AFRICAN ENERGY LEADERSHIP

THE CASE FOR 100% RENEWABLE ENERGY



This report is the result of a joint project by Power Shift Africa, The University of Technology Sydney's Institute for Sustainable Futures, The Independent Expert Group on Just Transition and Development, and The Least Developed Countries Renewable Energy and Energy Efficiency Initiative for Sustainable Development.

Power Shift Africa is a Nairobi-based think tank working on climate and development policy, providing cutting-edge analysis, solution-focused policy ideas, and up-to-the-minute media engagement from an African perspective, both within the continent and internationally. PSA is led by its founder and director, Mohamed Adow and this joint project was led and coordinated by PSA's Senior Programme Manager, Colin Besaans.

The University of Technology Sydney's Institute for Sustainable Futures works to create a world that is socially, ecologically and economically just and safe, where everyone has the resources and skills they need to flourish. ISF brings together expertise from a diverse range of disciplines to deliver practical solutions for our partners, and to empower its students to effect positive change in the years to come. Prof Sven Teske is the lead for ISF's energy modelling team which produced the technical analysis and country scenarios underpinning this report.

The Independent Expert Group on Just Transition and Development is a collective of independent academics and policy experts working on how to achieve a just energy transition through alternative development models. It builds on more than a decade of collaboration among its members, including the building of progressive policy institutions and formulation of major regional and continental level initiatives, such as the Africa Renewable Energy Initiative. The Group's seminal report, Just Transition: A Climate, Energy, and Development Vision for Africa, forms the basis upon which much of this report's policy and political analysis is built.

The Least Developed Countries Renewable Energy and Energy Efficiency Initiative for Sustainable Development (LDC REEEI) is an LDC-initiated, LDC-owned and LDC-driven overarching framework to accelerate the harnessing of the renewable energy potential across least developed countries and to promote energy efficiency and work towards 100% renewable energy and participatory and equitable energy systems.

The joint project was made possible by the generous support of Climate Breakthrough.
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POWER SHIFT AFRICA

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Executive summary

- If Africa were to invest in a 100% renewable energy system by 2050 it would save $3-5tn (approximately $150bn per year) and the total fuel cost savings ($8.3tn) would fully cover the total investment required to go 100% renewable ($7.3tn), and save more than double (2.2x) the additional investment (3.8tn) compared to business-as-usual.
- Africa has large untapped potential for renewable energy, particularly solar, that could more than meet the continent's needs. Renewable energy development consistent with a 1.5°C warming limit requires installed capacity of about 3,500 GW by 2050, less than 1% of the continent's technical potential. This would mostly come from solar photovoltaics (2,600 GW) and assumes that the continent continues on a path of sustainable industrialisation and growth, while electrifying and decarbonizing key sectors and activities including transport, buildings (heating/cooling), cooking and heavy industry.
- A fully renewable African energy system is not just technically possible but also compatible with universal access to affordable energy, sustainable economic growth and development. The significant investments needed in renewable energy generation, power grids, storage, energy efficiency and electrification would be more than offset by fuel cost savings. Phasing out fossil fuels by 2050 would also have considerable health benefits.
- 2.2 million extra jobs would be created by following a pathway towards a 100% renewable energy system: Business-as-usual would add around 3.2 million jobs in the energy sector (2.1 million in renewables), whereas a full renewables transition would see 5.4 million additional energy sector jobs by 2050.
- Enabling a renewable energy future for Africa faces structural barriers that include debt and a lack of access to finance. A new model of people-centred development is needed in place of an economy based on the extraction of capital and natural resources. At the international level this requires debt cancellation and reform of the financial system, alongside scaled up public climate and development finance. Regional policies could help build industrial capacity in Africa alongside national and local governance reforms to support decentralized renewable energy development, including through guarantees and feed-in tariffs.

The triple challenges of climate, energy and development

Africa's experience demonstrates that climate change, energy access and development are interconnected challenges. Moving towards a 100% renewable energy system offers the possibility of addressing all three together, and is by far the cheapest route to a sustainable economy and universal energy access.

Several barriers stand in the way of a fully renewable energy system, however. Africa faces structural deficiencies in terms of a lack of food and energy sovereignty, and low-value-added content of exports relative to imports. These contribute to structural trade deficits, weakened African currencies and pressure to issue debt denominated in foreign currencies, resulting in more indebtedness.

Old vested interests are also trying to block an energy transition away from fossil fuel dependence. Fossil fuel expansion - especially for more gas to serve European markets - is being pushed in the guise of a 'right to development'. This is a false promise that threatens to lock in fossil fuels and an economy based on extraction.

The 'right to development' really means the right to pursue one's own development agenda. Africa should be focussed on people-centred development, where renewable energy sovereignty can reinforce food sovereignty and regional industrialization.

Building a fully renewable energy system will also boost employment. If Africa continues its business-as-usual development, our projection is that an extra 3.2 million energy sector jobs would be added by 2050, with 2.1 million of these jobs in the renewable energy sector. If existing climate pledges are followed through then 4 million energy sector jobs (including 3.5 million in renewables) would be added by 2050, while a system based fully on renewable energy by 2050 would add an extra 5.4 million jobs.



Africa has an unprecedented opportunity to leapfrog the dirty and obsolete energy systems of the past towards more modern, people-centred, decentralised renewable energy systems. This is also the path to a future where global warming is limited to below 1.5°C.

A 100% renewable energy future for Africa is possible

Developing a fully renewable energy system in Africa by 2050 is both technically feasible and economically desirable.

Research commissioned from University Technology Sydney by the authors of this report has modelled a 100% renewable energy plan to decarbonize Africa's energy sector by 2050 consistent with a 1.5°C carbon budget, while simultaneously continuing to grow Africa's economy and achieve universal energy access.[1] Installed renewables capacity will need to reach about 306 GW by 2030, compared to 80 GW in 2023, and should reach 3,500 GW by 2050 (of which just over 2,600 GW would be from solar photovoltaics).

Although Africa faces many structural challenges, it has two distinct advantages in reaching for a fully renewable energy future. First, as Africa's currently existing fossil fuel infrastructure is relatively small it can leapfrog directly into a renewable energy supply system without leaving a trail of stranded assets. New renewables capacity is the fastest and cheapest way for Africa to increase its energy supply to a per capita level similar to OECD countries.

Second, Africa is the continent with the most favourable conditions for harnessing renewable energy, with potential far outstripping any projected needs. Africa's potential for solar photovoltaic energy amounts to 482,261 GW, while modelling that excludes areas more than 10 km from existing transmission lines still identifies 69,895 GW potential. This modelling excludes all protected areas, as well as steep slopes, closed forests, wetlands and certain other land-cover classes.

Africa's onshore wind resources are considerably lower than the solar potential, but still amount to 71,778 GW, of which 8,738 GW could be developed in areas within 10 km of existing transmission lines.

The electricity required under a 100% renewable energy scenario is a small fraction of this renewable energy potential, reaching 2,615 GW installed solar photovoltaics and 625 GW installed wind capacity by 2050.

	2030	2040	2050
Solar PV	190	946	2,615
Wind	40	182	625

Figure 1: Total solar and wind installed capacity (GW) under the 100% renewable energy scenario

Building a fully renewable electricity supply consistent with a 100% renewable energy scenario would use well below 1% of Africa's total landmass, even though it assumes that far more electricity will be used. Indeed, the major difference between a 100% renewable energy scenario and the reference case is high electrification rates, which would limit rises in overall energy demand (even with rising GDP and universal energy access) by reducing the significant losses that result from combustion processes.

Achieving 100% renewable energy assumes a much faster introduction of new technologies that will lead to the complete decarbonization of energy for stationary energy (electricity), heating (including process heat for industry) and transportation, alongside a major investment in storage technologies.

A 100% renewable energy future achieves energy access and sustainable development

Our analysis estimates that approximately 720 million Africans (around half of the total population) currently live over 10 km from existing transmission lines, most of whom lack affordable and reliable access to electricity. Building off-grid renewable generation and storage support should be prioritized to widen energy access.

Stand-alone grids can be sized in different capacities from a few kilowatts to several megawatts. The main advantage of island grids is that they can be implemented in different locations at the same time – no central planning is required. This model of bottom-up grid expansion allows for stand-alone grids to be interconnected to a nationwide electricity grid over time.

