

Energy Efficiency for Affordability

Improving people's lives through delivery
of a modern, sustainable energy system
in Kenya

International
Energy Agency



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Abstract

Energy efficiency continues to play a critical role in improving living standards around the world and is the first and best response to simultaneously meet affordability, supply security and climate goals. As Kenya looks to drive forward its clean energy transition in the face of the global climate and energy crises, there is a growing role for energy efficiency in supporting its aims to ensure affordable, reliable access to electricity while allowing greater integration of renewable energy technologies.

As part of the [Energy Efficiency in Emerging Economies \(E4\) Programme](#), this report aims to provide an overview of current progress in energy efficiency and its potential for improving people's lives through delivery of a sustainable, modern energy system. The report assesses progress, opportunities and challenges for energy efficiency across four key areas: **Buildings, Appliances, Clean Cooking and Electricity System Losses**.

The report gives suggestions on potential policy actions that can be taken to enhance progress, drawing on case studies and examples from Kenya and other countries in Africa and globally. It represents part of the IEA's growing collaboration with Kenya in the build-up to the IEA's Energy Efficiency in Emerging Economies Training Week and [9th Annual Global Conference on Energy Efficiency](#), which will take place in Nairobi in March and May 2024 respectively.

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Executive summary

Energy efficiency can play a key role in meeting Kenya's renewable energy and universal energy access goals, while ensuring affordability

Kenya is emerging as a leader in the global clean energy landscape, having recently hosted the inaugural [Africa Climate Summit](#) in Nairobi in September 2023. The country has made great progress on renewable energy and access to electricity, with renewables accounting for nearly 90% of energy generated and consumed in 2021, up from around [75%](#) in 2017. Access to electricity has more than doubled over the past decade from [37%](#) in 2013 to [75%](#) in 2022. According to the IEA, Kenya is on track to provide electricity to its entire population by [2030](#), in line with national plans to achieve universal access. The [Kenya Vision 2030](#) sets out a long-term development blueprint aiming to transform Kenya into “a newly-industrialising, middle income country providing a high quality of life to all its citizens in a clean and secure environment.” Under this vision, development of new and renewable energy sources, energy efficiency, and increasing electricity access are key focus areas, indicating ambition to provide greater support in accelerating towards clean energy and access targets.

Energy efficiency has and continues to play a critical role in improving living standards around the world and is the first and best response to simultaneously meet affordability, supply security and climate goals. As Kenya looks to drive forward its clean energy transition, following the impacts of the global pandemic, climate and energy crises there is a growing role for energy efficiency in delivering benefits that can ensure affordable, reliable access to electricity while supporting greater integration of renewable energy technologies. [Mobilisation of investments](#) to promote energy efficiency in buildings, appliances, clean cooking and electricity system losses will be key to building reliable, modern energy systems that can help Kenya develop its economy. The potential of energy efficiency to create jobs, improve health, and increase social mobility and gender equality highlights its potential role in delivering benefits beyond the transition to clean energy.

During the IEA's 8th Annual Global Conference on Energy Efficiency, held in Versailles, France, in June 2023, His Excellency Mr Davis Chirchir, Minister of Energy and Petroleum of Kenya, [announced](#) that the 9th Annual Global Conference would take place in Nairobi in June 2024. This followed Kenya's joining the IEA as an [Association Country](#), demonstrating its deepening engagement with the Agency on energy and climate issues. Kenya is well placed to leverage its position as a leader in the global clean energy landscape, providing an example to other countries across the continent on how to accelerate energy efficiency action to navigate the dual energy and climate change crises. This report aims to provide an

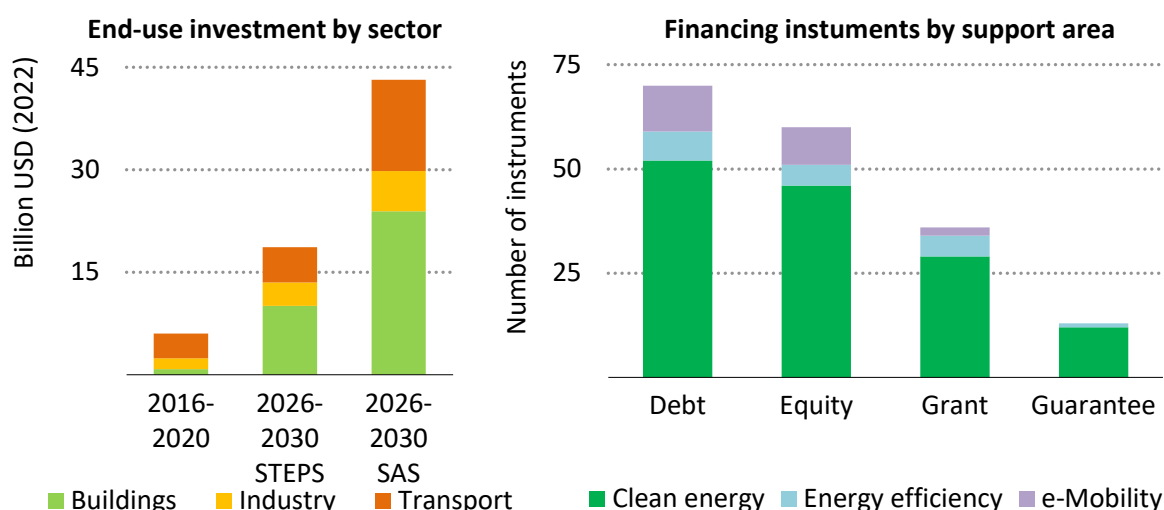
overview of current progress in energy efficiency in Kenya and its potential for improving people's lives through delivery of a sustainable, modern energy system.

The global energy crisis has highlighted the urgency of accelerating investment in cheaper and cleaner energy in Africa, outlining the potential for energy efficiency

Access to clean, secure and affordable modern energy services has not kept pace with the continent's expanding needs, with growth in the use of electricity [lagging behind growth in energy demand](#) in the decade from 2010 to 2019. Affordability of basic services is an important concern in many African countries, where many households still lack access to basic needs such as space at a comfortable temperature. Ownership levels of appliances, such as fans, air conditioners and refrigerators, are far below the average of other emerging and developing economies. For example, only around [5%](#) of households in sub-Saharan Africa are equipped with an air-conditioning unit, compared with more than 85% in Japan, Korea and the United States. Uncertainties over economic prospects and energy prices have limited opportunities for investment in energy infrastructure projects in Africa, with low levels of investment in absolute terms [despite enormous access needs](#) and significant long-term projected [growth in energy demand](#). Energy investment on the continent accounts for just [3%](#) of global totals, with a [cost of capital at least two to three times](#) higher than in advanced economies limiting overall investment.

An enhanced focus on energy efficiency will be essential for supporting sustainable economic growth in Africa, addressing increases in energy demand and carbon emissions and furthering progress towards universal electricity access and affordability. Investment in energy efficiency, electrification and renewables for end use in Africa has been relatively static for more than [five years](#), with many countries still lacking integrated and comprehensive policy frameworks. According to IEA analysis, energy efficiency spending could increase to around [USD 43 billion](#) annually, from slightly below USD 6 billion in the last five years, with a [sevenfold increase](#) in energy efficiency spending in areas including efficient green buildings and consumer appliances. However, financing energy efficiency projects can be challenging, and while many projects are cost-effective and result in savings, they are relatively small scale, there is low awareness of potential savings, risks are perceived to be high, and proven business models are inadequate.

Energy efficiency-related investment and current financing instruments, Africa, 2016-2030



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Notes: This covers instruments explicitly targeting energy efficiency. Elements of energy efficiency improvements in buildings, industrial facilities, small and medium-sized enterprises, and transport may be covered under other categories. STEPS = Stated Policies Scenario; SAS = Sustainable Africa Scenario

Source: IEA (2023), [Financing Clean Energy in Africa](#).

Kenya has made strong progress on expanding renewable energy and access to electricity, but as demand increases, energy efficiency can help to accelerate progress in an inclusive, affordable way

Kenya is an emerging leader in the global clean energy landscape, with renewables accounting for nearly [90%](#) of energy generated and consumed in 2021. It has also made strong progress towards achieving universal access to electricity, doubling electricity access from [32% in 2013 to 75% in 2022](#). This includes increasing access to electricity to over [97%](#) of the urban population and [68%](#) of the rural population in 2021, and according to the IEA, Kenya is on track to [provide electricity to its entire population](#) by 2030. Electricity demand in Kenya has increased in the past few years, marked by a 9% increase in demand for electricity and [3% increase in peak electricity demand](#) in 2021 with expansion in GDP of about 8%.

The government of Kenya has set out a range of strategies and plans aimed at achieving universal energy access and 100% renewable power by 2030. The [Kenya Vision 2030](#) sets out a long-term development blueprint aiming to transform Kenya into “a newly-industrialising, middle income country providing a high quality of life to all its citizens in a clean and secure environment.” Under this vision, development of new and renewable energy sources, energy efficiency, and increasing electricity access are focus areas in the strategy for [Deploying World Class Infrastructure Facilities & Services](#), indicating intentions to provide greater support for addressing energy demand to facilitate greater integration of renewable energy.

Four areas – buildings, appliances, clean cooking and electricity system losses – present key opportunities for progressing energy efficiency and directly improving people's lives

As part of the [Energy Efficiency in Emerging Economies \(E4\) Programme](#), this report aims to provide an overview of current progress in energy efficiency and its potential for improving people's lives through delivery of a sustainable, modern energy system. The report assesses progress, opportunities and challenges for energy efficiency across four key areas: **Buildings, Appliances, Clean Cooking and Electricity System Losses**. These areas have been prioritised because buildings and appliances account for the majority of Kenya's total energy consumption and are expected to drive the majority of growth in electricity demand in the next decade. Improvements in the energy efficiency of these sectors will play a key role in allowing Kenya to meet its universal electricity access and renewable energy targets, while at the same time unlocking new opportunities for demand side system flexibility and [digitalisation](#).

- 1) **Buildings:** The buildings sector is the dominant energy consuming sector in Kenya, accounting for around three-quarters of total final energy consumption. Demand will continue to grow as the sector expands over the coming decade, with total building stock expected to increase by [over 25%](#) between 2018 and 2025. Actions taken to address buildings efficiency will play a pivotal role in the country's clean energy transition, with current efficiency improvements [not adequate to outpace demand growth](#). To improve the energy efficiency of the building stock, Kenya is seeking to enhance the energy performance of new buildings and improve the energy performance of existing buildings. This analysis explores the potential for further enhancing efficiency through inclusion of minimum energy performance requirements for common building types and provisions for "[grid-readiness](#)" that include installation of solar PV, battery storage and chargers for electric vehicles.
- 2) **Appliances:** Electricity consumption from light industry, appliances and cooling systems in Kenya could [quadruple](#) through to 2040, emphasising the need for improved energy efficiency standards and action on dumping of inefficient appliances. To address growing future demand, Kenya aims to increase the energy efficiency of household electrical appliances through the implementation of minimum energy performance standards (MEPS). Looking at MEPS across the region, there is room for more adoption of more ambitious performance levels using known technologies that are widely available today. Kenya also faces the challenge of addressing dumping of low-energy-efficiency and obsolete household appliances, such as refrigerators and air conditioners. Import of these appliances results in increased energy bills, higher energy demand and strain on grids as cumulative use increases. This report aims to discuss barriers to adoption of improved energy efficiency standards and highlight their potential for expanding the domestic market for efficient-energy appliances in support of long-term goals.

- 3) **Clean cooking:** Over [80%](#) of the Kenyan population still relies on traditional biomass fuels for cooking, highlighting the role of clean cooking solutions in improving energy access and living standards. Traditional cooking methods using biomass can lead to significant health issues as a result of air pollution, are a contributor to deforestation, and enhance food stress that disproportionately affects women and girls. Liquefied petroleum gas (LPG) is a leading solution in urban areas; however, increasing prices for LPG in Kenya have impacted affordability, increasing the risk of people switching back to traditional fuels. Kenya remains committed to improving energy efficiency and reducing pollution caused by household thermal cooking applications. Kenya has set out a target of reducing over-reliance on wood fuels while providing access to electricity and modern cooking solutions to all households by 2028. This analysis provides recommendations for actions that could be developed in the very short term to support continued adoption of clean cooking fuels and technologies in Kenya that can ensure affordable access.
- 4) **Electricity system losses:** Investments in resilient and efficient power grids will be critical to meeting Kenya's growing energy needs while supporting universal access goals, with the country currently facing high rates of power losses of almost one-quarter. Current levels of electricity system losses are over 23%, compared with a global average of [8%](#), increasing the challenge of supplying energy to a growing demand base. Improving system efficiency reduces the need for costly investments in additional generation capacity and helps bring down electricity bills. This analysis discusses short-term actions to reduce losses in the distribution system, including improvements to regulations and monitoring, implementation of efficiency standards for distribution transformers and adoption of new financing and business model approaches. It also explores the potential for digitalisation and smart approaches as a solution for enhancing electricity system efficiency.

Policy makers in Kenya will need to co-ordinate action on access to electricity, clean cooking and electricity system efficiency with improved energy efficiency in the buildings and appliances sectors

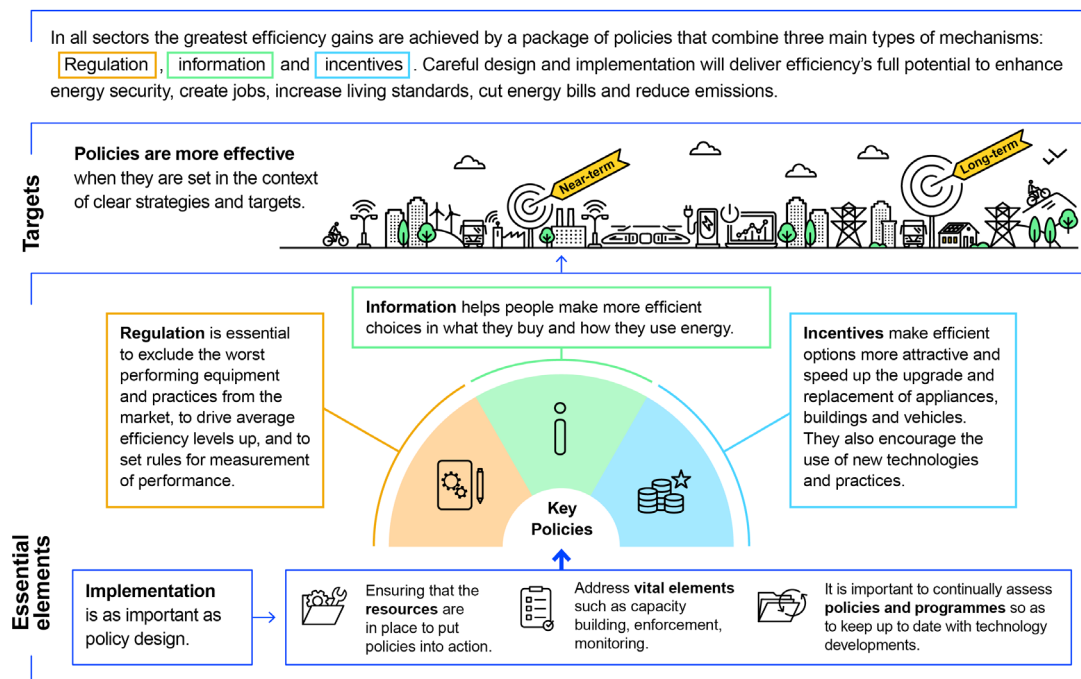
Energy efficiency is a relatively low-cost solution that can temper demand growth, reduce the strain on existing transmission and distribution infrastructure, support increased rates of access to electricity, and improve affordability. As demand for, and access to, electricity in Kenya increases, policy makers need to ensure that appropriate measures are introduced to limit impacts on overall affordability. Managing this balance effectively will require measures to boost energy efficiency in buildings, support access to efficient appliances and cooking solutions, and ensure adequate power system investment in actions to electricity system losses.

