have considerable impacts on transport and energy infrastructure. IEA assessment on hydropower shows Ugandan hydro capacity factors are likely to mildly increase, while the variability will significantly increase. The country should prepare for this greater variability, domestically and regionally, and it could play a key role in supporting other regions with plunging hydropower output. Adaptation framework policies for renewable power sites, power grids, and other energy and transport infrastructure need to take into account risks associated with extreme weather events, such as flooding. These weather events can damage infrastructure, and spread negative impacts across the economy through power cuts and transport disruptions.

Uganda can guard against risks of climate-related disruptions by making sure all new energy infrastructure investments are climate-resilient, built to manage possible flood risks, and develop appropriate contingency plans. This includes investing in institutions such as better climate and weather forecasting, as well as early-warning systems, smart grids and emergency handling protocols. Investments in the diversification of energy sources and grids can also help address other concerns around energy security, helping the energy system withstand changes and identify alternatives quickly against disruptions, not only caused by extreme weather events but also physical and cyberattacks on energy infrastructure.

Figure 3.7 Precipitation changes in Uganda with a global warming of 2.7°C, 2081-2100



Maximum one-day precipitation levels in Uganda are set to increase by 25% to 35% by the end of the century, impacting power infrastructures in the region, notably hydropower electricity generation.

Notes: Maximum 1-day precipitation and average temperature change measures are long term (2081-2100) and relative with 1850-1900 levels. SSP2-4.5 is an emission scenario in line with the upper end of aggregated NDC emissions levels by 2030 and associated with a global warming estimate for 2100 of around 2.7°C (roughly equivalent to the STEPS with a median surface temperature increase of 2.4°C).

Source: IEA based on data from the IPCC Working Group 1 Interactive Atlas.

Institutional capacity building

Strong, well-resourced institutions in the energy sector, including government bodies, regulatory agencies and utility companies, are key to implementing and delivering on the vision of the ETP. These institutions should be equipped with enhanced capabilities in managing and governing the energy sector, and should seek out support for specialised training in energy policy design, regulatory practices, and project management, as well as for the financial structuring of renewable energy projects. Building this capacity helps support the ETP's vision for an effective, domestically-driven energy transition.

The ETP also encompasses many socio-economic aspects that require the inclusion of stakeholders outside of the energy sector. This includes ministries covering the following domains, among others: Finance, Planning and Economic Development, Agriculture, Trade, Industry, and Transport. These ministries are instrumental in aligning the energy transition with national development goals to ensure that energy initiatives are integrated into various sectors, such as land use, agriculture, industry and infrastructure, to support the country in its economic transformation.

Furthermore, considering the private sector's significant role in the energy transition, it is essential to equip institutional actors with the ability to effectively collaborate and regulate these activities. This entails strong expertise in public-private partnership models, contract management, and investment frameworks conducive to private sector engagement. This comprehensive, multi-stakeholder approach will ensure that the energy transition enjoys robust participation and support across all relevant sectors. Such an integrated strategy is key to achieving a sustainable, comprehensive and inclusive energy transition.