No other issue illustrates energy injustice more than the challenge of cooking in Africa where 970 million people rely on wood-fuel, waste and charcoal. This bioenergy meets around 70% of Africa's energy demand for fuel-based cooking and heating but electrification has now emerged as a serious and viable alternative. All fuel-based cooking applications will need to be gradually phased out and replaced with electric cooking appliances by 2050 to meet a 100% renewable energy scenario. This has environmental, health and economic benefits.

There are various challenges that need to be overcome to ensure the introduction of electric cooking stoves, ranging from the relatively high initial investment costs to initial concerns about the learning curve for newly adopted appliances, and the fact that in some regions fire from cooking also heats rooms. Dedicated support instruments are required to ensure the dynamic development of e-cooking, including economic supports, supply-side improvements to ensure quality locally produced electric cooking stoves and kitchenware, and awareness programmes for retail staff.



Partnerships such as the Modern Energy Cooking Services programme, LDC REEEI and global eCooking Coalition are working to overcome barriers but policy and capacity gaps remain, most notably the need to rapidly increase access to reliable, affordable and stable electric power supplies.

Africa can achieve a fully renewable energy supply alongside improved living standards and universal energy access even while phasing out fossil fuels.

A 100% renewable energy future is the cheapest option for Africa

Power Shift Africa's commissioned research has modelled the costs of replacing fuels for power generation, cooking and transport with electricity. Initial investment costs in renewables for power generation and heat are higher and, as these are upfront expenditure, they will require financial support. As electrification gathers pace, however, the total costs for fuel reduce rapidly so that the overall cost is far lower.

	Fuel costs	Investment – Power generation/heat	Total
Reference	18,87	3,49	22,36
100% RE	10,61	7,31	17,92
Cost savings	8,26	-3,82	4,44

Table 1: Fuel costs versus investment required in power generation and heat, 2020-2050 (US$ trillions).

Solar photovoltaics and onshore wind energy are the most economic renewable power generation technologies. They are fast to build and modular so can keep pace with rapidly rising electricity demand. In short, the replacement of fuels with electricity is both economic and efficient.

Detailed case studies offering energy development plans to decarbonize the economy of six African countries can be found at www.powershiftafrica.org.

Key principles and approaches for a new Africa energy vision

Africa will need to move away from outdated models based on centralised infrastructure, towards more modern, integrated energy solutions that take advantage of Africa's massive renewable energy potential. The new energy system will embody a number of key principles and approaches that underpin a new African energy vision, including:

- ensuring African ownership and agency in energy initiatives and plans;
- integrating energy systems design into wider development objectives and planning;
- establishing clear policy priorities that phase out fossil fuels and prioritise renewable energy while continuing to grow African economies and investing in sustainable industrialization;
- prioritising and sequencing strategic investments to achieve energy sovereignty;

- fostering energy democratization, including diversification of energy generation and ownership, and support for the transition to clean cooking; and
- ensuring stakeholder participation, equity and sufficiency in terms of energy use.

A more inclusive, people-centred development that achieves universal energy access while keeping in line with a 100% renewable energy scenario will require an economy-wide transformation encompassing changes in industrial processes alongside prioritizing African manufacturing capacity; shifting away from export-oriented, industrial agriculture towards community-based agro-ecological systems to prioritize food sovereignty; the electrification of transport alongside planning for modal shifts (shifting users and freight to more sustainable modes of transport); and significant investments in energy efficiency alongside the transition to renewable energy.

Support is needed to make 100% renewable energy a reality

While renewable energy development is by far the cheapest option to 2050, finance is needed to help meet the significant upfront investment costs in a context of limited access to finance. Feed-in tariffs and properly designed payment guarantees are tried and tested policy measures that can help overcome initial investment barriers, and need to be financed and resourced.

Funding for these and other relevant policies will come through a mix of domestic and international sources. International climate and development finance must be scaled up. Alongside existing multilateral climate funds, further financial transfers are needed from a variety of financial sources such as financial transaction taxes, redirection of subsidies and special drawing rights (SDRs).

Domestically, governments should prioritize economic models that actively seeks to avoid capital extraction and increase domestic tax revenues to help expand fiscal spending capacity over time. This requires the systematic cancellation of unfair and illegitimate debts, alongside improved regulation of transnational corporations and tax evasion.

Building economies that can drive an energy transition means escaping the post-colonial trap of prioritising extractive industries, assembly-line manufacturing and low-value-added exports. To secure a greater share of benefits and revenue, a Pan-African approach to industrial policy is needed that takes advantage of economies of scale, expands internal markets, and prioritises strategic investments in key sectors including renewable energy (LED lights, solar panels, wind turbines, batteries etc.) and agriculture. This will require strategic targets and partnerships to foster research and development, build technical capacity, and develop new trade relationships that benefit Africa rather than reproducing structural debt traps and economic dependency.

A 100% renewable energy future is not only possible but beneficial for Africa, as it protects the environment while securing energy access and a truly sustainable path to development.



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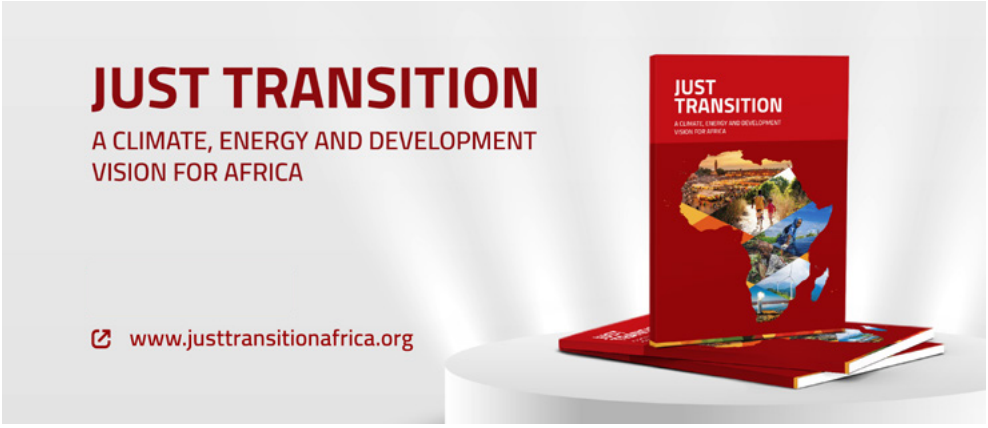
Introduction

The world is at a pivotal moment, reshaping its economic and geopolitical landscape amid significant challenges such as the climate crisis, financial instability, post-pandemic economic recovery, and ongoing conflicts, invasions, and genocides. Africa stands at the centre of this dynamic environment, becoming a focal point in a renewed contest for economic power between the United States of America, the European Union, and China. These regions are vying for resources, strategic investments, and markets, with Africa positioned as a crucial supplier of raw materials, labor, and consumer potential.

However, without a bold, cohesive development strategy, Africa risks remaining at the mercy of external agendas. Since colonial independence, 'development' in Africa has consisted mainly of gearing economies to be sites for cheap resource extraction into global markets. Little has been done to create real economic ownership, mobility, and independence, leaving much of the continent crippled by debt, poverty, and unemployment. Yet, this moment also sparks a call to action—an opportunity for African nations to assert control over their futures and engage with the global community on their own terms. By leveraging its rich diversity and shared history, Africa can redefine its role on the world stage.

As we confront the existential threat of climate change, the urgency for sustainable energy solutions, and the imperative to eradicate poverty, Africa can emerge as a beacon of prosperity. But this vision requires leadership that prioritizes the well-being of its people within thriving ecosystems and a stable climate. It demands a proactive approach to navigate external risks and opportunities, while challenging outdated narratives rooted in colonial stereotypes.

The Independent Expert Group on Just Transition and Development published a report on these topics in 2023 entitled *Just Transition: A Climate, Energy, and Development Vision for Africa*.[2] That report made the call for a bold new African development vision, and highlighted energy sovereignty, food sovereignty, and Pan-African industrial planning as the key levers through which to achieve renewed African prosperity. That report went into further detail about the principles, process, policies, and financing strategies for a just energy transition.