This report gives suggestions on potential policy actions that can be taken to enhance progress, drawing on case studies and examples from Kenya and other countries in Africa and globally. The report also explores the potential of

digitalisation for unlocking new opportunities as well as the importance of ensuring an inclusive energy transition that provides economic opportunity and improves livelihoods, especially those of women and children. Recommendations follow the IEA [policy package approach for energy efficiency](#), built on the foundation of three essential elements: **regulation, information and incentives**.

IEA policy package approach to strengthening energy efficiency

Policy Packages for Energy Efficiency



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Source: IEA (2022), [Energy Efficiency 2022](#).

Chapter 1. Buildings

Key facts

- The residential sector accounted for almost three-quarters of Kenya's total energy consumption in 2020, with continued growth expected in the coming decade.
- Kenya has made progress in developing buildings regulations; however, there are currently no mandatory requirements for energy-efficient practices.
- Promotion of energy management will be key to long-term savings in the buildings sector, and stricter regulations introduced in recent years will drive progress.
- Kenya has introduced incentives including tax exemptions, rebates and sustainable debt issuance to encourage energy-efficient building practices.
- Smart and digital solutions in buildings are becoming increasingly recognised as a solution for optimising energy use.

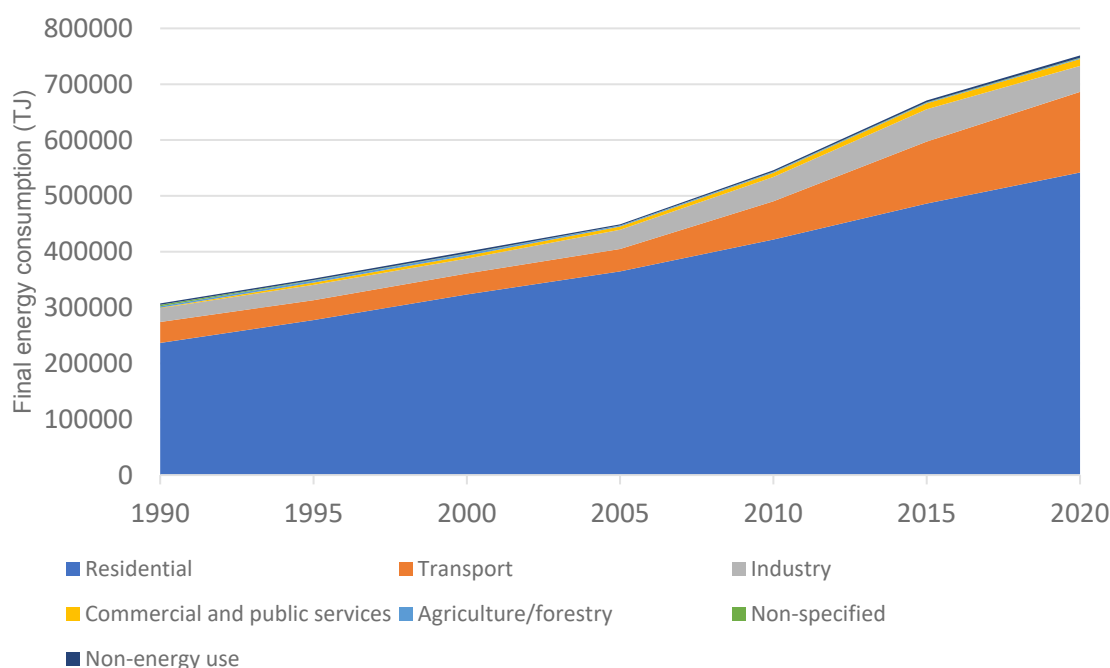
Progress on energy efficiency in Kenya's buildings sector

The energy performance of buildings is central to Africa's future energy needs and the clean energy transition. The continent is set to embark on one of the biggest expansions of building floor area in the world in the period to 2050, with the residential building stock projected to double to almost [50 billion square metres](#). Most new construction will be in urban areas that suffer from urban heat island effects as well as the effects of climate change, driving up energy demand. The role of mandatory building energy codes and energy efficiency requirements, among other measures, will be central to ensuring that buildings are well equipped to meet increasing demand sustainably while also ensuring affordability. African countries have the opportunity to leapfrog other regions by building energy- and resource-efficient buildings adapted to local climatic conditions, while lowering operating costs that can translate into reduced electricity bills for consumers.

The buildings sector is the primary source of energy consumption in Kenya and will remain so, driven by economic growth and expansion of the country's buildings stock

The residential sector accounted for [about 74%](#) of total final energy consumption in Kenya in 2020, with consumption growing by over [28%](#) in the preceding decade. Over the next few years, the total building stock in Kenya is expected to continue to grow from approximately [37 million square metres in 2018 to a projected 47 million square metres by 2025](#). This growth will bring increases in energy demand, highlighting the need, but also the potential, for improving sector efficiency to meet longer-term clean energy and electricity access targets. It is important to note that Kenya has a considerable residential housing deficit of 2 million dwellings, which has led the government to prioritise [affordable housing](#) initiatives with the aim to build [250 000](#) homes every year for low-income households.

Total final energy consumption by sector, Kenya, 1990-2020



IEA. CC BY 4.0.

Note: TJ = terajoule.

Source: IEA (2020), [Key energy statistics, 2020](#).

Kenya has made progress in developing buildings regulations, but there are currently no mandatory requirements for energy-efficient practices.

Kenya currently does not have [harmonised guidelines](#) for regulating the development and maintenance of green buildings, with regulations and legislation not requiring buildings to comply with energy efficiency standards. There are also

limited requirements for building construction, highlighting considerable potential for use of recycled materials, reduced carbon footprints and environmentally adaptable designs. There has been recent progress, however, in setting out clearer guidelines for the sector.

In 2022, Kenya introduced its [National Building Code](#), which includes support for energy efficiency in buildings covering key areas such as natural lighting, cooling and ventilation. The code highlights the importance of natural ventilation for reducing heat gains from outside sources and internal heat generated by people, lighting, equipment and other processes to reduce the need for active space cooling. Building owners have the option to adopt sustainable design strategies derived from independent green building certification organisations, further promoting energy-efficient and environmentally conscious practices. The code is not yet mandatory.

In terms of electrical appliances, the code requires building owners to prioritise energy efficiency by complying with relevant laws that mandate the use of energy-efficient appliances that consume less electricity and reduce overall energy consumption within the building. The code acknowledges the significance of renewable energy sources and specifies that their installation and use in buildings should adhere to requirements set out in the [Energy Act \(2019\)](#).

The government of Kenya has also introduced broader [initiatives](#) to promote energy-efficient building practices, including in its [National Energy Efficiency and Conservation Strategy \(NEECS\)](#) 2020. In addition, the programme Promoting Energy Efficiency in Buildings in East Africa, funded by the Global Environment Facility (GEF), has provided technical assistance for the construction of at least [400 000 energy-efficient housing units](#). The [Building Accelerator Programme](#), which Kenya joined in 2017, aims to implement green building guidelines for new building permitting, and carry out pilot studies on energy usage to inform future energy improvements. To date this programme has been [adopted](#) by Nairobi, Nakuru, Kisii and Homabay Counties. As of March 2022, data from the Kenya Green Building Society showed there were [48](#) certified and registered green buildings in Kenya, an increase of 25 over the preceding year.

Promotion of energy management will be key to long-term savings in the buildings sector, and stricter regulations introduced in recent years will drive progress

Over the past decade the government has placed a growing focus on promoting best practice for energy management in buildings. In 2012, Kenya adopted [Energy Management Regulations](#) introducing requirements for energy audits, implementation of energy savings measures and the concept of energy service companies (ESCOs). In 2021, a [revised version](#) was published by the Energy and Petroleum Regulatory Authority (EPRA) noting that only 43% of the facilities covered by the regulation had carried out energy audits between 2012 and 2020.

The revised draft regulations proposed several specific requirements companies need to comply with, including:

Energy audits: every owner of a designated (industrial, commercial, institutional) facility with an annual energy consumption of more than 180 000 kilowatt-hours is required to undertake an energy audit and designate an accredited energy manager (in accordance with the Kenya standard KS ISO 50002). Facilities are required to conduct energy audits every four years to assess their energy consumption patterns and identify opportunities for energy efficiency improvements.

Energy management plans: facilities are expected to develop and implement energy management plans that outline strategies for reducing energy consumption (to achieve at least 50% of the recommended energy savings within three years of submission of the plan), increasing energy efficiency and promoting the use of renewable energy sources.

Reporting and disclosure: facilities are required to annually report their energy consumption and other specified data to the relevant regulatory authorities.

Super ESCO accelerates buildings retrofits in India

Buildings account for over 30% of final energy consumption in India, a figure that is rising annually by 8%. Launched in 2017, the Building Energy Efficiency Programme (BEEP) issued requirements for energy-efficient buildings to all departments and ministries. The [Super ESCO Energy Efficiency Services Limited \(EESL\)](#), under the administration of India's Ministry of Power, has been key to the success of BEEP to retrofit commercial buildings into energy-efficient complexes.

As energy audits demonstrate energy savings potential of 30-50% in buildings in India, EESL has completed energy efficiency projects in over 12 000 buildings, including railway stations and airports. In 2021, EESL partnered with private ESCOs as part of the World Bank India Energy Efficiency Scale-Up Programme. The programme promoted progress towards achievement of lifetime energy savings, and avoided CO₂ emissions from light-emitting diode (LED) bulbs, tube lights, energy-efficient ceiling fans and LED street lights sold through EESL programmes of over [80%](#).

Kenya has introduced incentives including tax exemptions, rebates and sustainable debt issuance to encourage energy-efficient building practices

The [Green Fiscal Incentives Policy Framework](#), introduced in 2022, offers various fiscal and economic incentives such as tax exemptions and credits for off-grid renewable energy installations. The framework provides a definition for what constitutes a "green" building, including efficient use of energy, use of renewable energy and good indoor environmental air quality. Sustainable debt issuance for green buildings has grown in recent years, following publication by the Kenyan Capital Markets Authority of [Policy Guidance Note on Green Bonds](#) in February 2019. The guidance includes strict reporting requirements on allocation of proceeds and impact. Kenya's [first green bond](#) for the buildings sector was issued in October 2019, raising KES 4.3 billion (USD 28.6 million) (USD 41.5 million) for the construction of six student accommodation properties in Nairobi.

Kenya's market for green buildings has grown gradually; however, in 2020 the certified green building market accounted for just [3%](#) of new builds. Building Energy Efficiency Certification is not mandatory, though some private sector organisations promote well-known international certification systems such as Leadership in Energy and Environmental Design (LEED). Engagement with the Green Bond Programme Kenya (GBPK), [EDGE green building certification](#) and Climate Bond Initiative certification also raised awareness and offered investors a clear understanding of the project's environmental and energy performance.

Energy efficiency considerations are increasingly considered in measures to improve conditions in informal housing settlements

[Close to half of Kenya's urban population](#) lives in slums, and in some cities this share can reach [80%](#). Such informal settlements are characterised by severe deficiencies in potable water, access to sanitation and reliable energy services, proper housing, and security of tenure. It is projected that [the number of slum residents will double in the next 15 years](#). Rapid urbanisation, rural-urban migration, and population growth have contributed to the expansion of these informal settlements.

The government of Kenya recognises the challenges posed by informal housing and has implemented various initiatives to address their challenges. The [Affordable Housing Programme](#) aims to construct 250 000 houses every year for low-income earners, and also targets 6.5 million Kenyans living in slums and informal settlements. The [National Housing Policy](#) and the [National Slum Upgrading and Prevention Policy](#) aim to improve living conditions in informal settlements by providing affordable housing, developing infrastructure, establishing land use rights, and promoting energy efficiency and water conservation in buildings.

Smart and digital solutions in buildings are becoming increasingly recognised as a solution for optimising energy use

Kenya's [Digital Economy Blueprint](#) advocates for creating “smart networks”, which allow for comprehensive and systematic use of the possibilities for digitalisation in major infrastructure areas, such as energy, transportation, health, education and public administration. In the buildings sector, such networks can take the shape of smart meters, smart homes and other smart solutions (such as sensors and controls) that can help to optimise buildings operations, including energy use. [Britam Tower](#), located in Nairobi, serves as an impressive example of energy-efficient and smart solutions in modern construction. This iconic 32-storey tower building incorporates several innovative features to enhance sustainability and operational efficiency, providing numerous benefits for both the environment and building occupants. The intelligent data-driven building management system implemented in Britam Tower gives the facility management the ability to fully understand the building operational performance and has resulted in 39% energy savings and 50% water savings in comparison to a typical office building in Nairobi.

National-level strategies are in place to improve standards, promote passive cooling approaches and incentivise green buildings

Improvements to buildings sector energy efficiency are a core objective for realising Kenya's Vision 2030, which outlined [commitment](#) to inclusive green economic growth and investment including energy and building and construction. The government has set out a series of targets and objectives in national strategies aimed at improving energy efficiency in the sector, including plans to implement a minimum energy performance standard (MEPS), introduce building code amendments to promote passive cooling and implementing strategies for ESCOs.

Strategies and targets related to buildings sector energy efficiency in Kenya

Description	Targets and objectives
Kenya National Energy Efficiency and Conservation Strategy (NEECS)	• Develop MEPS for buildings • Establish a baseline energy use index for buildings • Increase share of newly built floor area compliant with energy efficiency requirements in the total building stock from 0% to 10% • Reduce lighting load in public buildings by 50% • Design and construct at least 20 energy-efficient/green public buildings • Increase share of green buildings used for affordable housing from 0 to 25% • Adopt American Society of Heating, Refrigerating and Air-Conditioning Engineers energy conservation standards or equivalent for public and commercial buildings.
National Cooling Action Plan for Kenya 2022	• Revision of building codes to mainstream passive cooling and avoid lock-in of poorly insulated new buildings • Analysis of cooling demand that caters to the thermal comfort and productivity of the people in their homes

Description	Targets and objectives
	• Focus on nature-based and passive cooling technology options in urban planning and building design • Pilot projects for cooling in urban planning and building design, such as deployment of cool roofs, that can raise awareness of passive cooling and nature-based solutions.
Green Fiscal Incentives Policy Framework	• Provide tax incentives for building materials locally manufactured using more than 50% recycled content • Incentives for meeting green buildings specifications and requirements set out in the buildings code.

Key issues to address

There are a range of challenges facing policy makers when addressing buildings energy efficiency in Kenya. However, there are key opportunities for improvement, including the adoption of new technologies, innovative financing mechanisms, capacity-building programmes and growing importance of digitalisation. Implementation of energy efficiency measures, smart technologies and enabling solutions for building-to-grid interactions can expand the potential for Kenya's buildings sector to shift from being a passive to an active consumer of energy, creating new opportunities for demand-side flexibility that can help to reduce overall strain on the power system.