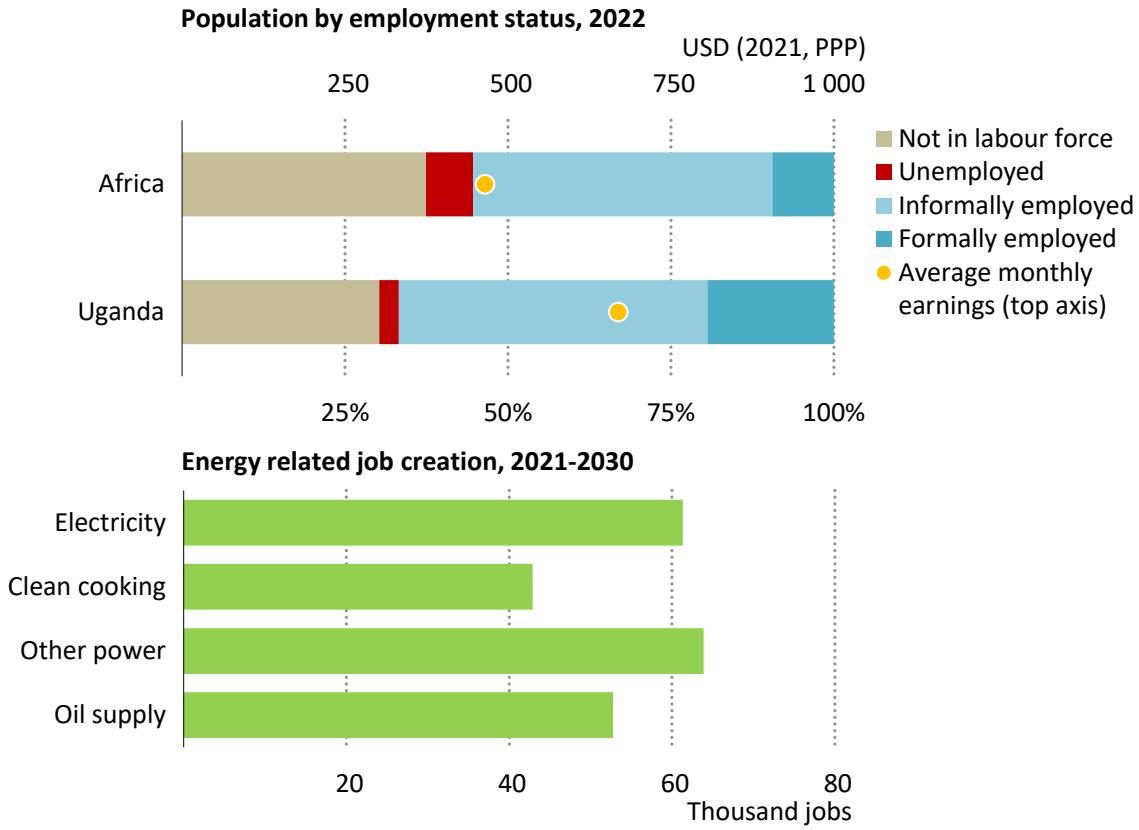
Skilled workers

Developing the country's human resources is crucial for the energy transition, which also holds new employment opportunities for Ugandans. It has a young and fast-growing population, with more than three-quarters under 25. Compared to other countries in the region, Uganda has a relatively strong education system. While completion rates for secondary education are low, adult literacy rates are well above the regional average. Still, Uganda currently faces challenges with wide-scale underemployment and informal employment. In terms of formal energy employment, the National Labour Force Survey 2021 found that around 0.1% of the working population is employed in electricity generation.

In this context, the government sees development of energy resources and infrastructure as critical for generating new employment opportunities for all Ugandans. The Third National Development Plan (NDP III) 2020/21 - 2024/25 calls key sectors like oil and gas, mineral extraction, and other industries as areas for growth. Many parts of the energy sector require high-skilled workers, with around 36% of energy jobs globally in high-skilled occupations, as opposed to around 25% economy-wide. This is a particularly true for workers in utilities, oil and gas, nuclear power, and other power projects. Ensuring these sectors have adequately trained staff will depend on capacity building, training local staff to operate projects, and putting sufficient labour protections in place.

At the same time, many jobs will be created with lower skilling requirements, especially in the provision of electricity and clean cooking access to millions of households each year. It is estimated that over 105 000 workers would be needed to provide clean cooking and electricity access between now and 2030, while an additional 65 000 would be required to build out generation and transmission assets on the power grid. The switch to improved biomass cookstoves and clean cooking fuels creates long-term employment opportunities as well, for example for the distribution of LPG canisters. The push for universal electricity access will require many workers to sell, install and maintain these systems. Uganda's ambitious targets for solar capacity installations imply that workers can remain employed once universal electricity access is achieved. Uganda's oil and gas industry is also set to add around 50 000 workers by 2030.

Figure 3.8 Share of population by employment status and earnings in 2022, and energy-related job creation in the Energy Transition Plan, 2021-2030



On a pathway to universal energy access, almost 220 000 new jobs are created by 2030, which can help bring more workers into the formal economy and offer higher wages.

Notes: Other power = clean power generation, transmission and distribution grids, and battery storage. The share of population by employment status is based on a population aged 15 years and above.

Source: IEA analysis based on data from the Uganda Bureau of Statistics (2021), World Bank (2023), and International Labour Organization (2022).