Recognising the fundamental role of energy across many sectors and as a critical enabler of sound economies and social wellbeing, this report follows from that seminal work to go further into the technical feasibility of achieving 100% renewable energy in Africa. This report represents the culmination of a process of work beginning in 2022 as a collaboration between Power Shift Africa, the University of Technology Sydney's Institute for Sustainable Futures, the Independent Expert Group on Just Transition and Development, and the Least Developed Countries Renewable Energy and Energy Efficiency Initiative for Sustainable Development (LDC REEEI).



The project began with spatial mapping of renewable energy potential in three East African Countries - Kenya, Rwanda, and Tanzania. It followed with a set of stakeholder consultations and workshops to refine the modelling, and ultimately, the production of three robust reports on the national potential for achieving 100% renewable energy in each country. This process was then repeated in three more countries from other African regions - Senegal, Malawi, and Tunisia. This report embeds the methodologies and findings of these six country case studies in a Pan-African mapping and analysis, looking at the potential for achieving 100% renewable energy not just in individual countries, but across the whole of Africa.

This report makes three major findings:

- **Africa can meet 100% of its energy needs through renewable energy.** Africa has large untapped potential for renewable energy, particularly solar, that could more than meet the continent's needs. Renewable energy development consistent with a 1.5°C warming limit requires installed capacity of about 3,500 GW by 2050, less than 1% of the continent's technical potential. This would mostly come from solar photovoltaics (2,600 GW) and assumes that the continent continues on a path of sustainable industrialisation and growth, while electrifying and decarbonizing key sectors and activities including transport, buildings (heating/cooling), cooking and heavy industry.
- **Substituting fossil fuels with renewables would save Africa US$3-5 trillion by 2050, and create fuel costs savings of more than double (2.2x) the increased investment needed.** Our analysis concludes that the business-as-usual development of power generation and heat in Africa with a fossil fuel focus would cost an estimated US$22 trillion from 2020-2050, most of which is accounted for by fuel costs. Investing in renewables requires greater investment in infrastructure (over US$7 trillion to achieve 100% renewables compared to US$3.5 trillion in business-as-usual) but would halve the continent's fuel bills over the next 30 years, with an overall estimated cost of $18 trillion in the 100% renewable scenario. A fully renewable energy system would be considerably cheaper, saving approximately US$150 billion per year on average. The fuel cost savings by going 100% renewable are more than double (2.2x) the additional investment required. It is clear that the faster the transition to renewable energy happens, the more money is saved.
- **Shifting to 100% renewable energy would create 2.2 million additional jobs** and move Africa up the value chain from raw material extraction site toward end-to-end ownership and real energy sovereignty. Continuing with business-as-usual would add around 3.2 million jobs in the energy sector (2.1 million in renewables) by 2050, whereas a full renewables transition would see 5.4 million additional energy sector jobs over the same period.

Building on the 2023 *Just Transition* report highlighted above, this report goes beyond the technical analysis and mapping of 100% renewable energy possibilities to make a set of recommendations on the principles and process required to ensure a successful just transition of Africa's energy systems. It further presents the components of industrial planning required to ensure Africa's build out of renewable technologies does not replicate issues of previous development models, a set of policy instruments available to practically implement a just transition, and strategies for addressing the financing of Africa's transition.

This report aims to galvanize all stakeholders—African leaders, policymakers, civil society, academics, businesses, and international partners—to collaboratively reimagine Africa's energy and development future. Together, we can tackle the intertwined challenges of climate, energy, and development, sparking a renewed Pan-African movement toward a brighter future for all. While the report has an Africa focus, many of its conclusions are relevant to most developing countries.



PART I: MODELLING FOR 100% RENEWABLE ENERGY IN AFRICA

Research Methodology and Assumptions

The research and modelling underpinning this report is based on *Africa: Energy Development Plan to decarbonize the Continent*, a report commissioned for PowerShift Africa from the Institute for Sustainable Futures, University of Technology Sydney (UTS-ISF), which contains fully referenced, detailed descriptions of the modelling, methods and assumptions used.[3] The scenarios for the energy pathways do not claim to predict the future, but provide a useful tool with which to describe and compare potential development pathways from the broad range of possible 'futures.'

The Africa 100% renewable energy scenario is designed to calculate the efforts and actions required to achieve the ambitious objective of a 100% renewable energy system and to illustrate the options available to change Africa's energy supply system into a truly sustainable one. Scenarios for electricity generation, energy demand, energy supply, and transport are included, alongside estimates of the investments required to achieve them. The report also includes simulations of the national grid capacities required now and in the future, and the necessary linkages between them.

The modelling process developed climate mitigation pathways using the One Earth Climate Model (OECM), an integrated energy assessment model that covers the entire energy system.[4] The OECM produces long-term projections using a range of national and international datasets.

An analysis of the availability of renewable energy resources (solar and wind) has been calculated according to the [R]E Space methodology, part of the OECM. It is based on spatial GIS data to consider physical capacity, distance from existing transmission lines, and constrained land availability conditions (excluding protected areas, areas with a steep slope, and certain land-cover classes, such as closed forests, wetlands, snow and ice, and permanent water).

The 100% renewable energy scenario is based on the following core assumptions:

- **Emissions reductions:** In a world where global temperature rise is limited to 1.5°C all countries need to achieve near zero emissions within a couple of decades. This includes African countries, although this would be deeply unfair unless their transition and adaptation measures are greatly supported by historic and large emitters.[5] The main measures taken to achieve CO_2 reductions include strong improvements in energy efficiency, which will double energy productivity over the next 10–15 years, the progressive electrification of key sectors (notably transport) by 2050, and the dynamic expansion of renewable energy across all sectors.
- **Population:** Projections of population growth are taken from the World Population Review and estimate that Africa's population will reach 2.485 billion by 2050.
- **Economic development:** GDP projections have been estimated based on a detailed assessment of over 50 African countries and projected under the assumption that all African countries will successfully develop towards middle-income status. These assume an annual GDP growth rate of 5.5% until 2050. For the purposes of this modelling, the analysis of Africa's economic development is based on a breakdown

of the fiscal year 2019 and assumes that the overall structure of the economy will not change, and that all sectors will grow at a rate equal to that of GDP over the entire modelling period.

- **Domestic energy demand:** A bottom-up electricity demand analysis was performed to develop a projection for the residential electricity demands in Africa over the coming 30 years. For example, household electricity demand was calculated based on different household types, with the assumption that demand will gradually increase as the electric applications for households progress from very basic needs, such as light and mobile phone charging, to a household standard equivalent to that of industrialized countries. In the case of cooking energy-demand, an average 3.3% transition from fuel-based to electricity-based cooking was assumed, to achieve a total phase-out of fuel-based systems by 2050.
- **Industry and business energy demand:** Energy demand projections for Africa's economic development including industrialisation were based on a breakdown of the fiscal year 2019 and assumes that the overall structure of the economy will not change, and that all sectors will grow at a rate equal to that of GDP (5.5%) over the entire modelling period.
- **Transport demand:** A bottom-up analysis was undertaken to develop projections for individual transport, public transport and freight transport. These took account of technical capacity as well as projected vehicle energy intensities and utilization. For example, it was assumed that annual passenger kilometres will increase by 3% annually until 2050, whereas freight transport demand will increase by 2% annually, and that energy intensities of all vehicles will decrease over time with the implementation of more efficient engines and the phase-out of fossil-fuels. The 100% renewable energy scenario assumes that all fossil-fuel-based vehicles must be phased out by 2050 to be replaced mostly with electric drives, supplemented with a limited number of biofuel-based large commercial vehicles, buses and large trucks.
- **Energy access:** It is assumed that the power generation system would expand so that there is essentially universal access to electricity across all of Africa by 2050, with a starting estimate that 720 million people (over half of Africa's population) do not currently have electricity grid access . The scenario also explores the potential for 'bottom-up electrification' through the development of stand-alone grids that can be interconnected later.
- **Renewable energy growth:** Dynamic growth in new capacities for renewable heat and power generation is assumed based on current knowledge of the potential, costs, and recent trends in renewable energy deployment.
- **Fossil fuel phase-out:** The operational lifetime of gas power plants is approximately 30 years. It is assumed that coal power plants will be phased out before their end of their lifetime, followed by gas power plants.
- **Security of energy supply:** The share of variable power generation is limited to maintain a sufficient share of controllable, secured capacity. Power generation from biomass and gas-fired backup capacities and storage are considered important for the security of supply in the earlier stages of the transition. Storage technologies will increase after 2030, including battery electric systems, dispatchable hydropower, and hydro pump storage.