Regulation

Developing building energy codes (BECs). Despite progress on developing a BEC, the code is not yet mandatory for new or existing buildings. With projected continued growth of Kenya's buildings sector, early implementation of a mandatory code would go a long way in ensuring efficient design, maintenance, operation and renovation of buildings. This could be delivered through adoption of stricter energy efficiency requirements for building envelopes and electricity-consuming systems, supplemented by prescriptive compliance options. Including requirements for a building code improvement cycle that strengthens performance requirements every three to five years would allow for regular assessment and updating.

Building code targets energy efficiency gains in Ghana

Ghana launched its first-ever Building Code in 2018 covering all areas [for a smooth and safe operation of the building and construction industry](#). It notes the energy efficiency standards for both residential and non-residential buildings and covers [mechanical ventilation systems, refrigeration equipment, hot water systems and lighting systems](#). With references to adequate planning, management and construction practices for buildings, it discusses building envelope properties as a

prescriptive compliance path to ensure energy-efficient buildings using [three passive design strategies](#) – passive ventilation, cooling and daylighting, including window to wall ratios, solar heat gain coefficients and exterior shading. A minimum of 5% of the occupied floor area must also be specified as openable windows to promote fresh and cooling air flow, alongside MEPS to ensure efficient air-conditioning equipment.

Energy efficiency requirements are applicable to private buildings throughout Ghana that are above 5 000 square metres (m²) total gross floor area and public buildings located in all the regional capitals, Accra, Kumasi and Takoradi, that are above 500 m² in total gross floor area. Green building certification systems are also considered as a replacement to all prescriptive requirements. Effective implementation of the code has the potential to create [100 000 green jobs](#) in the efficient building and construction value chain.

Making buildings grid-ready in a digital future. Future growth of renewable energy, rooftop solar PV, electric vehicles and household appliances will have a significant impact on electricity grids. Pairing implementation in buildings with digital solutions, such as smart meters, advanced controls, sensors and communications technologies, can ensure that buildings are [grid-interactive](#). This would require introduction of elements in Kenya's building code that promote grid integration, preparing buildings for a modern future energy system.

Energy-efficient renovations for existing buildings. Attracting the resources and financing needed for large-scale renovations can be challenging, but could be addressed by developing a nationwide programme for energy-efficient renovations. Such programmes could start with the most inefficient government and public buildings to lead by example, with the vision expanding to target building types in the medium and long term. The role of ESCOs could be key to accelerating renovation rates.

Passive cooling and nature-based solutions. Ensuring that new buildings minimise the need for active space cooling systems would be a key first step for reducing increased energy demand for cooling. Prioritising passive design strategies in buildings requirements could in some cases avoid the need for active cooling systems entirely.

Information

Tracking energy performance in buildings. The ability to track energy performance and actual energy use in buildings at a more granular level is key for informing decisions in the sector. Creating a robust data collection framework and developing a basis for comparing building energy performance across building types would go a long way to inform investment decisions for improving the overall performance of the building operation. Use of regular energy audits would provide

opportunities to identify energy-saving measures and could be made mandatory initially in buildings with high energy consumption.

Buildings certification and labelling. Kenya is already working towards implementing MEPS for buildings, an important first step for energy efficiency in the sector. Introducing mandatory certification and labelling programmes in support of this can further enhance performance comparison across building types, with data collected through benchmarking. An additional future step including certification on material efficiency, embodied carbon and [smart readiness](#) would further strengthen progress in the sector.

Energy performance disclosure. The ability to track and measure performance in buildings can be challenging, but Kenya's plans to establish a baseline energy use index are a positive step. Requiring mandatory disclosure requirements for buildings energy performance in the future, based on certificates or benchmark rating, would support improved data collection, promote competition and inform longer-term decision-making.

Training and capacity building. Realising the full benefits of energy-efficient buildings relies on development of a skilled workforce, underpinned by professional accreditation. Provision of accessible training on energy-efficient construction and renovation, building energy performance certification, and energy-efficient buildings operation accompanied by professional accreditation is critical to driving energy efficiency in the sector, and can also unlock significant potential for jobs creation and upskilling in urban and rural areas.

Incentives

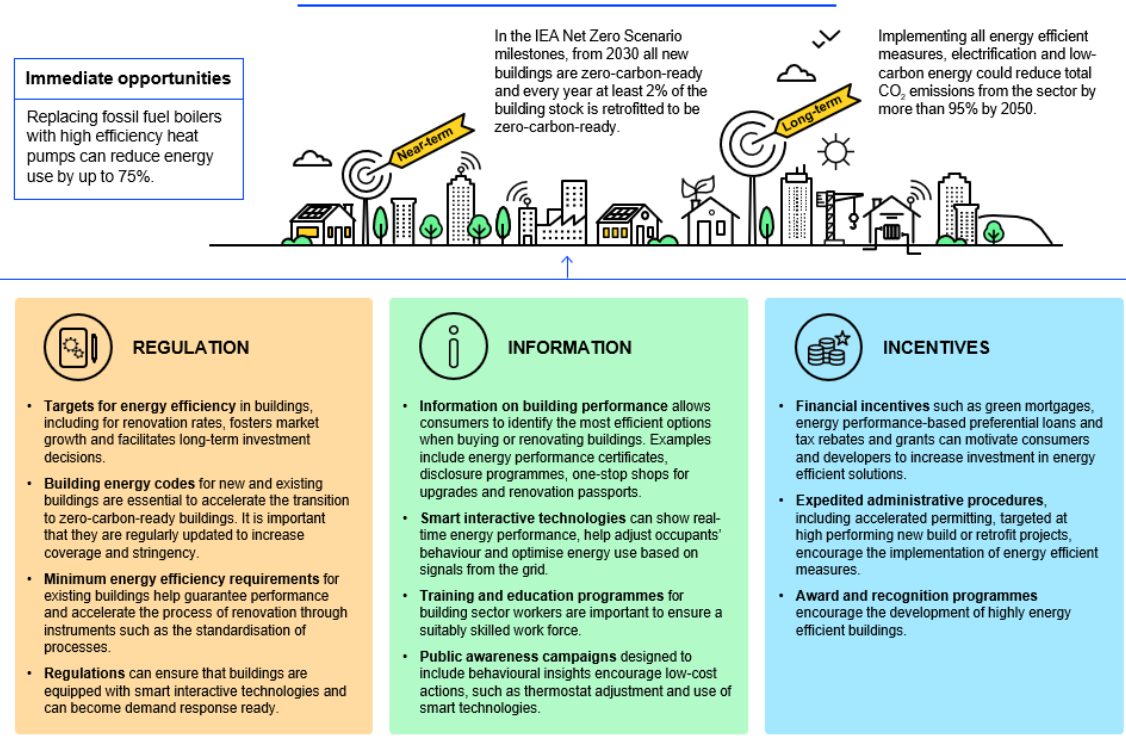
Financing energy efficiency in existing buildings. Financing energy efficiency in buildings remains a challenge, often due to their small scale and low awareness of potential, risks and business models. Linking financial incentives with certification and labelling schemes, underpinned by more granular data and disclosure, can increase visibility of investment opportunities in the sector. Attracting affordable low-cost debt, such as through green bonds, can also be impactful for attracting financing. The role of ESCOs should also be considered for promoting scaling up of retrofits.

Non-financial incentives for energy-efficient buildings. A combination of financial and non-financial incentives can strengthen incentives for both energy efficiency retrofits in existing buildings and development of new efficient buildings. Non-financial incentives could include the use of expedited permits or increased floor area allowances to encourage development of more energy efficiency projects for buildings construction and renovation.

Financing for new energy-efficient buildings projects. [IEA analysis](#) indicates a potential increase in investment in buildings efficiency in Africa over the next decade, but this will need to be underpinned by efforts to attract broad sources of financing. Policy makers in Kenya could consider a variety of options, including

developing dedicated credit lines to establish a revolving fund, which collects repaid loans for energy efficiency projects and reinvests them in new projects. Working with banks to provide funding for specific purposes such as deep renovation of buildings and bulk procurement of energy-efficient appliances can also deliver positive benefits.

Policy package for strengthening energy efficiency in buildings



IEA. CC BY 4.0.

Source: IEA (2023), [Energy Efficiency Policy Toolkit 2023: From Sønderborg to Versailles](#).

Chapter 2. Appliances

Energy-efficient appliances are critical in addressing the global climate crisis and achieving a clean energy transition in Africa. The IEA estimates that as climate change and urbanisation drive up the need for cooling, electricity demand for household appliances in Africa could more than double to 350 terawatt-hours (TWh) by 2030, highlighting an increased need for adopting energy-efficient models.

Barriers for consumers accessing more efficient models include a lack of availability in local markets and dumping of inefficient or second-hand appliances, as well as the perception that increasing the efficiency of available models will translate into higher costs for consumers. However, analysis of air-conditioning prices in sub-Saharan Africa, Latin America and Southeast Asia indicates that in fact highly efficient models can be as affordable as less efficient devices.

Despite deployment increasing globally, the penetration of space cooling solutions and air-conditioning equipment is not equally distributed across the globe. For example, only around [5%](#) of households in sub-Saharan Africa are equipped with an air-conditioning unit, and more efficient models have limited availability in local markets. Economic growth and increased incomes in Africa will increase access for consumers to appliances, refrigeration and other household appliances, increasing demand for electricity that would need to be matched by supply.

Transition to energy-efficient appliances can result in a range of multiple benefits, including reduced emissions and energy demand, improved air quality, and health benefits, as well as expanding access to affordable, reliable and sustainable energy.

Progress in Kenya on strengthening appliance energy efficiency

Key facts

- In 2022, less than 13% of households in Kenya owned a refrigerator, and air conditioning was estimated at only 15% for the residential sector.
- Electricity consumption from light industry, appliances and cooling systems in Kenya could quadruple through to 2040 as demand increases.
- Consumers in Kenya could purchase an air-conditioning unit that is more than twice as efficient as a low-efficiency alternative for the same price, but availability of more efficient models is limited.

- When considering the potential lifetime savings of more efficient products, consumers can benefit from both lower upfront and lower running costs.
- As an import-only market for air conditioners and domestic refrigerators, Kenya is exposed to issues of dumping and imports of second-hand appliances.

As Kenya continues to make progress on universal access to electricity and economic growth proceeds (Kenya Vision 2030 aims to increase annual GDP growth rates to an average of 10% per year out to 2030), this will drive increased demand for modern household appliances including refrigerators, fans and air conditioners. In 2022, less than [13%](#) of households in Kenya owned a refrigerator, while penetration of air conditioning was estimated at only 15% for the residential sector and 30% for the commercial sector.

According to Kenya's Ministry of Environment, Climate Change and Forestry, the effects of climate change are projected to lead to an increase in mean annual temperatures of up to [1.5° C](#) by the 2030s, further accelerating demand for household cooling appliances as a result of increased frequency of hot weather conditions. If unaddressed, energy demand from residential refrigerating appliances and room air conditioning alone could reach approximately [7% to 13%](#) of the projected total electricity demand in Kenya.

In the IEA Stated Policies Scenario, electricity consumption from light industry, appliances and cooling systems could quadruple through to 2040, with potential further demand rises to nearly [70 TWh](#) as light industry develops and ownership of household appliances and cooling systems increases. Implementation of standards and other measures to improve efficiency in the appliances sector therefore becomes increasingly critical in the next decade as demand for electricity increases.

Promoting efficient lighting and appliances in East and Southern Africa

Creation of a conducive market environment for energy-efficient lighting and appliances requires a combination of policy improvements, market incentives, capacity building and awareness raising. Markets in East and Southern Africa need to strengthen their action as an abundance of outdated and energy-draining products are barriers to accelerating sustainable and inclusive development in the region. [The Energy Efficient Lighting and Appliances in East and Southern Africa project \(EELA\)](#), funded by the Government of Sweden and implemented by the United Nations Industrial Development Organization (UNIDO) in partnership with the East African Centre of Excellence for Renewable Energy and Efficiency (EACREEE) and the Southern African Development Community (SADC) Centre for

Renewable Energy and Energy Efficiency (SACREEE) aims to stimulate the adoption of energy-efficient lighting products and appliances across the regions.

The project focuses on four key areas across 21 member countries:

- 1) Improving policies and regulations:** Creating a regional framework and harmonised minimum energy performance standards (MEPS) for various products.
- 2) Establishing market incentives:** Incentives are introduced to encourage the uptake of energy-efficient lighting and appliances. Technical and financial assistance is provided to deliver high-quality energy services.
- 3) Building capacity:** Building the capacity of governments, standards-setting bodies, accreditation bodies, testing facilities and the private sector.
- 4) Raising awareness:** Public information campaigns launched through TV, radio and social media to promote the benefits of energy-efficient technologies.

EELA also hosts an Annual Stakeholder Forum bringing together cross-sector representatives from the energy sector in East and Southern Africa. The last forum was held in [Nairobi](#) in March 2023.

Kenya has introduced measures aimed at improving appliance efficiency, with ambitious aims to expand coverage through standards and compliance

In the last decade Kenya has demonstrated its commitment to promote the use of energy-efficient products, primarily through adoption of a standards and labelling (S&L) programme. In 2016 the [Energy \(Appliances' Energy Labelling and Performance\) Regulations](#) introduced requirements for the first time for use of energy efficiency labels on selected electrical appliances manufactured, imported, distributed and sold for use in Kenya, as well as stipulating the testing requirements prior to labels being issued by the regulator.

Implementation of MEPS and labels is a key step in driving efficiency of appliances, and form part of a series of actions included in the IEA's [policy package approach](#). Adoption drives positive developments on the supply side of the market as manufacturers and retailers are incentivised to produce and sell energy-efficient products. The labels enable consumers to purchase higher-efficiency appliances, as well as provide information needed to better understand the financial benefits of their reduced energy consumption. The five-star labelling scheme used in Kenya tags the highest-performing appliance with five stars and the lowest with one star, giving consumers reliable information to decide on what they want to buy.

In addition to its S&L programme, Kenya has introduced measures aimed at ensuring compliance with energy-saving regulations. Since 2021, the regulator has

maintained an extensive registry of appliances meeting MEPS covering four key categories: refrigerators, air conditioners, motors and fluorescent lamps. Registration includes fees and charges set out under Kenya's Appliance Charges Regulations, which provide a source of financing needed for maintaining the register in support of effective regulation. By adjusting the fees, the regulations aim to facilitate compliance with MEPS while supporting consumers and businesses in their efforts to use more energy-efficient appliances.

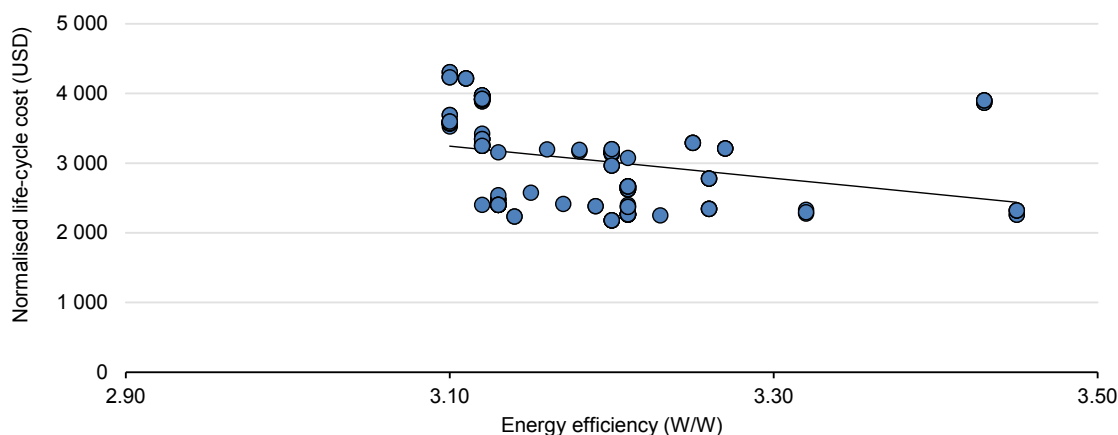
In order to facilitate manufacturers and retailers in adhering to the regulations, the regulator has introduced reductions in [charges](#) for registering certain appliances, including in 2018 when fees for specific appliances such as refrigerators were reduced. Combined with the almost zero marginal cost of applying labels to appliances, adjustments have helped ensure affordability to consumers and ease the compliance process for all stakeholders involved.