Several actions can help unlock the labour force needed for the energy transition. Strategic joint ventures that cultivate a skilled Ugandan workforce can help build local knowledge and capacity. This involves extensive training programmes for engineers, technicians and other professionals to equip them with the skills necessary for deploying and maintaining renewable energy technologies. Such training should not only cover technical aspects but also include management, policy formulation, and financial planning related to energy projects. Additionally, awareness and educational programmes for the general public are essential to foster a culture of energy efficiency and sustainability. Exchanges of energy-related training and curricula with international partners could help jumpstart the education system on energy issues. Targeted training and apprenticeship programmes within the country and abroad are key to develop a more inclusive and diverse energy workforce.

Box 3.2 Women's employment opportunities in the ETP

The ETP has the power to make a real difference in increasing women's participation in both the workforce and energy sector. Today, women make up half of Uganda's labour force, significantly higher than the global average which sits at 40%. Still, most women do not have access to formal work arrangements, employment safety nets and decent wages, with 80% of women working in vulnerable employment situations. Analysis by the UN Women and the Equal Opportunities Commission has found that a lack of efficient energy sources is a direct contributor to women's heavy work burden in Uganda.

Clean cooking and electricity access provisions are two of the major means to improve the situation of Ugandan women in the workforce. Expanded levels of electricity access enable the ownership of small appliances such as sewing machines and refrigerators which can support entrepreneurial activities led by women. Clean cooking significantly reduces the time spent by women gathering fuel and cooking, and enables them to pursue other activities, including within the family, the community, and within the commercial sphere. Reaching universal access in Uganda could save women two hours a day on average by 2030 in the ETP. A number of prominent access provision firms are women-led, often understanding better how to market and reach households that could switch. Ensuring women have a rising role in the Ugandan workforce takes intentioned efforts to attract more to training programmes, provide greater access to financing, and bring women more prominently into social dialogue and the political sphere.

3.5 Actions and recommendations

To reach the objectives of the Energy Transition Plan, the government needs to consider a number of important action steps. International support, including the involvement of the private sector, is essential to achieve Uganda's energy access and clean energy goals. Where possible, synergies should be captured to tackle multiple priorities simultaneously. For example, electrifying agricultural processes can provide a solid anchor load in rural areas for electrification projects, while increasing agricultural outputs and driving local economic development, which in turn helps reduce affordability concerns. This section concentrates on eight specific areas of focus, including electricity access, clean cooking, buildings, agriculture, transport, industry, power, energy and critical mineral supply, providing suggested action steps and recommendations for each section.

Access to electricity

- Implement a robust system for tracking and disseminating access to electricity indicators, incorporating technology and geolocation details as part of the process. This comprehensive approach ensures better governmental planning and provides a valuable tool for the private sector to prioritise investments. Both demand-side (e.g. household surveys) and supply-side (e.g. energy companies) data sources should be used in a sustainable data strategy.
- Ensure frequent updates to national electrification plans, monitoring progress based on the latest data and making details available to relevant stakeholders, including the private sector and investors.
- Strengthen, expand, and precisely target end-use affordability measures, extending beyond grid social tariffs to include off-grid solutions to ensure that everyone can afford basic electricity services. Special rates can be offered to households that adopt electric cooking, electric agriculture pumps, and electric vehicles to reinforce efforts for consumers to adopt these technologies.
- Provide affordability support or payment plans that help low-income consumers cover upfront costs related to securing a connection or installing an off-grid system.
- Develop policies that foster a fair market environment for decentralised systems, including tax reductions and import tariff exemptions for components dependent on adherence to quality standards, grid interconnection and interoperability standards. Provide appropriate protections for mini-grid operators to have reasonable line-of-sight on operating timelines, licenses, and terms if the project is integrated into the grid.
- Work with financial institutions to develop standard models for access financing to streamline investments for grid extensions and off-grids systems, including models like mass procurement of solar home systems.
- Co-ordinate with clean cooking and other development initiatives to leverage synergies for a more significant impact on energy use.

Access to clean cooking

- Ensure the National Clean Cooking Strategy, currently under development, includes provisions for all relevant clean cooking technologies tailored to different consumer categories and locations.
- Reinforce institutions working on clean cooking, and strengthen their mandate to engage across agencies to address gaps in clean cooking.
- Develop an implementation plan that incorporates best practice on clean cooking programmes, including peer-to-peer learning, awareness campaigns, mass procurement, and building up local supply chains.