Modelling and estimates on the costs of different energy development pathways are based on the most consistent sources of publicly available data.[6] Fossil fuel costs are based on International Energy Agency (IEA) price projections as these provide the most comprehensive data set. Cost assumptions for the power sector's investment, operation and maintenance costs were based primarily on the investment cost projections from the 450-ppm scenario in the IEA's World Energy Outlook 2016, including their regional disaggregation, and extended until 2050 based on the trends in the preceding decade.[7] Because the cost assumptions for solar PV systems by the IEA do not reflect recent cost reductions, these projections were based on a more recent analysis by Steurer et al. (2018).[8]

The modelling of employment under both the reference and 100% renewable energy scenarios shows only direct employment and aims to capture jobs in construction, manufacturing, operations and maintenance, fuel supply associated with electricity generation, and direct heat provision. The scenarios reflect the different demand and capacity assumptions of the two scenarios. For each technology, the calculations consider 'employment factors', or the number of jobs per unit of capacity, separated into manufacturing, construction, operation, and maintenance, and per unit of primary energy for fuel supply. The 2025, 2030 and 2050 figures incorporate a 'decline factor' for each technology, which reflects the fact that employment per unit will decrease as technology efficiencies improve. A range of data sources were used to model inputs, including the International Energy Agency, US Energy Information Administration, BP Statistical Review of World Energy, US National Renewable Energy Laboratory, International Labour Organization, World Bank, industry associations, national statistics, company reports, academic literature, and the UTS-ISF's own research.

The mineral resource requirement is calculated in line with the energy scenario – which determines the energy demand including the current and future utilisation of applications and vehicle types and the energy supply technologies, projected market shares of technologies to be deployed, and their resource intensities.

This report offers projections and estimates for the whole of Africa but also takes a more granular, bottom-up approach to developing comprehensive 100% renewable energy pathways for Tanzania, Rwanda, Kenya, Malawi, Senegal and Tunisia. These case studies have been published separately, and include fully referenced accounts of methodology and assumptions.[9]

Africa's renewable energy potential and resource requirements

Africa's potential for solar power

Africa has large untapped potential for renewable energy, in particular solar power. Each African country's solar and wind potential was assessed as an input for energy scenario development, starting with the technical potential under space-constrained conditions.

Solar potential was mapped using data from the Global Solar Atlas to calculate the average annual solar irradiation (DNI) levels across Africa, which range between 233–3,238 kWh/m2 per year, with the higher end of that range in the southwest and central north of the continent. A calculation was then made of available land area, with exclusions for protected areas (PA), extreme topography (slope > 30% (mountainous areas), and certain land-cover classes, including closed forests, wetlands, moss and lichen, snow and ice, and water (permanent water bodies). Under these assumptions, Africa has 19.3 million km2 with solar potential and a total potential for solar PV capacity of 482,261 GW.

An additional restriction was then applied by excluding areas ≤ 10 km from existing transmission lines. This resulted in a potential solar area of 2.8 million km2, from which utility-scale solar farms in Africa could potentially harvest 69,895 GW of solar PV. A country breakdown showing the countries with the highest solar potential under this scenario is shown in Figure 2, below.[10]

Top 20 countries with the highest potential for solar photovoltaic

Country	Solar Area (km2)	Solar Potential (GW)
South Africa	348,305	8,708
Namibia	295,856	7,396
Nigeria	184,779	4,619
Uganda	131,635	3,291
Ethiopia	125,416	3,135
Mozambique	115,751	2,894
United Rep. of Tanzania	108,435	2,711
Mauritania	106,718	2,668
Burkina Faso	104,367	2,609
Sudan	95,802	2,395
Zambia	89,744	2,244
Niger	82,966	2,074
Botswana	82,92	2,073
Libya	73,102	1,828
Senegal	64,538	1,613
Dem Rep of the Congo	54,247	1,356
Mali	52,987	1,325
Zimbabwe	50,248	1,256
Algeria	46,121	1,153
Angola	44,879	1,122

As this modelling clearly shows, Africa's solar potential (69,895 GW) far exceeds the required solar power, close to 27 times greater than the 2,615 GWof installed solar capacity needed by 2050 under a 100% renewable energy scenario.

Africa's potential for utility-scale wind power

Africa's potential for utility-scale wind power was assessed using a similar methodology to solar. The starting point was assessing data on average wind speeds in Africa, which range

from 0.5 to 21 m/s at 100 m height according to the Global Wind Atlas. Only areas with an average annual wind speed of ≥ 5 m/s were included in the mapping of wind potential. The same assumptions as for solar were made regarding available land, with an estimated 71,778 GW in onshore wind potential over an area of 14.4 million km^2.

Once these figures were adjusted to exclude areas ≤ 10 km from existing transmission lines, the spatial analysis identified wind potential of 8,738 GW over an area of 1.7 million km^2. As such, the potential for utility-scale onshore wind (8,738 GW) is almost 14 times higher than the 625 GW in installed capacity by 2050 required for the 100% renewable energy scenario.

A country breakdown showing the countries with the highest onshore wind potential is shown in Figure 3, below.[11]

Top 20 countries with the highest potential for utility-scale wind power

Country	Wind Area (km^2)	Wind Potential (GW)
Namibia	272,469	1,362
South Africa	262,600	1,313
Nigeria	122,609	613
Mauritania	106,436	532
Sudan	91,884	459
Burkina Faso	85,943	430
Niger	81,719	409
Libya	72,102	361
Botswana	68,187	341
Senegal	60,055 (59,447)*	300 (297)*
Zambia	58,922	295
Mozambique	54,439	272
Kenya	53,930*	270*
Mali	32,502	163
Ethiopia	30,910	155
Zimbabwe	28,426	142
Tunisia	26,525*	133*
Somalia	20,661	103
United Rep. of Tanzania	46,358*	232*
Ghana	15,875	79

The data clearly shows that Africa has more than enough untapped renewable potential to power its sustainable development ambitions. We also calculated how much land would be needed for the shift to a fully renewable energy system by 2050 and found that <1% of Africa's total landmass would be required to achieve the 100% renewable energy scenario.

Technology		Units	2030	2040	2050
Solar PV	**Total installed capacity under C-100% renewable energy scenario**	GW	190	946	2,615
	Land use required for installed solar capacity	km2	7,603	37,820	104,600
	Percentage of solar potential area	%	0.04%	0.20%	0.54%
	Percentage of Africa's Landmass	%	0.03%	0.12%	0.34%
Wind onshore	**Total installed capacity under C-100% renewable energy scenario**	GW	38	174	562
	Land use required for installed wind capacity	km2	7,553	34,838	112,374
	Percentage of onshore wind potential area	%	0.05%	0.24%	0.78%
	Percentage of Africa's Landmass	%	0.02%	0.11%	0.37%

Table 2: Areas required for three types of renewable energy technologies under the 100% renewables scenario

Material resource requirements

Mineral resources play a vital role in the development and deployment of renewable energy technologies. The main material requirements for a 100% renewable energy system include silicon for solar photovoltaics and as a component in batteries, and aluminium, which is used for structural support of solar module frames, as well as for lightweight (electric) vehicle parts and battery components. Lithium, cobalt, nickel, and a range of rare earth elements are also essential for manufacturing batteries, wind turbines, and solar panels.

The path to a renewable energy system requires that the necessary mineral resources can be acquired affordably and sustainably – and with respect for local peoples, communities and Indigenous Peoples' rights. For this reason, we examined the material requirements implied by our 100% renewable energy scenario. Besides the actual energy scenario – which determines the energy demand including the current and future utilisation of applications and vehicle types and the energy supply technologies – our calculation factored in market shares of future technologies and how their resource intensities define the material requirements. The results clearly show that Africa is well placed to meet the demand for all of the key minerals surveyed for covering the continent's energy transition .