The market for air conditioners remains dominated by low-efficiency options, with limited access for consumers to more efficient models

Data collected in 2023 show that in nearly every region of the world the typical air conditioner sold is less than half as efficient as the best product on that same market. This means that consumers are often paying more for products which are of lower energy efficiency, leading to higher long-term household energy costs over the lifetime of the product. Opting for a more efficient model does not always come with a higher price tag and in virtually all cases, a more efficient appliance will lead to lower running costs.

This situation is observed in Kenya, where despite introduction of the S&L programme and strengthened regulations, the market remains dominated by low-efficiency products. In Kenya, current data show that about 90% of air conditioners on the market carry a one-star energy label, the lowest energy efficiency class available, with most of the remainder at two-star. The implication is that consumers have limited access to better-performing models even though the best-performing options would cost less than the broadly available lowest-efficiency models. Opting for the high-efficiency model over the lowest-efficiency would more than halve energy bills over the lifetime, with cost savings accruing to almost USD 2 000. A similar situation exists in most other countries.

Normalised life-cycle cost (USD) versus energy efficiency rating (W/W) of air conditioners available for sale in Kenya (wall-mounted type), 2023



IEA. CC BY 4.0.

Notes: The normalised purchase price represents the air-conditioner price normalised with a cooling capacity of 12 000 British thermal units (BTU) per hour. The cooling capacity of air conditioners used in this analysis ranges from 9 000 BTU/hour to 35 000 BTU/hour. The assumed lifespan of air conditioners is ten years. The assumed annual running hours are 973 hours. W/W = Watt for Watt energy efficiency rating.

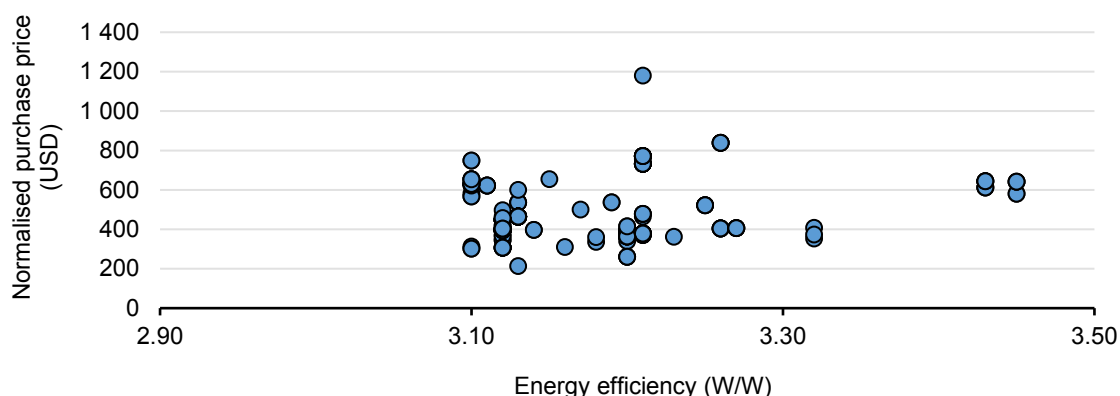
Source: IEA analysis of Kenya AC market.

More efficient products in Kenya do not necessarily translate into higher upfront costs for consumers

One key factor limiting the willingness of governments to adopt more stringent energy efficiency standards for appliances is concern over the potential for such actions to translate into higher upfront costs for consumers. However, recent market data show that in numerous markets including sub-Saharan Africa, Southeast Asia and Latin America, high-efficiency and even net zero compliant products are readily available on the market and are not necessarily more expensive than average efficiency models. When considering the potential lifetime savings of more efficient products, consumers can benefit from both lower upfront and lower running costs, increasing access to products that can deliver long-term energy savings.

Analysis of the market in Kenya indicates that for USD 300 consumers could purchase an air-conditioning unit that is more than twice as efficient as low-efficiency alternatives. The limited or lack of availability of higher-efficiency models, however, limits opportunities for consumers to obtain them, therefore missing out on the longer-term energy savings potential. In addition, limited competition in the market results in products with a range of efficiencies being available for the same price, limiting the ability of increased product efficiency to be reflected accurately in final consumer prices.

Normalised purchase price (USD) versus energy efficiency rating (W/W) in Kenya (wall-mounted split type), 2023



IEA. CC BY 4.0.

Notes: The normalised purchase price represents the air-conditioner price normalised with a cooling capacity of 12 000 BTU/hour. The cooling capacity of air conditioners used in this analysis ranges from 9 000 BTU/hour to 35 000 BTU/hour.

Source: IEA analysis of Kenya AC market.

Innovative financing approaches to domestic cooling in Ghana

Economic and population growth, combined with the impacts of increasingly frequent extreme weather events driven by climate change, are driving growing demand for refrigerators and air conditioners in the residential sector. Ghana and Senegal face challenges in their markets with outdated, low-efficiency products, limited information available to consumers on product performance, high prices and limited access to financing.

[The ECOFRIDGES Green On-wage \(GO\)](#) initiative is an appliance financing programme that facilitates the purchase of more than 1 300 energy-efficient air conditioners and nearly 1 600 refrigerators through bank loan products designed to address short- to medium-term financing needs. The programme effectively addresses the financial barrier to acquiring new, efficient appliances by offering consumers a credit facility with favourable repayment terms: 0% interest over 12 months.

To ensure that the supported products meet strict energy and environmental standards, eligible refrigerators have to adopt a five-star energy rating and use R-600a refrigerants, while eligible air conditioners need to have a minimum three-star rating and utilise R-32 refrigerant. Since its inception, the financing facility has supported sales of over 3 000 new certified refrigerators and air conditioners through deployment of more than [USD 1 million](#), leading to a reduction in energy demand of 25 megawatt-hours (MWh) and preventing over 20 000 tonnes of direct and indirect CO₂ emissions. This remarkable case study serves as a testament to the programme's success in promoting energy efficiency and environmental sustainability in Ghana.

Kenya, as an import-only market for air conditioners and domestic refrigerators, is exposed to dumping of inefficient, second-hand appliances

Dumping of obsolete and low-efficiency second-hand appliances from countries in Europe, Asia and the United States to Africa has been a long-term trend leading to increased costs in terms of electricity bills, energy security, safety and environmental impact. A report in 2020 by [CLASP](#) found that 35% of room air conditioners sold in Africa's largest countries are low-efficiency units, with 650 000 units not meeting common efficiency standards imported annually.

Often exporting countries [do not allow sale of appliances](#) below mandated energy efficiency thresholds (MEPS) in their own markets; however, these appliances still end up being sold in other markets. As demand for cooling appliances across Africa increases, for example, developing a market for high-efficiency appliances will be key to limiting impacts on electricity demand. Without stronger and co-ordinated policy and regulatory action, countries in Africa face the risk of continuing to be the [dumping grounds](#) for inefficient and harmful products.

Kenya is an import-only market for air conditioners and domestic refrigerators, and therefore exposed to issues of dumping and imports of second-hand appliances. A majority of air conditioners imported into Kenya are from the People's Republic of China (hereafter, "China"), with India the next largest export country. Kenya has taken some measures to address this in its [National Cooling Action Plan](#) which builds on previous adoption of MEPS, as well as plans for [regular revision](#), to both gradually improve market quality over time and address dumping issues. The first revision for air conditioner MEPS is aimed to be initiated in 2023 and implemented in 2025 with subsequent revisions every three to five years after this. [Impact assessments](#) on energy savings, GHG emissions and other benefits will be carried out to measure effectiveness.

Regional collaboration on compliance is also highlighted in Kenya's strategy as a key action in the plan, focusing on sharing of market intelligence and co-operation on testing efforts to strengthen and protect both Kenya and neighbouring markets. These actions represent a positive step towards addressing the issue of dumping, but for the time being low-efficiency appliances continue to find their way into the market via imports.

Dumping of inefficient appliances and electronic waste in Ghana

The effects of dumping have been most prominently studied in [Ghana](#), where regulators have been trying to address the issue of electronic waste and low-efficiency appliance dumping for almost two decades. From 2005 to 2019, Europe and other major manufacturing countries exported almost [3 million used](#)

[refrigerators](#) to Ghana. The country has taken steps to address the challenge, including setting MEPS for non-ducted air conditioners in 2005 and refrigerators in 2009. In 2013, legislation was enacted banning the import of used cooling appliances, aiming to improve energy efficiency, reduce household energy waste and meet Ghana's obligations under the Montreal Protocol. This was followed by Ghana's ratification of the [Kigali Amendment to Montreal Protocol](#) in 2019.

Between July 2010 and December 2021, enforcement of MEPS and a ban on imports of used cooling appliances led to [energy savings in Ghana of 11 367 gigawatt-hours \(GWh\)](#), more than the total output over 11 years of the country's Bui hydroelectric dam. Without this intervention, the country would have incurred a cost of approximately USD 522 million from 2010 to 2022 through additional purchase of 7.1 million barrels of crude oil, with an average oil price of USD 72.9 per barrel over the 12-year period. The savings are enough to construct six modern regional hospitals, 348 kilometres of asphalt road, or 1 045 modern six-classroom unit blocks for children's education. Despite these actions the issue of dumping remains in Ghana, and the Energy Commission has been conducting extensive data collection to track dumping. Other examples of countries acting to address dumping include the [Viet Nam Leadership Pledge](#) against ozone-depleting substances in 1995 and Thailand import restriction on refrigerators using chlorofluorocarbons (CFCs).

National targets focus on expanding coverage of energy efficiency standards, promoting bulk procurement and compliance

In order to address challenges with appliance efficiency and promote growth of the market for high-quality products, the Kenyan government has set out a series of strategies covering S&L, testing, and other measures. Setting out clear targets and objectives reflects increased recognition of the potential impacts of increasing adoption of appliances on Kenya's energy system, including the need to expand coverage of standards to cover additional household appliances where consumption will increase as economic growth and incomes rise.

Strategies and targets related to appliances energy efficiency in Kenya

Description	Targets and actions
Kenya National Energy Efficiency and Conservation Strategy (NEECS)	- Expand the number of household appliances subjected to MEPS from six to ten, including televisions, computers, cookers and light-emitting diodes (LEDs). This is projected to boost domestic power consumption efficiency by 3% by 2025, relative to 2020. - Scale up existing testing facilities to cover testing requirements of the newly included appliances. - Reduce the energy consumption due to lighting in public sector buildings by 25%.
National Cooling Action Plan for Kenya 2022	- Enhance access to sustainable cooling for all Kenyans. - Increase ambition of efficiency standards for air conditioners and refrigerators, including planned revisions for MEPS by 2025. - Raise awareness on energy labels for cooling products through annual retail awareness seminars and other measures. - Strengthen compliance and enforcement. - Launch bulk and government procurement programmes. - Implement favourable fiscal policies for high-efficiency products.

Key issues to address

Kenya has made progress on actions to strengthen the market for more energy-efficient appliances, including through S&L programmes, improved regulations and compliance measures, and actions to address dumping of obsolete or inefficient appliances. Market penetration of low-efficiency appliances remains high, however, and as demand grows the country will need to take action to reduce overall impacts on electricity consumption. Ensuring that standards for appliances, and measures to both track changes in usage and ensure compliance, are implemented effectively can go a long way to increasing access for consumers to higher-efficiency options.

Regulation

Harmonising standards with major exporting countries. Designing and revising MEPS to align with those of neighbouring countries and major exporting countries can both expand the market for higher-efficiency appliances and reduce the risks of dumping. Improved standards combined with a clear labelling programme would encourage market players to improve the efficiency of products sold and exclude inefficient products from sales. A ban on used or second-hand appliances could also be considered, as these are often sold at lower prices than those with better efficiency.

Tracking changes in appliance energy efficiency, ownership and usage. Implementing systems to measure and track changes combined with a comprehensive data collection and monitoring framework can provide valuable insights into energy consumption patterns and trends. Regular assessments of appliance energy efficiency can guide the formulation of targeted policies and incentives to promote the adoption of greener technologies. Additionally, tracking

ownership and usage patterns will enable policy makers to address potential barriers to access and identify opportunities for further efficiency improvements. Strengthening of Kenya's [national product registration database](#) would provide a central source of information on appliance performance, energy efficiency and other relevant data. Policy makers could draw on examples of actions taken in Ghana and other developing economies to collect and analyse customs data and enforce bans of importing second-hand products as waste.

Monitoring and verification to improve compliance. Enhancing monitoring and verification of S&L for appliances can help ensure that products in the market comply with established energy efficiency criteria, providing consumers with accurate and reliable information. Increased compliance can be achieved through inspections, market surveillance and other enforcement measures. By improving monitoring and verification mechanisms, Kenya can foster a transparent and trustworthy marketplace for energy-efficient appliances, encouraging consumers to make sustainable choices. Compliance certification schemes can also boost credibility, but should be underpinned by training for certified technicians.

Promoting regional co-operation on appliance testing. Kenya has set out plans to scale up testing facilities including to cover new appliances under its MEPS programme. No one country can support a commercial testing laboratory network covering all appliance types. Collaborating formally with neighbouring countries, developing mutual recognition agreements and sharing compliance responsibilities serve the wider region by ensuring verification and certification of energy-efficient appliances.

Information

Continuously improving the label for a better consumer experience. Kenya's five-star label for energy-efficient appliances provides consumers with key information on the performance of products available on the market. In a country that is increasingly connected online there could be opportunities to further enhance consumer experience and access to information. Applying a QR code to the label presents a low-cost step allowing consumers to verify the authenticity of the energy rating and access detailed information about the appliance's energy performance. It can also be used as a tool for data collection and market surveillance. Additionally, it will act as a deterrent against counterfeit products, ensuring that consumers receive genuine and reliable information. China provides an example of success in [applying QR codes](#) to labels, with voluntary application introduced for manufacturers as early as 2014.