- Deploy specific incentives that cover both the adoption of new stoves and the acquisition of fuel, employing diversified approaches based on technologies and well targeted to households and communities most in need. This is particularly important for households currently relying on free collected biomass.
- Develop LPG infrastructure such as distribution networks, storage and refilling stations to ensure availability of supply.
- Strengthen information campaigns to promote the benefits of more efficient cooking with tailored strategies to local traditions to address barriers rooted in cultural practices. Complementing measures to adopt include extensive training for stove use, safety education, cooking classes, and recipe books to facilitate the transition to new cooking methods.
- Develop and enforce quality standards for stoves and fuels, coupled with incentives that direct consumers towards safe, long-lasting and efficient products.
- Establish a national legal framework for accessing carbon credits markets specifically for clean cooking projects. These efforts need to be aligned with international standards, including markets developed under Article 6 of the Paris Agreement. This encourages sustainable practices and provides additional financial support for clean cooking initiatives.

Buildings

- Pass the Energy Efficiency and Conservation Bill to create the first legal framework for energy efficiency regulations in buildings and other sectors, and their enforcement.
- Approve the National Energy Efficiency and Conservation Strategy and Plan, due to be finalised following the adoption of the draft Energy Efficiency and Conservation Bill.
- Strongly enforce Minimum Energy Performance Standards for appliances such as refrigerators, air conditioners and lighting to reduce energy demand, with a particular focus on second-hand imports.
- Encourage the purchase of energy-efficient and electric appliances with financial incentives, especially for low-income households.
- Create and strictly enforce building energy codes for new construction and major retrofits to ensure energy efficiency. In addition, green building practices should be encouraged through tax rebates and other financial incentives.
- Utilise digital technologies for real-time energy monitoring and management in buildings to enable future demand-response capability.
- Implement widespread awareness campaigns on energy efficiency measures and benefits in residential and commercial buildings.

- Introduce mandatory energy audits for buildings to ensure compliance with efficiency regulations.
- Facilitate the growth of energy service companies (ESCOs) to finance and implement energy-saving measures in buildings.

Agriculture

- Encourage the use of energy-efficient electric pumps for irrigation, combined with solar PV solutions, through financial incentives and trainings.
- Facilitate the transition from diesel to electric-powered agricultural processing equipment.
- Invest in and support the development of efficient cold chain infrastructures for agriculture.
- Offer incentives for adopting energy-efficient and sustainable agricultural practices.
- Support the formation of co-operatives to provide affordable and efficient energy solutions for small-scale farmers.
- Encourage the use of bioenergy in agricultural processes where appropriate, facilitated, for example, through clusters that combine agricultural activities with energy production, like biogas from waste.

Transport

- Implement the National E-Mobility Strategy, currently under development, including vehicle purchase incentives and regulatory frameworks.
- Invest in modern and efficient public transport systems, including buses and rail, to reduce reliance on personal vehicles, thereby decreasing overall transportation energy demand.
- Focus on urban planning strategies that favour walkable, bike-friendly cities and reduce the need for long commutes.
- Offer subsidies or tax rebates for the purchase of electric vehicles (EV), particularly targeting two- and three-wheeler vehicles, to encourage their adoption over traditional internal combustion engine vehicles.
- Prioritise the development of comprehensive electric vehicle charging networks, focusing on urban areas and major transport corridors to support the growing EV market.
- Launch a government-led initiative to electrify its own vehicle fleet as a model for wider adoption. In parallel, private operators should be encouraged to transition to electric buses and light commercial vehicles through favourable procurement policies and financial incentives.

- Implement progressive taxation policies where higher taxes are levied on fossil fuel-based vehicles while offering tax exemptions or reductions for electric and hybrid vehicles.
- Launch campaigns to educate the public on the benefits of EVs and energy-efficient transport, with a particular emphasis on public transport.
- Set and enforce rigorous fuel economy standards for all new vehicles, gradually phasing out less efficient models.
- Implement low-emission days or zones restricting access in urban areas for high-emitting vehicles to encourage the use of cleaner transport options.
- Support the development and usage of biofuels in aviation and heavy-duty freight, where electrification remains challenging.