REFERENCE		2020–2030	2031–2040	2041–2050	2020–2050	2020–2050 average per year
		Billion USD	Billion USD	Billion USD	Billion USD	Billion USD
Power	Total	8.2	8.2	12.7	29.1	1.0
Heat	Total	2.5	3.0	2.6	8.1	0.3
Transport	Total	1.8	2.3	2.7	6.8	0.2
Summed Costs		12.5	13.5	17.9	43.9	1.5

100% RE		2020–2030	2031–2040	2041–2050	2020–2050	2020–2050 average per year
		Billion USD	Billion USD	Billion USD	Billion USD	Billion USD
Power	Total	0.4	0.4	0.0	0.8	0.0
Heat	Total	2.7	2.4	1.8	6.9	0.2
Transport	Total	1.7	1.2	0.7	3.6	0.1
Summed Costs		4.8	4.0	2.5	11.3	0.4
Difference REF vs 100% RE		7.7	9.5	15.4	32.6	1.1

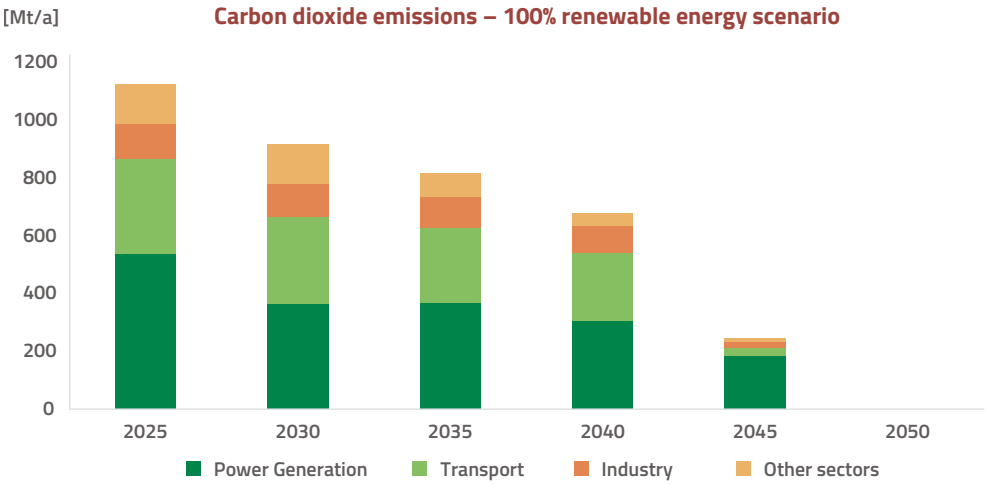
By far the largest annual mining capacities required for Africa's energy transition are for silicon and aluminium. However, Africa's current mining capacity for bauxite (for aluminium) could already supply more than two-thirds of this demand. There would need to be a substantial increase in silicon mining (typically silica sand), with an energy transition in Africa requiring almost 3 million tonnes per year compared to around 50,000 tonnes currently. Silicon is the second most abundant element in the Earth's crust (27.7% by mass), however, so supply is not an issue.

Finally, we compared the cumulative material demands for Africa with currently known global reserves and global resources to identify potential bottlenecks. The data for African reserves and resources are not available for all analysed minerals, so some of these calculations stress test the availability of resources against a proportionate share of global data. This clearly shows that the cumulative material demand of all analysed minerals used for energy transition technologies until 2050 does not exceed the currently known resources. In comparison with currently known reserves, the availability of material resources offers no particular impediment to Africa's renewable energy transition, and only silver shows a relatively high share of the globally known reserves, which indicates a possible competitive situation on the global market.

It is important to note, however, that the availability of materials is contingent on political, economic and infrastructure factors beyond the theoretically available resources in the ground. There are obviously real constraints that prevent unchecked expansion, most potently the need for sufficiency and prudency by those who are currently over-consuming. This emphasises the need for careful long-term planning and continental, South-South cooperation among African countries to ensure that the resources they have are used for their long-term needs and without waste.

Africa and the remaining carbon budget

The Africa 100% renewable energy scenario sets out a decarbonization pathway for the continent that is well aligned with the Paris Agreement. At a global level, the pathway assumes cumulative energy-related CO_2 emissions of 426 $GtCO_2$ (2020-2050). Our energy modelling shows that Africa could support sustained economic growth, achieve universal energy access by 2050 and a fully renewable energy system with a budget of 23 $GtCO_2$. While there are legitimate grounds for pushing for a more ambitious and less risky global target, such as a global pathway capped at 300 $GtCO_2$, this should not hamper or impose further limits on Africa, which is still way below its 'fair share' at 23 $GtCO_2$.



The 100% renewable energy scenario envisages a reverse in the trend of increasing energy-related CO_2 emissions after 2025, leading to a reduction of about -16% relative to 2020 by 2030 and of about -38.5% by 2040. By 2050, Africa's energy sector should be fully decarbonized. Africa's energy related per capita CO_2 emissions would remain at around 1 ton until 2030 and decline until full decarbonization has been reached in 2050.

It should be stressed that 23 $GtCO_2$ is not intended to reflect Africa's 'fair share' of the global carbon budget. The small budget – relative to the EU or the USA – is due to Africa's advantage in being able to leapfrog directly into a renewable energy supply. Africa's currently existing fossil fuel infrastructure isn't as large as in OECD countries so its energy transition could be significantly faster and more cost efficient. *A new renewable energy-based energy industry is the fastest and cheapest possibility for Africa to increase its energy supply to a per capita level similar to that of OECD countries.*

Africa currently hosts 19% of the global population and emitted only 3% of global emission in 2023. Africa's increased share of emissions would not reach its fair share of the global budget because renewable energy is cheaper, less polluting and creates more jobs. Achieving this pathway requires technology transfer and significant upfront investment, however. There is a very real climate debt by rich countries to Africa that must be honoured and repaid. Financing a large part of the renewable energy transformation in Africa is an obligation for rich countries, as well as helping to achieve global climate goals that benefit all countries. It is beyond the scope of this report to model the precise scale of the financing required, but it should be stressed that a principled, fair shares approach to the global carbon budget rests on the provision of considerable climate finance and technology transfers from developed countries to Africa.[12]



A new renewable energy-based energy industry is the fastest and cheapest possibility for Africa to increase its energy supply to a per capita level similar to that of OECD countries.



PART II: APPLYING THE MODEL – SCENARIOS FOR AN AFRICAN 100% RENEWABLE ENERGY FUTURE

100% renewable energy scenarios vs. reference scenarios

Africa must build up and expand its power generation system to increase the energy access rate to 100% and cater to all energy needs, including industrial development. Building new power plants—no matter the technology—will require new infrastructure (including power grids), spatial planning, a stable policy framework, and access to finance.

Our research sought to identify the practical implications and financial costs of building up Africa's renewable energy capacity compared to following a business-as-usual approach. To do so, it compared Reference and 100% renewable energy scenarios.

The reference case for Africa is based on the 'Stated Policies Scenario (STEPS) scenario published in the International Energy Agencies' *World Energy Outlook 2024*.[13] Our reference scenario shares most of the main IEA assumptions – such as the development of the energy supply mix for electricity, heat and required fuels for transport and industry – but assumes a higher (5.5%) rate of GDP growth consistent with the continent's development goals.

The 100% renewable energy scenario for Africa would see a significant increase in overall electricity generation as power from renewable sources becomes the main 'primary energy'. By 2050 this would see the complete decarbonization of energy for stationary energy (electricity), heating (including process heat for industry), and transportation. In the latter, there will be a strong role for batteries and other storage technologies. The 100% renewable energy scenario shares the reference scenario's ambitious assumptions about development and GDP growth, which would also contribute to higher energy demand across all sectors.

Meeting this increased demand while rolling out a fully renewable energy system should include:

Growth of renewables capacity, especially solar: Solar PV is expected to be the main pillar of the future power supply, complemented by the contributions of wind energy and some bioenergy. A 100% renewable energy scenario requires dynamic growth in new capacities for renewable heat and power generation, with a significant role for communities in the development and operation of regional and/or community-owned renewable power projects.

- **Energy efficiency:** Strong improvements in energy efficiency should double energy productivity over the next 10–15 years.
- **Fossil -fuel phase-out:** The operational lifetime of gas power plants is approximately 30 years, which means existing fossil fuel infrastructure would be dismantled and no new constructions initiated. Coal power plants would be phased out before their end of lifetime, followed by gas power plants.
- **Security of energy supply:** Any future scenario needs to limit the share of variable power generation and maintain a sufficient share of controllable, secured capacity. For this reason, short to medium-term security of supply would be partly provided

by power generation from biomass and gas-fired backup capacities, while after 2030 non-emitting approaches such as concentrated solar power and storage technologies would need to play key roles, including battery electric systems, dispatchable hydropower, and hydro pump storage.