Raising awareness of the benefits to consumers. Although analysis shows that more efficient air conditioners have lower lifetime costs and do not necessarily cost more to purchase, this is not necessarily apparent to the consumer. Public information campaigns aiming to highlight the benefits of energy-efficient technologies could be launched on multiple channels including radio and social media. Government could draw on examples of campaigns in Kenya, such as the [Pika na Power](#) (Cook with Electricity) programme run by Kenya Power, to design

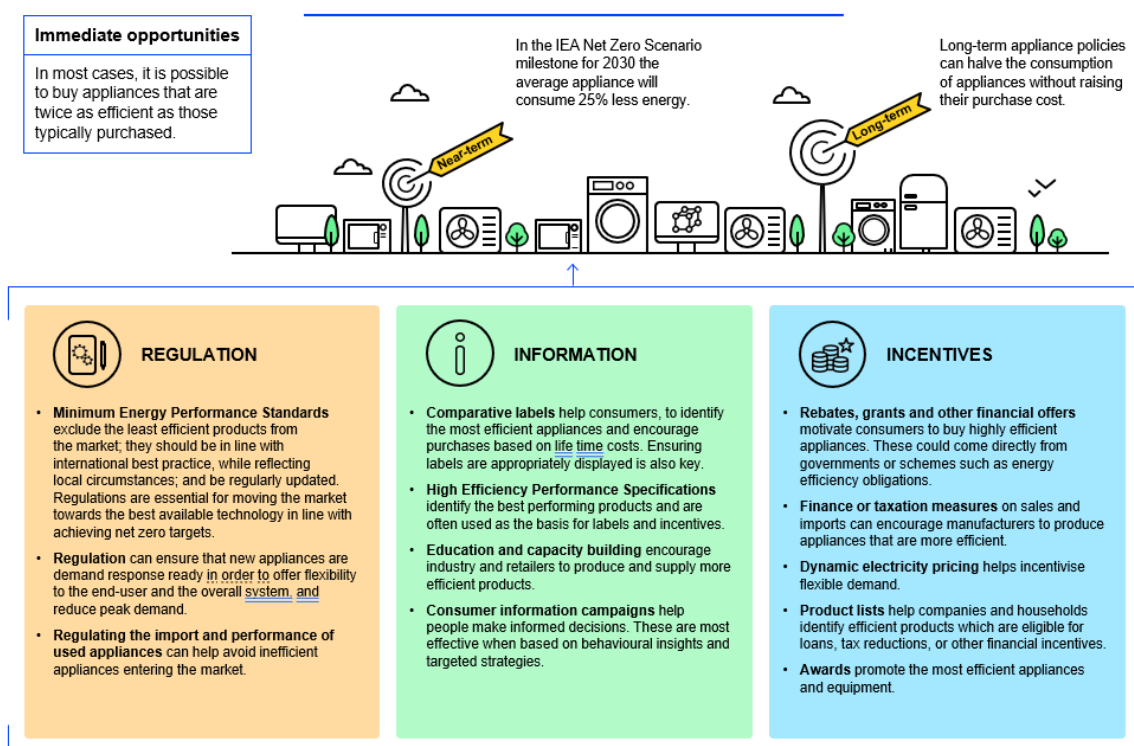
similar initiatives. Awareness campaigns that target women can be key in promoting inclusivity by helping to mitigate gender-related barriers to acquiring efficient appliances.

Incentives

Addressing the affordability of modern, efficient appliances. The upfront cost of appliances is often the primary barrier to their uptake. Introducing rebates, grants and other financial support can encourage consumers to purchase more efficient products, strengthened when combined with clear provision of information. Other measures, such as integrating energy access funding with funds dedicated to appliance market development in energy-poor areas, can also promote wider access. An integrated funding strategy can empower communities with affordable access to efficient appliances, while reducing their longer-term energy bills.

Encouraging procurement of efficient appliances. Bulk procurement of efficient appliances can lead to widespread adoption, delivering energy savings, emissions reduction and benefits to consumers in terms of reduced energy bills. Kenya could leverage the creation of a new [Super ESCO \(energy service company\)](#), as well as private sector [ESCOs](#), to promote procurement initially for public sector buildings. The use of clear [Green Procurement Guidelines](#), linked to Kenya's S&L scheme, can play a key role in developing technical criteria and award schemes that help large consumers to identify energy-efficient options in their procurement schemes.

Policy package for strengthening energy efficiency in appliances



IEA. CC BY 4.0.

Source: IEA (2023), [Energy Efficiency Policy Toolkit 2023: From Sønderborg to Versailles](#).

Chapter 3. Clean cooking

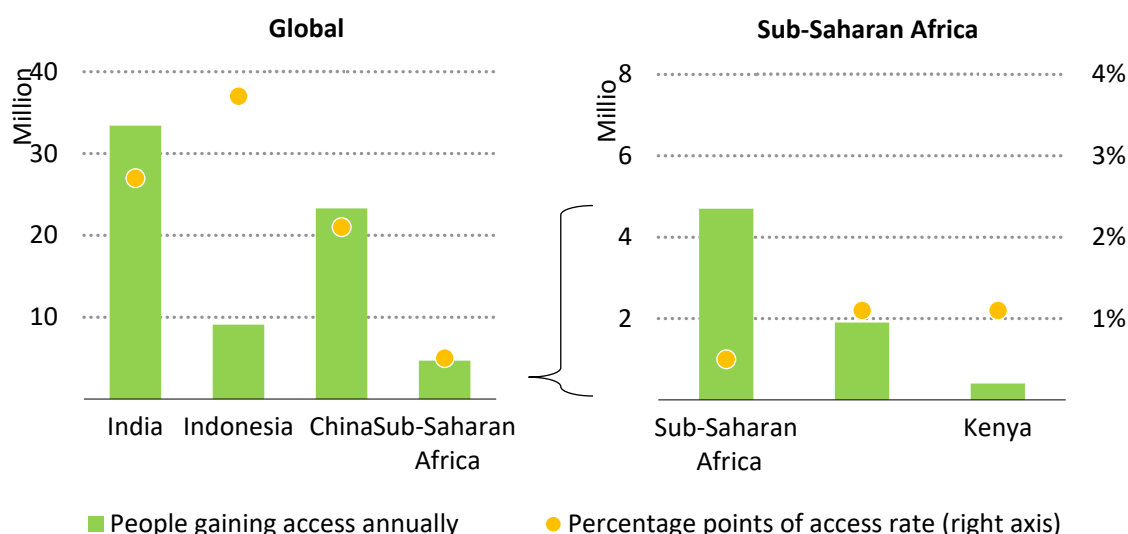
Key facts

- Nearly 80% of Kenyans rely on fuels such as wood and charcoal for cooking, generating almost 20% of the country's greenhouse gas emissions.
- Around 51% of the urban population had access to clean cooking fuels and technologies in 2021, compared with 8% in rural communities.
- LPG, ethanol and electric cooking are multiple options for the shift to clean cooking, but all face challenges with affordability, access or both.
- Accelerating access to clean cooking is critical for improving the lives of women and girls in Kenya, where the average time spent collecting fuel is about an hour a day.
- Innovative, smart solutions are expanding in Kenya, taking advantage of increased access to the internet and mobile phones.

Today, nearly [one-third](#) of individuals globally still rely on rudimentary cooking methods, accounting for a total of 2.3 billion people worldwide. In sub-Saharan Africa, the number of people without access to clean cooking fuels and technologies has been increasing throughout the years, with roughly 1 billion people, or four out of five, continuing to lack access today. Globally, investments in clean cooking stoves, equipment and infrastructure need to reach [USD 8 billion annually](#), with sub-Saharan Africa accounting for half of the total investment required this decade.

The traditional use of biomass continues to dominate residential energy demand in sub-Saharan Africa, with more than 80% of the population relying on it. Basic cooking methods, including the use of wood and charcoal, affect women and children disproportionately and contribute to food stress and climate change. Liquefied petroleum gas (LPG) and electrification present the leading solutions, especially in urban areas, but recent price spikes in LPG are making it unaffordable for millions of people across Africa, pushing many to revert to the traditional use of biomass. Achieving universal access to clean cooking fuels and technologies by 2030 requires shifting 150 million people away from dirty cooking fuels each year in sub-Saharan Africa.

Annual improvement in clean cooking access, 2010-2022



IEA. CC BY 4.0.

Source: IEA (2022), [A Vision for Clean Cooking Access for All](#).

Clean cooking progress in Kenya

A majority of Kenyans still rely on biomass for cooking, placing significant costs on the economy, exacerbating health issues and contribution to carbon emissions

The overarching Kenya Vision 2030 emphasises the social, economic and political pillars in improving the quality of life including education and training, health improvements, and financial and information technology-enabled services that will facilitate the achievement of universal access to clean cooking for all Kenyans by 2028.

In Kenya nearly [80%](#) of the population rely on fuels such as wood and charcoal for cooking, generating almost 20% of the country's greenhouse gas emissions. This is estimated to cost the economy [KES 5.7 trillion](#) (38 billion USD) each year and highlights the importance of switching to clean alternatives for addressing climate and affordability concerns. Biomass, primarily firewood and charcoal, accounts for more than two-thirds of Kenya's final energy consumption and is mostly used for household wood fuel for cooking and heating. As outlined in the National Energy Efficiency and Conservation Strategy (NEECS), 55.1% of Kenyan households used wood as their primary cooking fuel in 2019, followed by 23.9% using LPG, 11.6% using charcoal, 7.8% using paraffin, and less than 1% of households using electricity, biogas and solar.

The most common method for cooking in Kenya remains three-stone open fire (TSOF), used by [59% of Kenyan households in 2019](#). Although this dropped from 76% two decades previously, the overall number of users increased from 4.7 million

to about 7.3 million households over the same period. TSOF and other traditional stoves that burn wood, charcoal and other forms of biomass have very low efficiencies, ranging from 25% to as low as 5%. The use of charcoal, fuelwood and kerosene is dangerous, creating indoor air pollution, causing premature deaths, injuries and damage to property and contributing to climate change by raising GHG emissions from incomplete combustion and deforestation. Over [23 000](#) lives can be saved each year in Kenya from cooking with cleaner fuels and technologies.

The urban-rural discrepancy in Kenya is also prevalent in clean cooking, with 51% of the urban population having access to clean cooking fuels and technologies compared with about [8%](#) in rural communities in 2021. The World Health Organization (WHO) estimates that approximately [24%](#) of Kenya's total population had access to clean cooking fuels and technologies in 2021, a figure that has been steadily increasing by roughly 2% each year. This represents a steady increase from access of [under 2%](#) in 2000 to around [7%](#) in 2010 and [over 19%](#) in 2019.

Doubling access to clean cooking in Indonesia

Indonesia has made great strides in increasing access to clean cooking fuels and technologies, providing access to about 4% more of its population each year since 2010 and doubling the population with access to clean cooking from 2010 to 2018 from [40% to 80%](#). These numbers compare to India, which increased from 30% to 50%, and sub-Saharan Africa, remaining below 20% today.

In order to tackle cooking with unclean fuels, which is associated with 4 million deaths annually according to WHO, the Indonesian government started a cooking fuel conversion programme in 2007 that replaces kerosene with LPG at a national scale. Complementary policies, including dedicated public funding and government subsidies for LPG stoves and cylinder refills for over a decade, have increased the role of LPG. The government's LPG subsidy programme increased cooking with LPG by 60 million individuals between 2015 and 2022, representing over 20% of the total population.

Presently, the government seeks to take the next step and encourage the transition from LPG to electric cooking to reduce the economic burden on the government of subsidies on imported LPG. Nevertheless, this must be done with appropriate policy design to avoid reverting to polluting cooking methods or cooking with new and older methods (fuel stacking) simultaneously.

LPG is playing a key role in advancing the transition to clean cooking, providing a cleaner near-term alternative to traditional fuels

LPG remains a versatile, rapidly scalable and practical fuel that produces fewer air pollutants than kerosene, wood or coal. It presents a less intensive alternative to traditional use of biomass, for example, which is on average [more than 2 times as intensive as LPG](#) but can be more than 15 times if the biomass is harvested unsustainably. While still a fossil fuel, LPG remains a valuable transition fuel in the near-term to ensure that Kenyan households have access to clean cooking fuels and technologies.

The number of households using LPG for cooking [increased by six times](#) from 0.6 million users in 1999 to 3.7 million in Kenya in 2018. Nevertheless, higher prices for LPG in Kenya and across sub-Saharan Africa restrain efforts to expand the use of clean cooking fuels, with LPG prices increasing by over 60% since December 2019. Skyrocketing prices have driven the upfront cost of a standard 13 kg LPG cylinder from the equivalent of 7.5% of the poorest households' monthly income to [more than 10%](#) in Kenya. This financial obstacle incentivises families to switch back to polluting cooking fuels with harmful health and environmental consequences.

The reintroduction of the 16% value added tax (VAT) on LPG in July 2021 was also a setback and reversed significant progress that had been made in Kenya's clean cooking sector. The government of Kenya provided VAT exemptions to some technologies including biogas, ethanol and briquettes, but not for improved cookstoves and LPG. [Half of urban households](#) that cooked with LPG in western Kenya reduced their consumption after the reintroduction of the VAT, switching most prominently back to charcoal and wood. Kenya's National Treasury then [halved the VAT from 16% to 8%](#) in 2022, and finally proposed in their 2023 Finance Bill to [remove the VAT entirely](#) from LPG to encourage the switch to cleaner cooking. Financial incentives for households to switch to LPG remain critical to encourage clean cooking methods and ease the transition to more sustainable fuels.

Innovative pay-as-you-go business models increase affordability and encourage households to switch to LPG in South Africa

South Africa has been a champion in Africa in increasing access to clean cooking, with over [80%](#) of the population cooking with electricity today. Through historically low tariffs and providing subsidies for electricity, South Africa has made significant progress in removing barriers to switching to clean cooking, with less than 10% of South Africans relying on biomass for cooking today. Power supply shortages and recent reforms that removed many subsidies and led to higher residential electricity rates have, however, incentivised the government to diversify cooking fuels.

Founded in 2018, PayGas, a pay-as-you-go (PAYG) start-up, brings affordable clean cooking methods to lower-income households by adjusting the quantity of LPG delivered to the price that they can afford. PayGas partnered with the Clean Cooking Alliance (CCA) to pilot an LPG micro-refilling station in Soweto, Johannesburg, and recorded over 3 000 transactions in the first three months using its [cashless payment system](#) after its launch in March 2021 with an increase in sales of over [10 tonnes of LPG](#). Following the success of the pilot, PayGas formed agreements with operational actors to create 50 new PayGas stations in larger townships in South Africa over the next two years. Overall, PAYG systems and innovative business models can help decrease the cost of supply and upfront costs of LPG cylinders to incentivise households to switch to clean cooking methods through affordable mechanisms.

Ethanol provides an affordable clean cooking alternative, and access has expanded in Kenya through expansion of urban distribution networks

Bioethanol stoves and fuel are playing an important role in the Kenya's shift to clean cooking, with more households using it as a [complementary fuel to LPG](#) when shifting away from kerosene and charcoal. An extensive network of [distributors](#) in Nairobi is supporting growing use of the fuel in urban areas, and as a [cheaper alternative](#) to other fuels it has the potential to meet the needs of lower-income Kenyan households. KOKO networks, a company operating in East Africa and India, operates a clean fuel and carbon platform now serving more than [650 000](#) household subscribers in Kenya using the company's bioethanol for cooking through a network of "KOKO Fuel ATM" [vending machines](#).

Cultivation of sugar cane, cassava and [sisal](#) in Kenya provides an opportunity for greater production of ethanol from biowaste and residues, while supporting creation of [370 000](#) rural jobs in the agricultural sector and boosting incomes for smallholder farmers. The Kenyan government has taken steps to promote growth of the sector through improving affordability, including [exemptions on VAT](#) for denatured ethanol and biogas.

Electric cooking accounts for a small proportion of overall use, with low awareness, high upfront costs and electricity tariffs limiting uptake

Although [75%](#) of households have access to electricity through either direct connection to electricity grids or off-grid systems, less than [1%](#) of Kenyans use electricity as their primary fuel for cooking. High upfront costs of electric cookstoves and cost of electricity tariffs, reliability of household connections and power supply,

lack of awareness of efficient electric cooking appliances, and limited distribution points have all contributed to low rates of electric cooking in Kenya.