Industry

- Implement energy efficiency assessments for industrial facilities designed to recommend efficiency measures, notably efficient electric motors, electrifying heating, and improving heat recovery systems.
- Introduce electric heat pump units for low-heat processes in industrial sectors such as food drying and processing.
- Develop a road map for industrial infrastructure development, such as rail extensions, so industrial players can make informed decisions on their long-term expansion plans.
- Develop a long-term industrial plan to reach carbon neutrality in each major industry, identify near-term emissions reduction opportunities and ensure new long-lifetime assets are compatible with national decarbonisation targets.
- Advance dematerialisation codes to minimise the demand for construction materials where possible.
- Optimise for lower clinker-ratios in cement use, which would scale depending on the specific cement application to not sacrifice on performance.
- Introduce electric kilns or upgrade existing kilns for cement production with more modern types.
- Ensure new direct reduced iron (DRI) steel facilities can accommodate alternatives to fossil fuels, such as green hydrogen, in order to further abate fossil fuel emissions from high-temperature heat processes.
- Increase the use of electric arc furnaces (EAF) to reduce reliance on coking coal and to increase the flexibility of feedstocks. In parallel, cultivate a robust scrap steel recovery programme that guards against risks for illegal scrap trade.

Power

- Expand interconnections and power trade with neighbouring countries, enhancing energy security, increasing flexibility, optimising on production costs and enabling exports.
- Reinforce power infrastructure, notably distribution grids, to improve reliability and power quality for consumers.
- Prioritise the diversification of generation sources to improve the reliability and security of electricity supply.
- Continue to systematically monitor the impact of climate change on generation assets, particularly hydropower generation.
- Integrate the Energy Transition Plan's capacity expansion into long-term planning for distribution and transmission grids, particularly with a lens toward ensuring new projects do not face delays in interconnection and initial investments are rightsized for future expansion needs.
- Reduce the risk and uncertainty associated with investments in new generation capacity through financing pre-feasibility studies and developing contract structures that provide long-term certainty while guarding against over generous terms.
- Continue consultations on power sector reforms and providing clarity to stakeholders on details as soon as practicable. During the transition period, it is key to ensure continued investment in, and maintenance of, the distribution grid.
- Develop a strategy and regulations for net metering. Amendments to the Electricity Act mean that net metering is now allowed in principle, but supporting regulations need to be developed to allow market participants to take advantage of this mechanism.
- Support the development of a robust and well-regulated domestic solar PV industry.
- Continue co-operation with IAEA and other international authorities in the development of a robust domestic nuclear programme and work with diverse international partners to explore possible suppliers for nuclear power equipment and fuels.
- Identify key review periods for long-term capacity plans in light of changing costs, flexibility needs, storage technology advances, and shifting timelines to deliver large projects and to ensure security of supply throughout.
- Enhance power sector scheduling and dispatch protocols, particularly in light of rising levels of variable renewables, consulting with other dispatchers globally to build capacity.

Energy and critical mineral supply

- Ensure that oil projects, including refineries, pipelines, and storage, are sized appropriately given domestic and regional demand in the ETP.
- Take into account changing global oil demand and price trajectories for export considerations, as prices stabilise or decline, across all IEA scenarios going forward.
- Strictly comply with all environmental, social and other regulations, as well as commitments for new projects.
- Operate oil production, transport, and refinery operations, where possible, on low-carbon electricity sources to minimise the carbon intensity of oil projects.
- Ensure that extractive projects are subject to rigorous environmental impact assessments, as well as monitoring, reporting and verification requirements to reduce methane leakage from oil and gas operations to around 0.3 kt/mboe.
- Continue to work with the Extractive Industries Transparency Initiative and other partners regarding best practice for oil revenue transparency, management and investment, including the use of its Petroleum Fund, to ensure that oil revenues help Uganda achieve its economic, social and sustainable development goals.
- Develop a policy for maintaining and managing oil stocks to strengthen oil supply security, with a particular focus on transport and cooking fuel.
- Implement biofuel blending requirements, and support local biofuel production in parallel.
- Advance biogas production facilities, both for access applications in agricultural regions as well as centralised facilities, to support industrial demand.
- Monitor the seasonal production of agricultural residues and implement feedstock production and collection protocols to support formalised bioenergy supply chain management.
- Monitor and enforce sustainable firewood and charcoal harvesting and production.
- Undertake geological surveys to better understand critical mineral mining potential.
- Provide tax incentives to cultivate critical mineral mining and processing.
- Implement and enforce rigorous environmental and labour standards in the mining sector, including reporting obligations, transparency standards, and integrating these regulations into the permitting process.
- Assess the energy needs of mining operations and develop infrastructure to power these operations, and ensure sustainable transport to markets.
- Ramp up conservation measures such as restoring wetlands and forests, while developing local economic activities to limit impacts on local livelihoods.