- **Electrification of transport:** Efficiency savings in the transport sector will result from fleet penetration by new highly efficient vehicles, such as electric vehicles, from changes in mobility patterns and, for the near transition, the implementation of efficiency measures for combustion engines.
- **Sustainable biomass:** Africa's (and the world's) potential for sustainable biomass use is very limited. Low-tech biomass use, such as inefficient household wood burners, should as fast as possible be replaced by state-of-the-art technologies, primarily highly efficient heat pumps and solar collectors.
- **Hydrogen and synthetic fuels:** Targeted and limited use of hydrogen and synthetic fuels generated by electrolysis using renewable electricity in the transportation sector, and limited hydrogen utilization for industry by 2050 (up to 5% of the energy supply and not for export beyond Africa).

The 100% renewable energy scenario also requires a shift in the heating sector towards the increased direct use of electricity, in part due to the limited availability of renewable fuels for high-temperature process heat in industry. This includes increased implementation of district heating infrastructure (interconnections of buildings in central business districts), some bio-energy-based heat generation, and solar collectors and heat pumps for office buildings and shopping centres in larger cities, as well as a rapid expansion of solar and geothermal heating systems.

The increasing shares of variable renewable power generation, principally by solar PV, will require the implementation of smart grids and the fast interconnection of micro- and mini-grids with regional distribution networks, storage technologies such as batteries and pumped hydro, and other load-balancing capacities.



Energy demand analysis

The 100% renewable energy scenario is set to reach universal access to energy—especially electricity— by 2050, while increasing the electrification and comfort standards to the levels of OECD countries. Growing economies require reliable power supply for small and medium businesses, industry, and the transport sector. It is assumed that households will use modern energy-efficient applications, according to the highest efficiency standards, to slow the growth of the power demand and to allow the parallel expansion of the energy infrastructure and the construction of renewable power plants.

In the reference scenario the total final energy demand will almost double from 23 EJ/a to 43 EJ/a in 2050. The 100% renewable energy scenario will lead to an increase of final energy demand by only 50% to 34 EJ/a – mainly due to higher electrification rates in transport, process heating (industry) and cooking for the residential sector, which significantly reduce the losses associated with combustion processes. Under both scenarios, the share of energy consumed by industry would grow significantly if the continent's growth and development projections are met.

The electrification of the heating, cooking, and transport sectors would result in significantly increased electricity demand, displacing other forms of energy. By 2050, Africa's electricity demand would increase to 4,500 TWh per year under the 100% renewable energy scenario compared to under 700 TWh per year currently.

Household electricity demand

To develop a projection for the residential electricity demand in Africa over the coming 30 years to achieve the 100% renewable energy scenario, a bottom-up electricity demand analysis was performed.

According to the most recent IEA data over 57% of Africa's households have access to electricity.[14] The current average electricity demands of Africa's households are significantly lower than those of OECD countries.

In our modelling it is assumed that household electricity demand will gradually increase as the electric applications for households progress from very basic needs, such as light and mobile phone charging, to a household standard equivalent to that of industrialized countries. By 2050, most households should have equipment that brings a medium-to-high level of comfort. The authors of this report have deliberately chosen a high standard for Africa's households to close the gap between households in OECD countries and countries in the global south, as such increased equity is an imperative.

Household Fuel demand—cooking

The main energy demand for Africa's households is currently energy for cooking.[15] Firewood is the main energy source for rural households, whereas cylinders of liquefied petroleum gas (LPG) are the main source of energy for cooking in semi-urban and urban households. Electricity is currently used for cooking in fewer than 5.6% of Africa's households.[16] Yet a comprehensive analysis of cooking technologies has shown that cooking with electricity using high-efficiency appliances could make cooking cheaper

than it is in many households currently using firewood and charcoal.[17] The World Bank's bottom-up research from across Sub-Saharan Africa indicated that households use on average US$1–31 per month on cooking fuels.[18] With slow cookers and pressure cookers enabling household cooking costs of between US$15–21/month for SHS and US$3.56–9.53/month for mini-grids, the economics of cooking with high-efficiency cooking appliances is becoming increasingly compelling.[19]

Based on the current energy usage for cooking, we assume a transition from fuel-based cooking to electric cooking (e-cooking) has been developed for the 100% renewable energy scenario. On average, at least 3.3% of all fuel-based cooking applications would need to be phased out year on year and replaced with electric cooking appliances. The total phase-out of fuel-based systems will be achieved for both environmental and economic reasons. Fuel-based cooking requires fuel that generates emissions, and the fuel supply is, in most cases, not sustainable. Collecting fuel wood puts forests under pressure, is time-consuming, and has a negative economic impact on a country's productivity. Burning LPG causes CO_2 emissions, and its production is based on fossil gas, which must be phased out by 2050 to remain within the global carbon budget to limit the global mean temperature rise to a maximum of +1.5 °C.

Achieving this transition involves overcoming a series of technical, policy and social challenges to support the increased utilization of electric cooking devices, as discussed further in the technical report.[20]

Industry and business

The analysis of Africa's economic development is based on a breakdown of the fiscal year 2019 and assumes that the overall structure of the economy will not change, and that all sectors will grow at a rate equal to that of the growth of GDP over the entire modelling period. It should be stressed that this assumption is not intended as a normative statement, but is adopted in order to conduct consistent modelling. On this basis, it is assumed that industry (including construction) accounts for a quarter of all GDP growth. Countries may very well choose a different structure of their economies, which is in fact highlighted in the discussion of new industrial policies and South-South cooperation in the **Just Transition** and this report.

Transport

To develop a future transport scenario, the technical parameters of all vehicle types were examined, as well as energy intensities for individual transport, public transport and freight. Estimates also took account of the projected utilization of different vehicle types.[21]

For the purposes of modelling, it was assumed that fossil-fuel-based vehicles must be phased out and mostly replaced by electric vehicles, as well as a limited number of biofuel-based vehicles. It was also assumed that the share of cars will grow at the expense of two-wheelers (scooters, motorbikes, bikes and e-bikes), which will increase the average energy intensity per kilometre alongside an assumed increase in average journey lengths. These parameters were adopted to ensure a plausible model of future development and are consistent with most modelling of future transport scenarios but

are not normative recommendations. Indeed, proactive policies and incentives including shifting transport infrastructure investments away from road capacity increases towards rail and improved public transport coverage, and urban planning that encourages shorter average journeys, are needed to limit energy demand increases in the transport sector.[22]

Electricity supply analysis: generation, capacity, and breakdown by technology

A 100% renewable energy scenario for Africa requires an increasing share of new renewable electricity, mainly from solar PV. Our modelling shows that by 2030, the share of new renewable electricity production should reach 46% -compared to 23% in 2023 - and increase to 90% by 2040. A 100% electricity supply from new renewable energy resources under the 100% renewable energy scenario by 2050 will lead to around 3,500 GW of installed generation capacity in 2050.