For some cuisines, electric cooking may be perceived as incompatible with certain regional cooking norms and cultural practices. However, electric pressure cookers (EPCs) align well with preparing ingredients for Kenyan dishes – the Modern Energy Cooking Services (MECS) launched an [online cookbook](#) using energy-efficient cooking methods to prepare beans and cereals, which are one of the most energy-intensive food groups in Kenyan cuisine. The eCookBook proves that adopting energy-efficient practices and appliances, such as soaking beans and using EPCs, will lead to time savings and reduced fuel consumption for households in Kenya. As sales of EPCs have been increasing rapidly, alongside growing interest in air fryers and induction stoves, education campaigns, recipe books and financial incentives will be critical to encourage the switch to electric cooking.

Kenya Power and Lighting Company (Kenya Power) has also set out to improve access to clean cooking in its five-year [Strategic Plan](#) for the period 2023-2028, including through a drive to promote electric cookers that can encourage consumers to adopt e-cooking. The company aims to increase the number of users from around [90 000](#) in September 2023 to more than [500 000](#) in the next three years. To raise awareness of e-cooking with its customers, Kenya Power has launched a public awareness campaign, [Pika na Power](#) (Cook with Electricity), including setting up demonstration centres in Nairobi, Kisumu, Nakuru and Mombasa. The utility is looking for pathways to scale up the campaign, as well as bringing together the clean cooking and electricity access sectors to develop a network of [e-cooking Champions](#).

Digitalisation and smart solutions have the potential to accelerate access to all forms of clean cooking

Innovations in digitalisation have also been playing a growing role in Kenya's clean cooking sector, harnessing growth in the country's mobile ecosystem. BURN, a modern cookstove company, recently released a tech-enabled [electric cooking](#) (e-cooking) product with internet of things (IoT) connectivity, which allows for monitoring of real-time consumption. Users pay for the equipment in instalments, and are estimated to be able to save around [50%](#) on household fuel costs per year. [M-Gas](#), a project supported by [Safaricom](#), provides users with a package of smart meter, gas cooker, key card and gas cylinder, after which they are able to pay for the gas they need via M-PESA¹. The model allows users to [avoid upfront costs](#) for a gas cylinder and gas cooker, and smart meter technology provides greater control and monitoring of use.

Other innovative models such as [PayGo Energy](#) found that [59%](#) of customers saved money on cooking fuels and 82% of customers saved time due to PayGo. [Bboxx](#), a

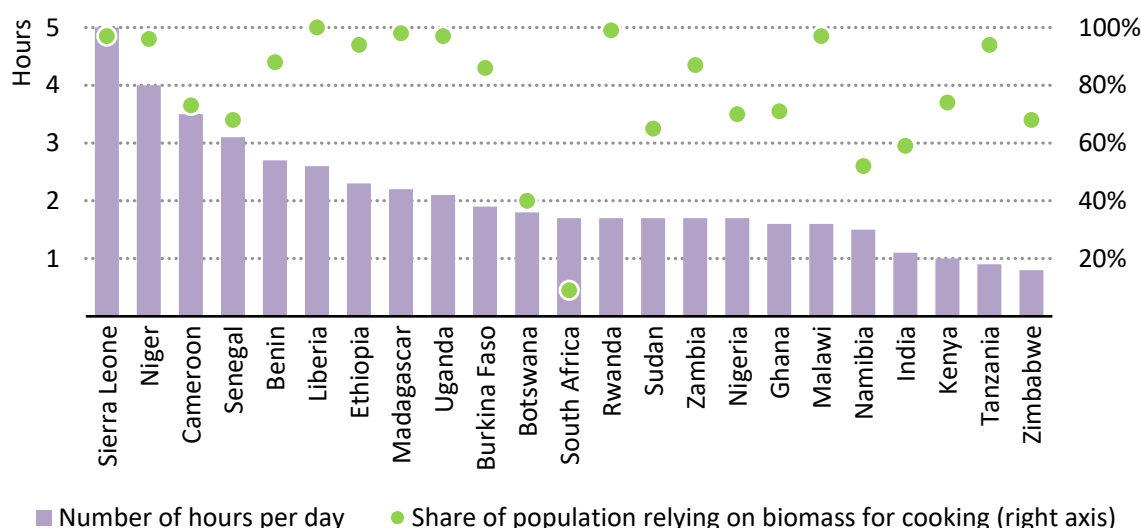
¹ M-PESA is a mobile phone-based money transfer service, payments and micro-financing service, launched in 2007 by Vodafone and Safaricom, the largest mobile network operator in Kenya.

manufacturer of solar home systems, has combined PAYG LPG with PayGo Energy's smart metering technology in various successful pilots in Kenya, Rwanda and the Democratic Republic of Congo. Other innovations such as remotely switching on and off the clean cooking appliances and providing phone charging and flexible mobile payments have also been gaining traction in Africa and play an innovative role to accelerate cleaner cooking practices.

Unsafe cooking practices have a disproportionate impact on women and girls, while a transition to clean cooking could improve safety and women labour force participation

Women and girls disproportionately endure the consequences of lacking access to clean cooking compared with men, due to their time-intensive responsibilities of gathering biomass, preparing fires and cooking meals. These actions prevent women and girls from taking opportunities to pursue schooling, employment and economic freedom as they spend an [average of two hours a day](#) gathering fuel and an additional three hours cooking across sub-Saharan Africa. In Kenya, the average time spent collecting fuel is [about an hour a day](#). The World Bank estimates that these activities represent an opportunity cost of almost USD 1 trillion per year globally.

Average number of hours spent collecting fuel per day per household in selected African countries



IEA. CC BY 4.0.

Source: IEA (2022), [A Vision for Clean Cooking Access for All](#).

Collection of firewood for cooking also puts women and girls at a higher risk of gender-based violence as they must wander outside community boundaries to search farther afield. For example, [42% of households in Chad](#) reported incidents of gender-based violence during firewood collection over a six-month period. In addition, household air pollution is the third-leading cause of death among women

and children globally and the second in sub-Saharan Africa, where women and children also represent 60% of those deaths. Many of these premature deaths are associated with respiratory and cardiovascular disease, which are accelerated by inhaling particulate matter produced through the incomplete combustion of solid biomass in a TSOF.

Accelerating access to clean cooking could therefore provide safer spaces for women in an affordable and energy-efficient manner. A study demonstrates that electrification, including electric cooking, has increased women's labour force participation by [over 9% in South Africa](#). Transitioning to cleaner cooking fuels and technologies would generate a larger workforce with positive economic impacts as more female talent enters the labour market, providing more opportunities, financial freedom and empowerment to women. Women must be involved at the centre of designing and implementing clean cooking strategies and policies to ensure they achieve lasting adoption at home.

Kenya has introduced ambitious targets for boosting clean cooking uptake, including funding for standards and labelling programmes

Strategies and targets related to clean cooking in Kenya

Description	Targets and objectives
National Clean Cooking Strategy (KNCCS) 2022-2028	• Achieve universal access to clean cooking by 2028. • Establish a baseline scenario for the clean cooking sector and identify key barriers and drivers that affect the uptake. • Assess the gender dimensions in Kenya's clean cooking sector and facilitate gender mainstreaming in programme design, implementation and evaluation.
National Energy Efficiency and Conservation Strategy (NEECS)	• Aim to reach 50% of households using clean energy for cooking by 2025. • Develop MEPS for four new cooking appliances, such as biomass cookstoves, and gas and electric burners and appliances, using investments of KES 20 million (USD 133 000). • Create a testing lab for common domestic fuels and thermal cooking appliances, including LPG. • Introduce one standards and labelling framework for improved household biomass cookstoves with a budget of KES 250 million (USD 1.6 million) and the aim to have 50% of households using clean energy. • Develop a clean cooking awareness and communication strategy, enhance R&D in the clean cooking sector and explore financial incentives to promote clean cooking technologies.

Key issues to address

Regulation

Alignment of clean cooking, energy access and electrification priorities.
Clean cooking should not be viewed in isolation from other energy, development

and climate objectives, and should be integrated into policies targeted at buildings and electricity system losses. [Metrics](#) could be developed to track progress, with information shared to all relevant stakeholders to ensure that progress in one area does not come at the expense of another. The government's [Clean Cooking Delivery Unit](#) provides the oversight needed to make this a reality, and should look to engage with cross-government department stakeholders at the national and local level, utilities, the private sector and local decision-makers to maximise impact.

Improving the efficiency of cookstoves through higher standards. Early adoption of MEPS for new clean cooking appliances would set a clear baseline for growing the market. Ghana launched a national standards and labelling programme for improved cookstoves in 2017 to encourage a move away from biomass fuel. Kenya could draw from its existing labelling programme for appliances in design of a label for cooking appliances. Co-ordinating a regional approach early on could be key for ensuring wider quality of the market as it begins to grow more rapidly.

Information

Behaviour change and the role of women. The role of women at all levels – designing, implementing, demonstrating – is fundamental to ensure that policies, and resultant strategy delivery, properly reflect the needs and concerns of people. A study in Kenya found that [women sell three times more cookstoves than men](#), and that when women sold cookstoves to other women, those consumers reported more consistent and correct cookstove use. Supporting [women entrepreneurs](#) is key as they can play a crucial role in scaling up access, especially in remote communities.

Tracking public perception of clean cooking. There are already strong examples of information such as Kenya Power's [Pika Na Power](#) that are helping to raise awareness about the benefits of clean cooking. Strengthening efforts to track progress through surveys and engagement with clean cooking companies can help to identify barriers to uptake. Ensuring active participation of [community groups](#), in particular women and youth groups, can be critical in delivery of long-term roll-out.

Incentives

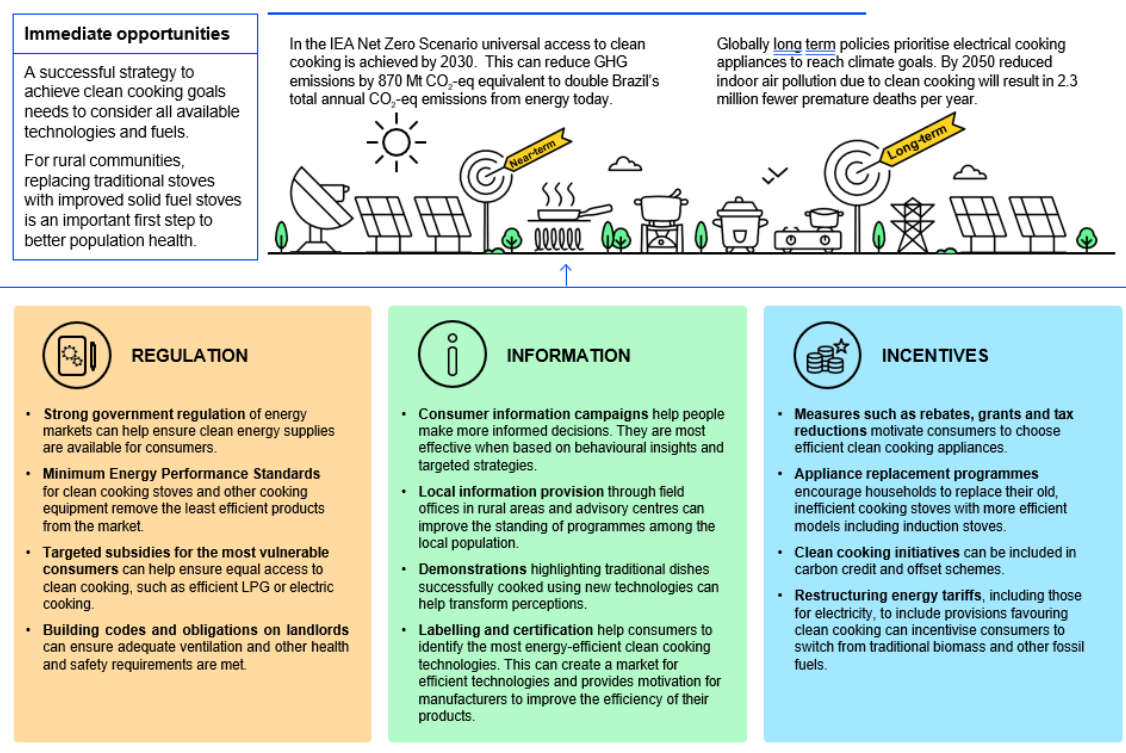
Replacement programmes in urban and rural communities. Kenya could examine the potential for replacement programmes in both urban and rural communities to encourage the shift to clean cooking methods. Such programmes could be co-ordinated via the recently established [Clean Cooking Delivery Unit](#), as well as harnessing the roll-out potential of energy service companies. In Ecuador, the National Efficient Cooking Program (NECP) seeks to replace [3 million LPG cookstoves](#) with induction cooktops, which continues to benefit consumers with safer and faster cooking practices.

Financial support to increase access for consumers. Targeted subsidies for low-income households combined with zero-rating of VAT for LPG could alleviate

immediate affordability challenges, reducing inequalities in access to clean cooking. Specific electricity tariffs for e-cooking could also be deployed, as has been done in Uganda, while the short- and long-term cost impacts of emerging innovative programmes should be considered carefully. A focus on improving rates of [uptake in rural areas](#) will be important when considering targeted schemes for consumers.

Digital approaches to clean cooking. As digitalisation continues to gain traction in Kenya, the government should support local partners and multiple hubs across Kenya to adopt digital solutions for affordability and cleaner cooking. Many emerging digital platforms aim to address upfront costs to expand access to clean cooking solutions, but attention should be paid to solutions that overlook potential longer-term increases in fuel costs.

Energy efficiency policy package for clean cooking



IEA. CC BY 4.0.

Note: Mt = million tonnes.

Source: IEA (2023), [Energy Efficiency Policy Toolkit 2023: From Sønderborg to Versailles](#).

Chapter 4. Electricity system losses

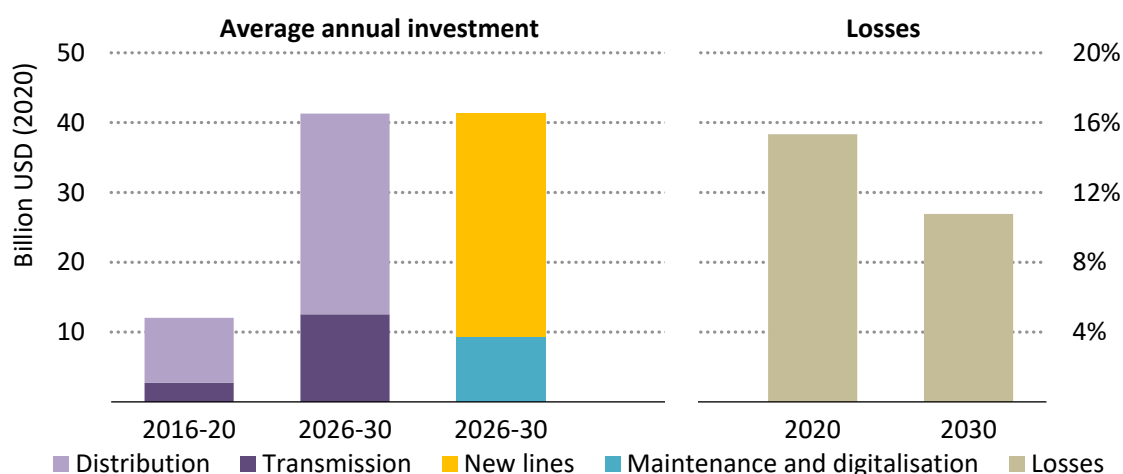
Key facts

- Almost a quarter of electricity generated in Kenya is lost, placing pressure on utilities' finances and increasing costs to consumers.
- Expansion in networks and growth in customers led to a decline in system efficiency for Kenya Power from around 82% in 2015 to 76% in 2021.
- Introduction of improved standards for distribution transformer efficiency and actions to address vandalism can reduce losses.
- Increased investments in maintenance, upgrading and off-grid solutions can contribute towards improved system efficiency.
- Ongoing expansion of smart and digital solutions can promote improved monitoring and electricity system optimisation.