3.6 Next steps for operationalising the Energy Transition Plan

The Energy Transition Plan, while based on robust energy modelling, is not designed to be an implementation strategy. Accordingly, Uganda has called for the creation of an Integrated Energy Resource Master Plan based on the high-level targets of the ETP, which will be carried out in subsequent years. Similarly, it is important to note that with such rapid growth, and changing regional and global dynamics, elements of the ETP may need to be adapted to shifting circumstances, and should be revisited periodically. But the high-level targets and direction of travel set by the plan remain an important north star for Uganda's energy development, and will be key to signal long-term certainty and rally needed support from citizens, investors, and the international community around the plan.

Annexes

Annex A - Tables for scenario projections

This annex includes global historical and projected data for the Energy Transition Plan (ETP) for the following tables:

- Table A.1: Energy supply
- Table A.2: Total final energy consumption
- Table A.3: Electricity sector: gross electricity generation and electrical capacity
- Table A.4: CO_2 emissions: carbon dioxide (CO_2) emissions from fossil fuel combustion and industrial processes
- Table A.5: Indicators and activity: selected economic and activity indicators

Abbreviations/acronyms used in the tables include: CAAGR = compound average annual growth rate; g CO_2 = grammes of carbon dioxide; GDP = gross domestic product; GJ = gigajoule; GW = gigawatt; kt = kilotonnes; kWh = kilowatt-hour; Mt CO_2 = million tonnes of carbon dioxide; PJ = petajoule; PPP = purchasing power parity; toe = tonne of oil equivalent; TWh = terawatt-hour.

New information from Ugandan industries indicates the use of coal, which does not appear in Uganda's official 2022 energy balances reported to the IEA. Accordingly, these tables include the latest estimates of energy demand by fuel, reviewed by the Ministry of Energy and Mineral Development, which differ from those reported on the IEA's website and official balances in other recent IEA publications on Uganda.

Both in the text of this report and in these annex tables, rounding may lead to minor differences between totals and the sum of their individual components.

Definitional note: Table A.1: Energy supply and transformation

Total energy supply (TES) is equivalent to electricity and heat generation plus the other energy sector, excluding electricity and heat, plus total final consumption, excluding electricity and heat. TES does not include ambient heat from heat pumps or electricity trade. Solar in TES includes solar photovoltaic (PV) generation, concentrating solar power (CSP) and final consumption of solar thermal. Energy demand from international marine and aviation bunkers are not included in TES.

Definitional note: TableA.2: Energy demand

Sectors comprising total final consumption (TFC) include industry (energy use and feedstock), transport, buildings (residential and services), agriculture and other non-energy uses. Energy demand from international marine and aviation bunkers are not included in global transport totals, TFC.

Definitional note: TableA.3: Electricity

Electricity generation expressed in terawatt-hours (TWh) and installed electrical capacity data expressed in gigawatts (GW) are both provided on a gross basis, i.e. includes own use by the generator. Projected gross electrical capacity is the sum of existing capacity and additions, less retirements.

Definitional note: Table A.4: CO_2 emissions

Total CO_2 includes carbon dioxide emissions: from the combustion of fossil fuels and non-renewable wastes; and from industrial and fuel transformation processes (process emissions).

Definitional note: Table A.5: Economic and activity indicators

The emission intensity expressed in grams of carbon dioxide per kilowatt-hour (g CO2 per kWh) is calculated based on electricity-only plants and the electricity component of combined heat and power (CHP) plants.

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Table A.1 Energy supply

			ETP scenario (PJ)			Shares (%)		
	2010	2021	2030	2040	2050	2021	2030	2050
Total energy supply	**571**	**927**	**809**	**1 351**	**2 787**	**100**	**100**	**100**
Oil	46	81	194	251	219	9	24	8
Natural gas	-	-	7	20	34	-	1	1
Coal and lignite	1	4	12	15	15	0	1	1
Bioenergy and waste	519	825	430	357	430	89	53	15
Nuclear	-	-	-	101	441	-	-	16
Hydro	5	17	47	68	71	2	6	3
Solar	0	0	48	141	276	0	6	10
Wind	-	-	9	23	47	-	1	2
Geothermal	-	-	63	376	1 254	-	8	45
Electricity and heat sectors	**19**	**24**	**191**	**771**	**2 247**	**100**	**100**	**100**
Fossil fuels	11	1	3	3	6	2	2	0
Bioenergy and waste	3	7	21	59	151	27	11	7
Nuclear	-	-	-	101	441	-	-	20
Hydro	5	17	47	68	71	68	25	3
Solar	0	0	48	141	276	2	25	12
Wind	-	-	9	23	47	-	5	2
Geothermal	-	-	63	376	1 254	-	33	56
Other energy sector	**114**	**217**	**148**	**164**	**277**	**-**	**-**	**-**