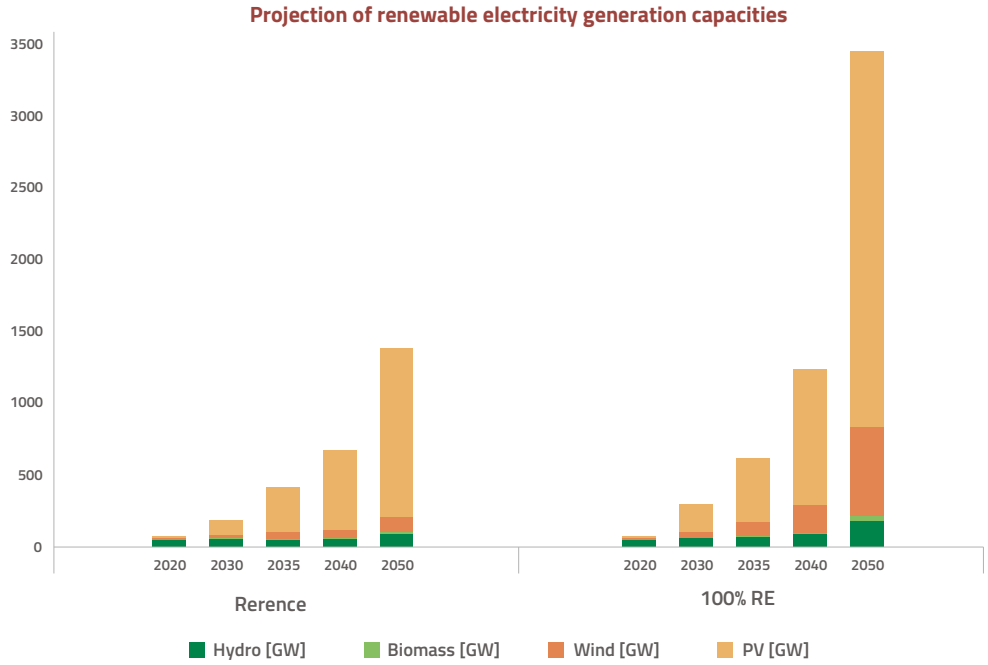


Figure 5 shows the comparative evolution of Africa's power generation technologies over time. Solar PV would overtake hydropower in installed capacity just after 2035.

The development of smart grid management will be required from 2025 onwards to increase the power system's flexibility for grid integration, load balancing, and a secure supply of electricity. The 100% renewable energy scenario phases out all fossil fuel-based power generation by 2050, with most gas and coal power plants shut down after 2040. The solar photovoltaic market will have to grow to reach a generating capacity of 205 GW by 2030, 933 GW by 2040 and 2,615 GW by 2050. In comparison, the global solar photovoltaic market in 2023 was 447 GW.

Africa will have to develop a large solar PV market and capacity for the domestic manufacturing of solar systems to affordably meet this demand and ensure that the economic benefits of this transition stay in Africa.

Wind generation would increase to 45 GW by 2030, 192 GW by 2040 and 625 GW by 2050. In comparison, the global wind market in 2023 was 116 GW. Manufacturing all important components for the wind industry in Africa would also have significant cost and logistical advantages.

Energy supply for cooking and industrial process heat

Today, bioenergy meets around 70% of Africa's energy demand for fuel-based cooking and heating. Dedicated support instruments are required to ensure dynamic development, particularly of electric cooking stoves, renewable heating technologies for buildings, and renewable process heat production.

In the 100% renewable energy scenario, fuel-based cooking (mainly firewood and LPG) will be replaced by electric cooking stoves. The increased electricity used for e-cooking will increase the electricity demand but will replace a significant amount of bioenergy (firewood) because the efficiency of burning wood is low. Under the 100% renewable energy scenario, the use of heat pumps as one of the leading new heating supply technologies will accelerate especially between 2025 and 2035.

Transport

The electrification of Africa's transport will require policy and fiscal incentives for people to transition towards electric mobility, especially in urban and semi-urban regions. It is also vital that transport use patterns shift to efficient public transport modes, such as rail, light rail, and buses, especially in the large expanding metropolitan areas. Highly efficient propulsion technology, with plug-in hybrid and battery-electric power trains, will bring large efficiency gains. By 2030, electricity will provide only 4.4% of the transport under the 100% renewable energy scenario but this would then be ramped up significantly to achieve the total decarbonization of the transport sector in Africa by 2050. Under the 100% renewable energy scenario, fossil-fuel-based vehicles must be phased out and mostly replaced by electric vehicles, as well as a limited number of biofuel-based vehicles. Given the limited supply of sustainable biofuels — and the widespread negative socio-economic, ecosystem and even climate impacts of many biofuels — these should be minimised, and when used, reserved for large commercial vehicles, buses, and large trucks in remote rural areas where the required charging infrastructure for large electric vehicles may be more difficult to develop during the next two decades.

Cost analysis

Investment in power generation

Introducing new electricity generation capacities requires additional capital investment, although this is more than balanced out over time by the reduced expenditure on natural gas and oil fuel.

Our modelling shows that by 2050, Africa would need to invest over US$ 3.3 trillion – around US$ 110 billion annually - in new power generation under the 100% renewable energy scenario. The reference case requires a total investment of less than half this figure – US$ 1.4 trillion.

Most investment will go into solar photovoltaics followed by onshore wind. The 100% renewable energy scenario does not envisage investment in new nuclear power plants after 2025 due to the significant cost advantages of renewable power generation. Furthermore, renewables are much faster to build so are better able to meet rising electricity demand from one year to the next, while nuclear power plants generally take around 10 years or more to construct and entail significant risks and security concerns.

Africa has significant solar and wind potential throughout the continent. Solar power stand-alone grids can supply electricity to remote villages which are unlikely to get grid connection over the next 10 to 15 years. Therefore, solar electricity systems need to be the premier choice to provide access to modern energy services.

However, wind energy systems can and should play a role in many areas across the African continent. The generation pattern is different from that of solar and will therefore reduce the energy storage requirements because electricity generation is distributed throughout the day and is not limited to daylight hours.

Investment in the heating sector

The main difference between the 100% renewable energy pathway and the reference case for heating is the significant investment in heat pumps and the diversification of heating technologies.[23]

The 100% renewable energy scenario requires an investment of US$ 1.9 trillion in heat pumps between 2020 and 2050. Investing in electrification (heat pumps) and 'fuel less' technologies (solar thermal) is significantly higher than the US$ 0.7 trillion investment cost of the reference scenario. However, the significant savings achieved as fuel costs decrease would refinance the initial investment costs over the technical life-time of those applications.

Fuel cost savings

While increased electrification will lead to higher investment costs in power generation, fuel costs will decrease significantly. The reference case requires US$ 18.9 trillion in fuel costs from 2020 to 2050, compared to US$ 10.6 trillion for the 100% renewable energy scenario.

The 100% renewable energy pathway requires investments of US$ 3.4 trillion in power generation and US$ 3.9 trillion in heat generation, or twice as much as in the reference case, with average annual investments in renewable energy generation capacity between 2020 and 2050 of US$ 243 billion compared to US$ 117 billion.

By comparison, the average annual fuel costs based on IEA projections for the reference case amount to US$ 629 billion, while the fuels costs for the 100% renewable pathway are US$ 354 billion - 44% lower.[24] As such, the average annual fuel cost savings of US$ 275 billion can refinance the higher investment costs of the 100% renewable energy pathway entirely.

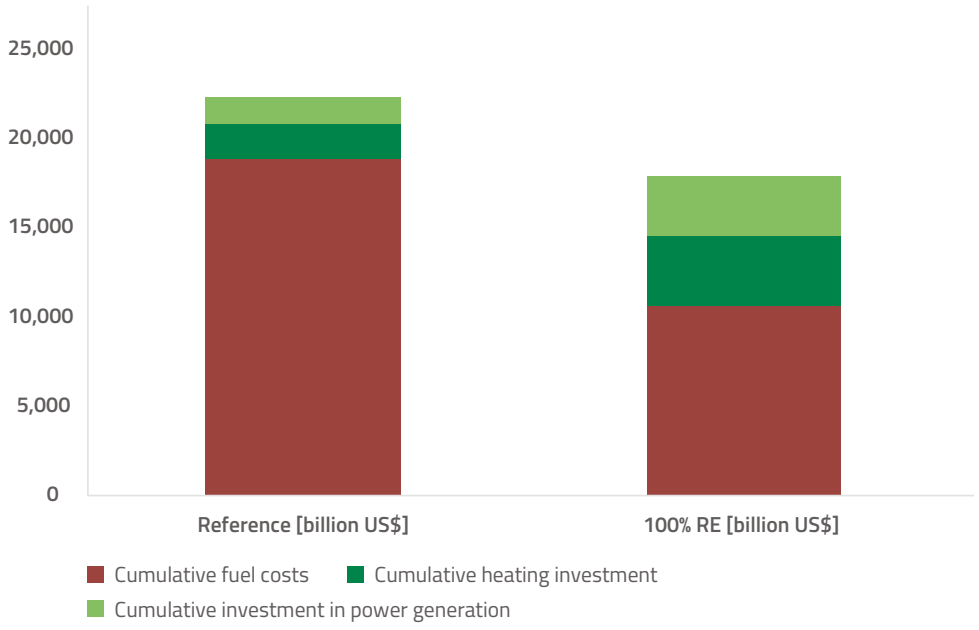
In addition, crucially, the reference scenario entails considerable further indirect costs from the use of fossil fuels, including negative health and environmental impacts. The

prolonged dependence on fossil fuels in an increasingly geopolitically unstable world poses further risks and costs.