Electricity system losses during transmission and distribution can lead to increased strain on power systems while demand for electricity continues to grow, increasing the risk of power outages, reducing overall access and increasing energy costs that constrain economic growth and ultimately impact livelihoods. Globally, it is estimated that the commercial effects of non-technical losses amount to between [USD 80 billion to USD 100 billion](#) each year. Across Africa high average network losses of around [15%](#) in 2020, almost twice the global average of [8%](#), contribute to broader factors that could constrain the continent's future sustainable economic growth and clean energy transition.

Countries often lack tools to monitor the condition of grids and ensure problems are fixed in a timely manner, and the equipment used is often of a low quality and energy efficiency grade, in particular for distribution transformers. Investment in improvements to grid infrastructure has great potential to provide economic opportunities and improve livelihoods, with an estimated [700 000](#) jobs linked to grid connections, 700 000 to mini-grid connections and 400 000 to solar home systems in Africa by 2030. Increased policy support for and investment in distribution networks to reduce system losses will bring a range of additional benefits, including reducing the cost of energy for consumers, increasing access to electricity in urban and rural areas, and improving system resilience and reliability.

Average annual investment in electricity grids and network losses in Africa



IEA. CC BY 4.0.

Note: Losses are calculated as the share of electricity injected into the grid lost during transmission and distribution, based on the Sustainable Africa Scenario (SAS).

Source: IEA (2022), [Africa Energy Outlook 2022](#).

Progress on addressing electricity system losses in Kenya

Almost a quarter of total electricity generated in Kenya is lost through system losses, increasing costs for utilities and consumers.

Despite strong progress on clean energy and access, Kenya's electricity system is subject to a high level of losses, measuring over 22% in 2020, [2021](#) and [2022](#), almost a quarter of all power generated in the past three years. Electricity system losses present a barrier to continued progress, with loss rates of over 20% placing increasing pressure on the power system to meet growing demand. With current levels it is estimated that an additional 20% supply would need to be built to meet increasing electricity demand, a costly and time-consuming investment compared with the much more cost-effective approach of addressing system losses directly. Sustained high rates of losses combined with growing electricity demand therefore increase the overall investment and resources that would be needed to meet Kenya's universal access and renewable energy targets.

A general breakdown of distribution losses in Kenya has attributed around [half to technical losses and half to commercial losses](#). Commercial losses have been targeted through the recovery of lost units, removal of illegal connections and the replacement of faulty meters, while redistribution and balancing of electrical loads has been addressed to improve technical losses. Nevertheless, losses from poor equipment, lack of proper metering, inadequate transformers to control voltage and theft remain prevalent [factors](#) that continue to threaten the efficiency of distribution

systems. System losses, alongside taxes and cost of power generation, are considered in the [pricing of final cost of electricity](#), so that an increase in system losses translates into higher final costs for consumers. Reducing the overall rate of losses will play an important role in lowering electricity tariffs for consumers in the future, as well as ensuring more reliable provision in support of electricity access, economic growth and inclusivity goals.

Increasing levels of system losses are also placing pressure on the financial health of Kenya's utilities, including Kenya Power, which owns and operates most of the electricity transmission and distribution system. It is estimated that rising commercial and technical losses from 2015 to 2020 resulted in a loss of [KES 16 billion](#) (USD 106 million). From 2020-2021, Kenya Power estimated that for each 1% of system losses it incurred a loss of around KES [800 million](#), ([USD 5.3 million](#)) translating to approximately KES 3.2 billion (USD 21 million) in total. During the 2022/23 financial year the utility purchased 6 671 gigawatt-hours (GWh) and sold 5 104 GWh, indicating that over a fifth of all electricity purchased over the period was lost through the system. Combined with the ongoing global energy crisis, sustained high rates of system losses risk deepening the [financial difficulties of utilities](#), reducing electricity system reliability and reducing ability to invest in system upgrades and maintenance. Challenges with collection of payments from customers is a further issue for the utility.

Urgency to address losses is increasingly reflected in utilities' strategies and power grid regulations

As Kenya's electricity demand is expected to continue increasing in the near term, there remains an urgency for upgrading transmission and distribution infrastructure to ensure efficient delivery of electricity in an accessible and reliable manner for all consumers in the coming years. Kenya's Vision 2030 programme included aims for investment of nearly [USD 3 billion](#) by Kenya Power in power distribution, covering "investment in grid intensification and expansion to achieve universal access to electricity, expand the distribution network, and improve the reliability of the power supply."

To meet growing demand, Kenya Power has undertaken extensive network expansion of 62% throughout a seven-year period from 2015 to 2022. However, expansion and growth in customers has led to a decline in system efficiency from around [82%](#) in 2015 to [76%](#) in 2021. Projected increases in demand for electricity will come primarily from the buildings sector, while increasing demand for household appliances as well as through general progress towards universal electricity access and clean cooking will boost overall demand. Penetration of electric vehicles in Kenya is currently very low, however an announcement by the Kenyan Ministry of Energy to target a [5%](#) minimum of all imported vehicles to be electric by 2025 could begin to see demand increase, further emphasising the need for an efficient distribution infrastructure.

Other utilities have also set out targets for addressing system losses, including Kenya Electricity Transmission Company Limited (KETRACO), which in its [Strategic Plan 2023-2027](#) aims to develop a robust grid system that can:

- reduce electricity transmission losses, from a baseline of 4.74% in 2022 to 3.6% by the end of 2027
- improve the quality of supply, operational safety, stability and reliability of electricity supply
- protect electricity consumers from high cost of power by absorbing capital costs of transmission infrastructure.

Kenya's [National Grid Distribution Code \(KNDGC\)](#), updated in April 2021, includes a significant section aimed at addressing distribution losses, including setting out responsibilities for distribution network services providers (DNSPs) to identify and mitigate system losses. Under the code DNSPs are required to develop a five-year distribution plan including measures for reducing distribution losses, as well as providing regular reports on losses to the regulator. In addition, the regulator requires development and implementation of anti-theft and vandalism programmes and reporting on a monthly and six-monthly basis of information related to energy purchase and sales. Finally, DNSPs are required to develop loss performance indicators including data on feeders and transformers, and energy metered at each connection point at different voltage levels.

Low-quality or faulty distribution transformers present a key source of electricity system losses, reducing reliability of supply

Electricity distribution transformers are essential for the operation of the electricity system and play a crucial role in supplying power to homes and businesses. They are, however, a key source of losses as all power on the system effectively flows through them, and therefore represent an important area for addressing losses. Across Africa, research indicates that [5%](#) of all electricity generated is lost due to distribution transformers, including around [30%](#) in Botswana. This can exacerbate the impacts of power interruptions, increase maintenance costs, require reinvestment in new equipment and lead to increased electricity prices for end consumers.

In 2020, Kenya had [over 70 000 transformers](#) across the country, a majority of which are managed by Kenya Power. As part of the [Last Mile Connectivity Project](#) launched in 2015, Kenya aimed to maximise the use of distribution transformers spread across the 47 counties in the country. The project aimed to harness the existing distribution transformers to their maximum capacity through extension of the low-voltage network to reach around 1.2 million people. In support of electricity access plans all [public facilities and households located within a radius of 600 metres](#) from an existing transformer were prioritised for connection. In addition to providing increased electricity access, the project also supported improvements in standards of living through education, health and access to information, as well

as supporting growth of small businesses. Further, new transformer installations on existing grid networks for promoting households' electricity connection have been undertaken.

The installation of poorly designed or inefficient infrastructure serves as a key contributor to reduced efficiency and technical losses in power systems, such as [distribution transformers](#). Provision of faulty and low-quality transformers has presented challenges for utilities, with a recorded [897 transformers](#) supplied to Kenya Power between 2010 and 2018 found to have defects. While there are effective standards that utilities may comply with, no minimum energy performance standards have yet been adopted for distribution transformers in Kenya. In 2016 Kenya Power developed [new specifications](#) for distribution transformer equipment aimed at increasing durability and reducing vandalism. Vandalism remains a challenge, with estimates of losses of around [KES 600 000](#) (USD 4 000) for every transformer vandalised due to the need for repairs or replacement.

Investment in off-grid solutions has boosted rural energy access, while creating opportunities for local communities

Provision of energy access to people in rural areas in Kenya had reached over [68%](#) as of 2021, a significant increase compared with only [25%](#) in 2011. This growth has been driven in part by a growing focus from the government of Kenya on expanding access through off-grid solutions such as [solar-powered mini-grids](#) in remote areas. The Kenyan government, in partnership with the [Kenya Off-Grid Solar Access Project \(KOSAP\)](#), is [developing 137 solar mini-grids across 12 of the country's 14 counties](#). The project is financed by the World Bank, which approved a credit of USD 150 million in 2017. Solar mini-grids will electrify 567 public facilities, including secondary schools, health facilities and administrative offices, as well as power water pumps for 380 boreholes. The project aims to close the energy access gap by providing electricity to approximately 277 000 households (1.5 million people). According to the Kenyan government, as of March 2023 there were about [62 mini-grids fully operational](#) and 28 under construction, with aims to deploy more mini-grids in order to ensure universal access to electricity by 2030.

Growth in investment in off-grid solutions has also expanded opportunities for community-oriented approaches to energy infrastructure development. [Power Africa](#), a US government-led partnership, has been working with power producers, transmission companies, distribution companies and regulators to develop [best practices](#) for community engagement in Kenya. The programme has also provided support to utilities to improve their community engagement strategies, including KETRACO's development of a revised [Resettlement Policy Framework](#) that provides plans for compensating communities affected by land acquisition for transmission infrastructure.

Expanded coverage of smart and digital technologies across Kenya's power system can enhance power system efficiency

A growing focus on the digital economy in Kenya has emerged in recent years. Initiatives such as the [Kenya Digital Economy Acceleration Project](#), a two-phase programme running from 2023-2030, aim to expand access to high-speed internet, promote innovation and development of skills, and build a data-driven and secure environment for enhanced digital service delivery. Digital innovation alone is not a full solution to solving system reliability problems, but some technologies can be essential in monitoring critical infrastructure, subject to cable and transformer theft, and the use of drones for light maintenance and repair operations. These solutions can be especially valuable in countries such as Kenya, where large service areas with infrastructure in harder-to-access areas limit options for in-person inspection and maintenance.

In the energy sector, Kenya Power has played a leading role in taking forward digitalisation initiatives, and by 2021 had digitised more than 70% of its network. In July 2021 the utility launched plans through the World Bank-funded Kenya Electricity Management Programme (KEWP) to digitise the remaining 30% at a cost of [KES 225 million](#) (USD 1.5 million). The project involves installing consumer meters on transformers to show their location and track performance, providing the company with a more accurate register of its assets and identify hotspots for losses, identify poorly performing transformers, and improve billing and revenue collection.

In 2023, Kenya Power launched a [new project](#), Fiber-to-the-Premise (FTTX), a service which will pilot connection of the company's transformers to a central unit for monitoring and provision of meter data. Kenya Power has set out actions including [committing KES 40 billion](#) (USD 266 million) for strategic network expansion and maintenance in the 2023/24 financial year to improve the power infrastructure countrywide. The utility also plans to install smart meters at 1 300 distribution feeders, 73 000 distribution transformers and 600 000 large consumers, aiming to bring in additional revenue of USD 627 million over eight years. With these developments, it remains critical for energy efficiency to be explicitly addressed to successfully curb system losses.

In addition, [Kenya Power has been working with Safaricom](#) on a pilot project to install special utility poles that will support provision of high-speed internet connectivity, as part of aims to promote "last mile" access to broadband internet. As of June 2022, Kenya Power had installed [over 7 000 kilometres](#) of fibre optic cables across 44 counties, using its existing power transmission network. Through this initiative the utility could also increase its oversight of transmission and distribution systems, opening up opportunities for application of data-led, smart solutions to reducing system losses.

Strategies and targets related to clean cooking in Kenya

Description	Targets and objectives
National Energy Efficiency and Conservation Strategy (NEECS)	Decrease the technical and commercial losses of the energy system from 2019 levels of 23% to 15% by 2025.
	Creation of a Super Energy Service Company (ESCO) in 2021 run by Kenya Power, supported through KES 5 billion (USD 33 million) in investments to run on a Super ESCO model.
	Address enhanced transformer and feeder metering, system mapping to identify areas at high risk of theft.
	Introduce revised transformer standards.
	Undertake resource mobilisation in power companies to invest KES 500 million (USD 3.3 million) to increase energy efficiency and studies on ancillary service requirements, energy storage and distributed energy generation.
Kenya National Electrification Strategy (KNES)	Increase grid stability through installing 1 megawatt of energy storage facilities.
	Government agencies to finance energy efficiency programmes.
	Address grid and off-grid expansion planning, technology solutions for grid expansion in rural areas, use of microgrids and standalone solar systems.
	Map out roles and responsibilities among three key stakeholders, the Ministry of Energy, Kenya Power and the Rural Electrification Authority.

Key issues to address

Unstable power provision creates additional burdens for individuals and businesses that need to secure alternative sources of backup power, often in the form of diesel-powered backup generators. Businesses incur additional costs in acquiring these systems, and it is estimated that companies in emerging and developing economies spend [USD 6 billion](#) to procure generators and almost [USD 60 billion](#) on operating costs for fuel and maintenance each year. [Investments in resilient and efficient power grids](#) will be critical in meeting the growing energy needs of densely populated urban centres and growing industries, while distributed and off-grid solutions are providing increased opportunities for electricity access in remote areas.

Regulation

Improving standards for distribution transformers. Adopting a nationwide mandatory [MEPS](#) for distribution transformers would incentivise utilities to upgrade this infrastructure across their networks. Development of the standard would be best based on the economics of the domestic market, drawing on existing work in

Kenya on [mapping the location of transformers](#). Expanding co-operation with neighbouring countries would also help to align standards in a future of increased network integration. Three countries in Africa, [Ghana](#), [Botswana](#) and [Egypt](#), have adopted mandatory MEPS for distribution transformers that can provide a point of reference.

Identifying and prioritising system loss hotspots. Strengthening oversight of the electricity system and introducing methods to measure and verify system losses can help to prioritise action on hotspots. Enhanced sharing of information and data among the government, regulators and utilities should be prioritised to identify and address issues.

Application of digital and smart solutions. Policy makers could look to match needs of reducing system losses with relevant digital solutions, prioritising actions based on a cost-benefit approach. This could include for example through incorporating smart data requirements into the [grid code](#). Kenya is well placed to leverage existing programmes to expand distribution of smart meters, sensors and telecoms networks that can enable greater real-time coverage of networks.