Table A.2 Final energy consumption

			ETP scenario (PJ)			Shares (%)		
	2010	2021	2030	2040	2050	2021	2030	2050
Total final consumption	**447**	**704**	**589**	**739**	**982**	**100**	**100**	**100**
Industry	97	153	184	253	364	22	31	37
Transport	18	53	78	99	113	7	13	12
Buildings	330	491	318	376	491	70	54	50
Agriculture	2	8	9	11	13	1	2	1

Table A.3 Electricity sector

			ETP scenario (TWh)			Shares (%)		
	2010	2021	2030	2040	2050	2021	2030	2050
Total generation	**2.8**	**5.2**	**33.1**	**90.1**	**200.1**	**100**	**100**	**100**
Renewables	1.7	5.1	32.8	80.5	159.7	99	99	80
Solar	0.0	0.1	13.4	39.1	76.8	2	40	38
Wind	-	-	2.5	6.4	12.9	-	8	6
Hydro	1.5	4.6	13.1	18.8	19.7	90	40	10
Bioenergy and waste	0.2	0.4	2.1	5.7	15.4	7	6	8
Geothermal	-	-	1.7	10.5	34.8	-	5	17
Nuclear	-	-	-	9.3	40.4	-	-	20
Oil	1.1	0.1	0.3	0.4	-	1	1	-

			ETP scenario (GW)			Shares (%)		
	2010	2021	2030	2040	2050	2021	2030	2050
Total capacity	**0.7**	**1.5**	**12.1**	**33.6**	**70.5**	**100**	**100**	**100**
Renewables	0.5	1.2	11.8	31.8	64.2	84	97	91
Solar	0.0	0.1	7.5	21.9	43.1	4	62	61
Wind	-	-	1.0	2.5	5.2	-	8	7
Hydro	0.4	1.1	2.3	3.3	4.5	72	19	6
Bioenergy and waste	0.0	0.1	0.8	2.5	6.5	8	6	9
Geothermal	-	-	0.3	1.5	5.0	-	2	7
Nuclear	-	-	-	1.5	5.9	-	-	8
Oil	0.2	0.2	0.3	0.3	0.3	16	3	0

Table A.4 CO_2 emissions

			ETP Scenario (Mt CO_2)			Shares (%)		
	2010	2021	2030	2040	2050	2021	2030	2050
Total CO_2*	**3.7**	**7.0**	**16.7**	**22.1**	**21.0**	-	-	-
Combustion activities	**3.1**	**5.7**	**14.9**	**19.5**	**17.6**	**100**	**100**	**100**
Oil	3.0	5.4	13.4	17.1	14.6	94	90	82
Natural gas	-	-	0.4	1.0	1.7	-	3	10
Coal and lignite	0.1	0.3	1.1	1.4	1.4	6	7	8
Electricity and heat sectors	**0.8**	**0.05**	**0.2**	**0.2**	-	-	-	-
Other energy sector	-	-	**0.5**	**0.5**	**0.5**	-	-	-
Final consumption*	**2.9**	**7.0**	**16.0**	**21.3**	**20.5**	**100**	**100**	**100**
Industry*	1.3	2.5	6.0	7.8	8.7	37	38	43
of which processes	0.6	1.3	1.8	2.6	3.4	18	11	17
Transport	1.3	3.8	5.0	5.8	5.7	54	31	28
Buildings	0.2	0.1	4.3	7.1	5.6	1	27	27
Agriculture	0.2	0.6	0.6	0.6	0.5	8	4	3

*Includes industrial process emissions.