Distribution control centres reduce technical losses and boost efficiency in Egypt

Egypt's power network is subject to a high rate of system losses, at over [18%](#) from 2022-2023. To meet the electricity needs of a growing population and boost industrial development, the government set a target to reduce losses to below 17% through addressing issues with theft and faster installation of meters. In support of this goal the government and Schneider Electric piloted a project with the digital technology EcoStruxure Grid to successfully implement 14 distribution control centres (DCCs) in Cairo. The smart grid is aimed at helping the country to meet future energy demands, and support plans for an increase of energy output from renewable sources from 20% in 2022 to 42% by 2035.

The new smart grid will be able to manage and optimise distributed energy resources, including renewables, and enable new technologies such as microgrids to be connected to the main grid. Over [12 000 smart ring main units](#) were installed throughout the network and 1 000 distribution points and substations upgraded. The DCCs used Schneider's Advanced Distribution Management System to monitor, control and reconfigure the network to use data and professional algorithms, allowing for increased real-time visibility and awareness of the distribution network, improved operations efficiency, effectiveness of field operation and service quality, and improved grid reliability, availability and security.

As a result of the project, power generation was decreased by 2% and technical losses by 7.9%. The pilot project led to a reduction of 3 300 tonnes/DCC of CO₂ emissions annually, including a reduction in emissions linked to logistics and travel

to sites due to remote diagnostics and operations and the use of diesel generators. It serves as the first nationwide smart grid in Africa and provides an example of reliable, efficient, and safe electricity supply.

Information

Awareness raising around the economic and social impacts of system losses.

Design of campaigns and messaging should involve stakeholders from government, utilities, the private sector and local communities to ensure more inclusive collaboration and [decision-making](#). Local-led campaigns that involve citizens are more likely to obtain success in deterring actions including theft of electricity and can be combined with skills development and job creation schemes. In addition, broader campaigns that encourage more efficient use of electricity can help to reduce overall strain on electricity grids.

Highlighting the benefits of efficient distribution transformers. Kenya could draw on implementation of its five-star labelling scheme for appliances to promote adoption of more efficiency distribution transformers. Ongoing efforts to map the location of distribution transformers could be enhanced by collecting data on efficiency, as well as other aspects including theft and vandalism. Adoption of a label based on international examples that presents clear information to utilities on [performance and minimum energy efficiency level of transformers](#) can provide the ability to differentiate between equipment, supporting utilities in procuring higher-efficiency products and aiding identification of low-quality or faulty equipment across the distribution network.

Incentives

Limited financial resources for power grid maintenance and upgrading. The Kenya Power managed [Super ESCO](#) could be leveraged to support accelerated roll-out and replacement of smart and efficient technologies in urban and rural areas. This could include [performance-based contracting for distribution transformers](#), bulk procurement of high-efficiency equipment, and attracting financing for other needed investments in distribution system maintenance and upgrades. Procurement processes may also need to be restructured, encouraging utilities to interact with a wider range of start-ups or smaller digital technology and service providers.

Jobs and skills potential in the electricity transmission and distribution sector. Developing targeted programmes for jobs creation and upskilling in the power distribution sector can deliver benefits both in urban and rural areas. Conducting an assessment of existing occupation gaps in line with future needs for upgrading and maintenance of grid systems can inform education and training schemes to fill these gaps, while ensuring that these approaches are gender-inclusive. Community capacity building and training can support an increase in local

skills availability, important for responding to system issues in hard-to-reach areas as well as handling [local payments and customer service](#).

The role of people in delivering a sustainable, affordable power system.

Placing people at the centre of strategies for addressing distribution system losses can boost empowerment and inclusivity, while delivering real benefits to electricity bills and reliability. [Local energy communities](#) can help address numerous challenges faced by power systems, including losses and grid congestion. Digital platforms and tools are making it easier to set up co-operatives, engage stakeholders, make investments and exchange electricity in rural areas. Kenya could leverage its existing programmes for expanding [off-grid solutions](#) to explore models that prioritise access for low-income households, including [energy-as-a-service](#) that allows customers to pay for access without having to purchase solar system hardware.

Conclusions

Energy efficiency has played and can continue to play a critical role in supporting Kenya to meet its economic growth, renewable energy and universal energy access targets

Under its [Vision 2030](#), Kenya has made strong progress towards its goals of achieving universal energy access and 100% renewable power, improving the lives of millions of people in the process. With aims to achieve an average economic growth rate of [10%](#) per annum until 2030, rising incomes and a significant increase in economic activity will drive up energy demand. An enhanced focus on provision of affordable and reliable energy to all Kenyans, and in particular those from low-income backgrounds, will therefore be pivotal to achieving energy access targets that can improve people's lives while growing the economy sustainably.

Energy efficiency is centrally important to improving the lives of all people, providing affordable and reliable energy access, supporting economic growth and resilience, enhancing security of supply, and accelerating clean energy transitions. This report has highlighted four sectors where increased action on energy efficiency can provide a cost-effective way to boost delivery of a sustainable, modern energy system in Kenya. Measures taken by the government of Kenya across buildings, appliances, clean cooking and power system losses have already led to positive progress and can provide a foundation from which to design and implement a suite of policies that allow the country to capture the full benefits of energy efficiency.

Early action will be essential in order to realise the full suite of benefits that energy efficiency has to offer

While the design and implementation of policies in each of the four sectors will vary in their scope and starting point, the importance of a co-ordinated approach cannot be underestimated – activities and action should be considered as elements of an integrated policy development approach. Careful consideration should be taken to ensure that actions taken in one sector do not result in adverse effects in other areas. For example, stimulating an accelerated uptake of electric cooking combined with rapid electrification in the buildings sector could place increasing strain on local or national grid systems, impacting the country's ability to provide stable electricity to all. A cross-government approach to policy making that involves regulators, utilities, the private sector, small businesses and local communities will be essential for developing a clear roadmap that is able to capture the multiple benefits of energy efficiency.

Buildings present a critical sector where strengthened energy efficiency action can offset growth in electricity demand

As the buildings sector is the largest source of energy consumption in Kenya, measures targeted at improving its energy efficiency will play a crucial role in achieving long-term energy access and affordability. Continued unabated growth in the sector's energy consumption would place an upward pressure on rising energy bills at a time when the current power infrastructure is struggling to provide reliable electricity supply. In addition, a lack of mandatory requirements for energy efficiency in buildings risks locking in inefficiency as the sector expands, losing the opportunity to benefit from broad efficiency gains.

Many of the key elements for accelerating energy efficiency in Kenya's buildings sector are already in place, including a non-mandatory building code, aims to introduce incentives for construction of green buildings, improving energy management regulations and aims to expand passive cooling solutions. Early actions to introduce mandatory energy-efficient requirements in existing and new buildings, underpinned by more robust data collection and information campaigns, can help Kenya to address growing energy demand in the sector while at the same time delivering increased comfort and affordability that can improve lives. The role of buildings as an active source of power system flexibility should also be considered early in development of sector strategies to account for future growth in appliances, electric cooking and adoption of electric vehicles, realising the sector's potential for supporting power system reliability and efficiency.

The IEA's policy package approach for buildings energy efficiency provides a useful source for combining policy elements that can maximise progress in the sector. Future analysis could explore this approach in more detail, for example through more comprehensive assessment of Kenya's building code, other regulations and incentives, and development of a [roadmap](#) for the sector.

Increased access to energy-efficient appliances can boost affordability, with longer-term gains for emissions and demand reduction

Projected growth in use of appliances, in particular for cooling and refrigeration needs, can play a key role in increasing standards of living in Kenya. However, with access to energy-efficient products limited, growth risks exacerbating growth in demand for electricity and placing strain on Kenya's electricity system.

Strengthened and expanded coverage of minimum energy performance standards and labelling, underpinned by robust tracking and data, will be important for both understanding access and consumption trends as well as in updating future regulations. Regional co-operation on harmonising standards, as well as alignment with those of key exporting countries, presents an opportunity in sub-Saharan Africa

where MEPS programmes are not yet widespread. When combined with off-grid energy generation systems, energy-efficient appliances enable the supply of energy services to sparsely populated regions that are far from the existing energy grid, while having the potential to boost overall system resilience and flexibility.

Finally, raising awareness of the affordability and energy bill savings potential of efficient appliances should be a priority, using a combination of incentives and targeted campaigns to increase purchases as the market expands. In addition to their environmental and energy access advantages, energy-efficient appliances enhance the overall household quality of life, and [can reduce labour-intensive efforts and save valuable time for households](#). This particularly impacts the lives of women and girls, giving them greater flexibility to participate in other productive pursuits, such as education and income generation.

The IEA could work more closely with policy makers in Kenya to further analysis in this area, conducting analysis of costs across different appliance categories that can inform strategies for standards, labelling and targeted incentive schemes. This information can also support information campaigns, by translating the benefits to consumers more clearly.

Clean cooking is core to improving people's lives, but high costs and low uptake present key barriers

A majority of Kenyans still rely on traditional biomass for cooking, but there is great potential for shifting to clean alternatives including liquefied petroleum gas, ethanol and electric cooking. Cost remains a critical barrier for increasing access to clean cooking solutions, as well as limited expansion of initiatives in both urban and rural areas. Ongoing campaigns to highlight the benefits of clean cooking solutions can help to increase uptake, but will need to be supported by incentives that in particular target clean cooking adoption by women.

Kenya has set out a clear strategy and ambitious targets for clean cooking, with the aim to achieve universal access by 2028. Increased rates of electrification both in urban and rural areas can promote uptake of electric cooking solutions, but will need to take into account cost differentials across different clean cooking types. The recent establishment of a [Clean Cooking Delivery Unit](#) in the Office of the President emphasises the country's aims to place clean cooking at the centre of its energy access agenda, and will be able to play an important role in co-ordinating actions across different government departments.

Future analysis on Kenya's clean cooking potential could look to explore in more detail the interactions between a shift to electric cooking, buildings sector energy efficiency and the impact on electricity grids. In addition, assessment of costs across different forms of clean cooking can help to design incentive schemes that target households from of different income levels, in both urban and rural areas.

The IEA's policy package approach to clean cooking can act as a useful reference for combining regulation, incentives and information campaigns that can accelerate Kenya's progress towards clean cooking.

Empowering people is key to improving electricity system efficiency, and reducing losses can translate into improved access and affordability

With almost a quarter of all electricity produced lost in the process of transmission and distribution, improvement of electricity system efficiency should be a key priority for Kenya both in the short and long term. This analysis has shown that there is clear recognition by government and utilities of the challenges faced by the power system, including setting out aims for promoting cost-effective investments in supply infrastructure and expanding investments in modern energy monitoring, smart metering and meter calibration.

The impacts of high system losses on affordability of energy are not yet fully understood, but it is clear that in Kenya high loss rates have contributed significantly to the worsening financial health of its utilities and rising energy bills. Continued high rates of losses in the long term risks locking in a negative feedback loop in which investments from transmission and distribution operators are channelled towards servicing and maintenance of losses rather than investments in upgrading network infrastructure. A tendency to pass on the impacts of losses to consumers exacerbates increases in electricity prices, placing pressure on the government to introduce measures that limit overall costs to consumers.

Future analysis could aim to focus on identifying key bottlenecks preventing improvements in system efficiency, including the role of efficient distribution transformers and the potential of [local energy communities](#). Empowering people in support of reliable energy supply, especially in rural areas, can realise a range of benefits such as jobs creation, reduction in bills and greater inclusivity. In addition, progress in this area to reduce losses would reduce overall strain on the system as Kenyans increasingly adopt efficient appliances and cooking solutions.

A policy package approach can ensure that affordable and reliable energy access are at the centre of energy efficiency actions in Kenya, improving peoples' lives in the long term

Developing an overall coherent suite of policies and actions for energy efficiency based on a [policy package](#) approach can be impactful in ensuring an effective mix of **regulation, information and incentives**. Many policies that fall into these categories have already been developed or are under implementation in Kenya, and can be strengthened by promoting closer alignment.

During the IEA's 8th Annual Global Conference on Energy Efficiency, the [Energy Efficiency Policy Toolkit 2023: From Sønderborg to Versailles](#) was launched. This includes policy packages for buildings, appliances and clean cooking that are highlighted in this report, acting as a source of reference for governments to design and implement actions.

The IEA is committed to working closely with the government of Kenya on analysis, training and capacity building that can boost energy efficiency

In the build-up to next year's 9th Annual Global Conference on Energy Efficiency, to be held in Nairobi in June 2024, the IEA is committed to working closely with the government of Kenya to further strengthen national, regional and global action on energy efficiency. A next step to building on this report would be to identify potential areas of further analysis for energy efficiency in Kenya across one or more of the four sectors covered, aiming to identify key policy barriers and milestones on the pathway to Kenya's Vision 2030.

Aiming to capture best practices in Kenya and highlight regional and international examples that can inform domestic policy development and implementation would play a key role in these activities. This could be in the form of specific sector-based studies, [roadmaps](#), [training](#) and capacity building that can inform policy decision-making in both the short and long term. The IEA has also developed [policy packages](#) for the Buildings, Appliances, Clean Cooking and other sectors that Kenya can draw from in implementing a suite of co-ordinated policies that allow the country to capture the full benefits of energy efficiency.

During the Africa Climate Summit in September 2023, IEA Executive Director Dr Fatih Birol called for a [New Energy Pact for Africa](#), urging governments and their international partners to work toward universal energy access, accelerating the deployment of renewables and boosting investment in green industries. A focus on increased comfort in living spaces, access to more efficient appliances and cooking solutions, and reliable and affordable supply of electricity will be important for improving the lives of the continent's citizens.

Kenya is well placed to leverage its position as a leader in the global clean energy landscape, providing an example to other countries across the continent on how to accelerate energy efficiency action to navigate the dual energy and climate change crises. As a recently announced [Association country](#) to the IEA there is great potential to strengthen co-operation with Kenya on energy efficiency, with the ultimate goal of improving people's lives.

Annex

Abbreviations and acronyms

BEC	Building Energy Code
BEEP	Building Energy Efficiency Programme
CFCs	Chlorofluorocarbons
CCA	Clean Cooking Alliance
DCC	Distribution control centre
DNSP	Distribution network services provider
E4	Energy Efficiency in Emerging Economies Programme
EPC	Electric pressure cooker
EPRA	Energy and Petroleum Regulatory Authority
EELA	Energy Efficient Lighting and Appliances in East and Southern Africa
EESL	Energy Efficiency Services Limited
ESCO	energy service company
FTTX	Fiber-to-the-Premise
GBPK	Green Bond Programme Kenya
GDP	Gross domestic product
GEF	Global Environment Facility
GHG	Greenhouse gas
IEA	International Energy Agency
IoT	internet of things
KES	Kenyan shilling
KETRACO	Kenya Electricity Transmission Company Limited
KEWP	Kenya Electricity Management Programme
KNDGC	Kenya National Grid Distribution Code
KOSAP	Kenya Off-Grid Solar Access Project
LEDs	Light-Emitting Diodes
LEED	Leadership in Energy and Environmental Design
LPG	Liquified Petroleum Gas
MEPS	Minimum energy performance standard
MECS	Modern Energy Cooking Services
NECP	National Efficient Cooking Program
NEECS	National Energy Efficiency and Conservation Strategy
PAYG	Pay-as-you-go
PV	Photovoltaic
R&D	Research and development
S&L	Standards and labelling
SAS	Sustainable Africa Scenario
STEPS	Stated Policies Scenario
TSOF	Three-stone open fire

UNIDO	United Nations Industrial Development Organization
USD	United States Dollar
VAT	value added tax
WHO	World Health Organization

Units of measurement

Btu	British thermal units
GWh	gigawatt hour
Mt	million tonnes
TJ	terajoules
TWh	terawatt-hours

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