Table A.5 Economic and activity indicators

			ETP Scenario			CAAGR (%) 2021 to:	
	2010	2021	2030	2040	2050	2030	2050
Indicators							
Population (million)	32	46	58	73	88	2.7	2.3
of which urban	6	12	18	28	39	5.0	4.2
of which rural	26	34	40	46	49	1.8	1.2
GDP (USD 2021 billion, PPP)	71	118	209	433	870	6.6	7.1
GDP per capita (USD 2021, PPP)	2 189	2 564	3 572	5 933	9 928	3.8	4.8
Electricity access rate* (%)	14	43	100	100	100	n.a.	n.a.
Clean cooking access rate** (%)	1	15	100	100	100	n.a.	n.a.
TES/GDP (GJ per USD 1 000, PPP)	8.1	7.9	3.9	3.1	3.2	-7.6	-3.1
TFC/GDP (GJ per USD 1 000, PPP)	6.3	6.0	2.8	1.7	1.1	-8.0	-5.6
CO_2 intensity of electricity generation (g CO_2 per kWh)	281	8.8	6.7	2.8	-	-2.9	n.a.
Industry							
Energy intensity (toe per million USD)	127	107	72	46	33	-4.3	-4.0
Transport							
Cars per thousand capita	4	8	12	20	34	4.0	4.9
Buildings							
Households (million)	7	10	14	20	27	4.1	3.5
Services energy intensity (toe per million USD)	32	27	21	14	11	-2.5	-3.0
Residential energy demand per capita (GJ per capita)	9.0	8.8	4.1	3.6	3.4	-8.1	-3.3

*Includes multi-light systems
**Includes improved cookstoves

Annex B - Abbreviations and acronyms

AfCFTA	African Continental Free Trade Area
AFOLU	agriculture, forestry and other land use
APS	Announced Pledges Scenario
CCUS	carbon capture, utilisation and storage
CH_4	methane
CHP	combined heat and power; the term co-generation is sometimes used
CO_2	carbon dioxide
CO_2-eq	carbon dioxide equivalent
DAC	direct air capture
DFI	development finance institutions
DRI	direct reduced iron
EAF	electric arc furnace
EAPP	Eastern Africa Power Pool
ESCO	energy service companies
ESIA	environmental and social impact assessment
ETP	Energy Transition Plan
EV	electric vehicle
GDP	gross domestic product
GHG	greenhouse gas
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transport Model
HFO	heavy fuel oil
HPP	hydropower plant
HSFO	high sulphur fuel oil
IAEA	International Atomic Energy Agency
ICE	internal combustion engine
ICS	improved cookstove
IEA	International Energy Agency
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
LPG	liquefied petroleum gas
MEMD	Ministry of Energy and Mineral Development of Uganda
MEPS	minimum energy performance standard
MER	market exchange rate
MG	mini-grid
MLS	multi-light system
N_2O	nitrous oxide
NDC	Nationally Determined Contribution
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NNC	No Nuclear Case

NZE	Net Zero Emissions by 2050 Scenario
OECD	Organisation for Economic Co-operation and Development
PLDV	passenger light-duty vehicle
PPA	Purchase Power Agreement
PPP	purchasing power parity
PV	photovoltaic
RBF	results-based financing
REHC	Regional Energy Hub Case
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SDG7	Sustainable Development Goal 7
SHS	solar home system
SL	solar lantern
SME	small and medium-sized enterprises
SSA	Sub-Saharan Africa
STEPS	Stated Policies Scenario
TES	total energy supply
TFC	total final consumption
UETCL	Uganda Electricity Transmission Company Limited
UN	United Nations
USD	US dollar

Annex C - Units of measure

Distance	km	kilometres
Emissions	Mt CO_2	million tonnes of carbon dioxide
	Mt CO_2-eq	million tonnes of carbon-dioxide equivalent
	Gt CO_2-eq	gigatonne of carbon dioxide equivalent
Energy	PJ	petajoules (1 joule x 10^{15})
	Mtoe	million tonnes of oil equivalent
	kWh	kilowatt-hour
	GWh	gigawatt-hour
	TWh	terawatt-hour
Mass	kt	kilotonnes (1 tonne x 10^3)
	kt/yr	kilotonnes per year
	Mt	million tonnes (1 tonne x 10^6)
Monetary	USD/t CO_2	US dollars per tonne of carbon dioxide
	USD/bbl	US dollar per barrel
Oil	kb	thousand barrels
	kb/d	thousand barrels per day
	mb/d	million barrels per day
Power	W	watt (1 joule per second)
	Wp	watt peak
	kW	kilowatt (1 watt x 10^3)
	kWp	kilowatt peak
	MW	megawatt (1 watt x 10^6)
	GW	gigawatt (1 watt x 10^9)
	PJ	petajoule

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Typeset in France by IEA - November 2023
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Revised version, December 2023
Information notice found at: www.iea.org/corrections