Cumulative investment and fuel costs under two scenarios for Africa – 2020 to 2050

	Fuel Cost	Power generation /heating investment	Total
Reference Scenario	629	117	746
100% RE Scenario	354	243	597
Savings	275	-126	149

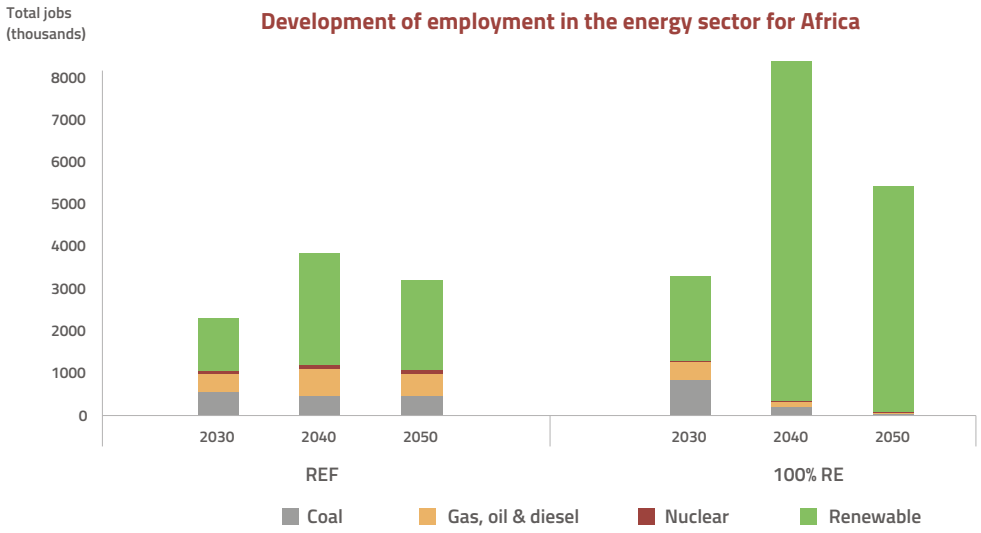
Cumulative investment and fuel costs under two scenarios for Africa – 2020 to 2050



Employment

Building a fully renewable energy system will boost employment. Our scenarios show that if Africa continues its business-as-usual development, employment in the energy sector – across all technologies and energy sources – will more than double from around 1.5 million in 2023 to 3.2 million in 2050. By comparison, 5.4 million more people would be employed in the energy sector by 2050 under a 100% renewable energy scenario, amounting to 2.2 million extra jobs.

Direct employment in renewable energy would increase from around 350,000 currently to 2 million under the reference case to 5.3 million jobs in the 100% renewable energy scenario, more than compensating for job losses in the fossil fuel sector.

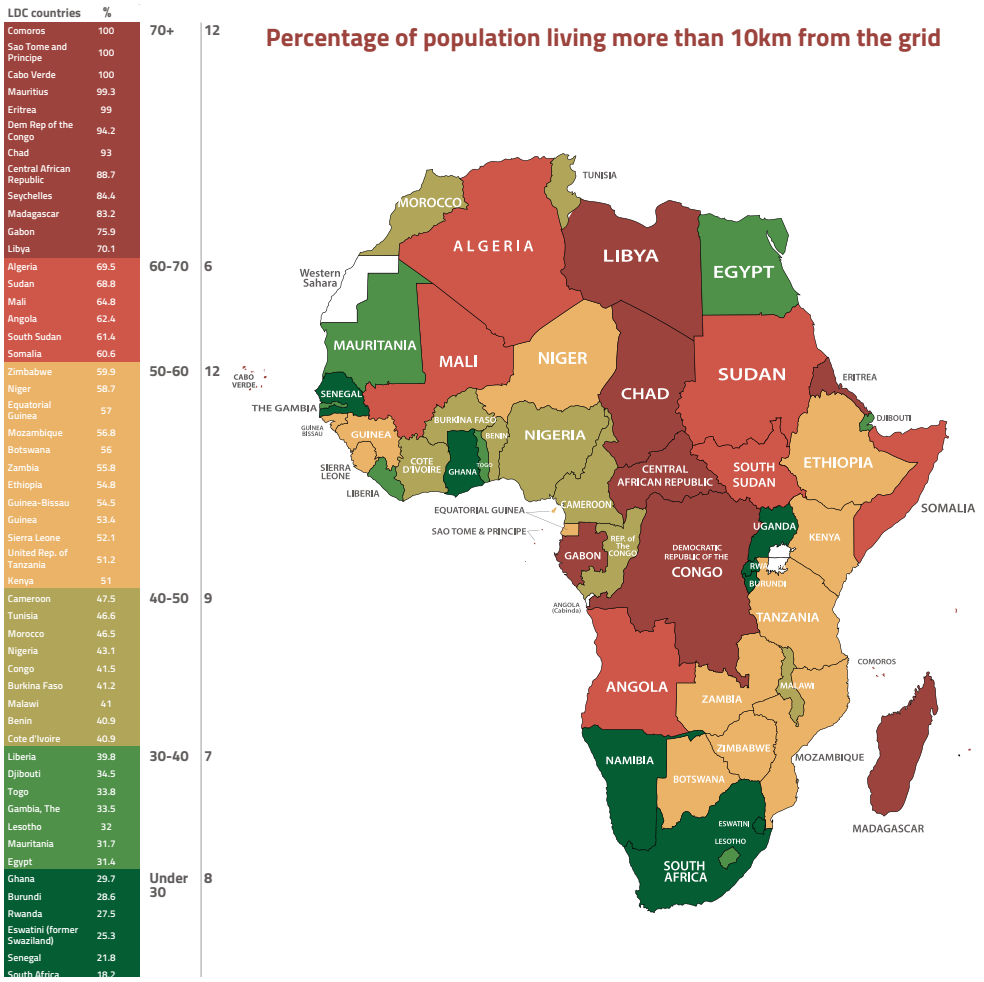


These estimates are based on several variables, including projections for energy use and capacity and Africa-specific 'employment factors', which calculate the number of jobs per unit of capacity, separated into manufacturing, construction, operation, and maintenance, and per unit of primary energy for fuel supply. A 'decline factor' was also applied for each technology, which reflects the fact that employment per unit will decrease as technology efficiencies improve. Only direct employment is included—jobs in construction, manufacturing, operations and maintenance, fuel supply associated with electricity generation, and direct heat provision.

Bringing electricity access to Africa's "off-grid" population

We estimate that 720 million Africans (50.2% of the total population) live "off grid", defined as living more than 10 km from mapped electricity transmission lines. A sizable proportion of Africa's population – around 600 million people - live without reliable and affordable access to electricity altogether.[25]

Figure 8 shows the distribution of Africa's off-grid population.



Increasing access to electricity services can be achieved either by expanding the central grid or through decentralized island grids with distributed generation.

Expanding the existing electricity grid is the conventional way of ensuring access to modern energy services. For a village that is not yet electrified, connecting to the grid is considered the preferred option, as it is then directly integrated into the central grid and the country's electricity company — often organized as a monopoly — can be contracted to provide the electricity. In Africa, however, the central grid supply is often insufficient to meet all demand, and small rural connections are often cut in favour of supplying cities and industries — leading to frequent power outages. Another problem is that centralized

grid operators often do not know exactly how much electricity is being used within the system due to a lack of metering equipment and rampant energy theft. This makes it difficult to control power quality, such as maintaining voltage and frequency within normal operating limits. Moreover, in some cases, rural communities cannot afford the connection costs even if grid expansion is the cheaper option.

Stand-alone grids with distributed renewable generation and storage support offer fast and often much more efficient bottom-up approach to rural electrification. Stand-alone grids can be sized in different capacities from a few kilowatts to several megawatts. The main advantage of island grids is that they can be implemented in different locations rapidly and at the same time – there can be bottom-up energy revolutions. In addition, these stand-alone grids may be interconnected over time. Thus, interconnected stand-alone grids can form a nationwide electricity grid over time: bottom-up grid expansion.

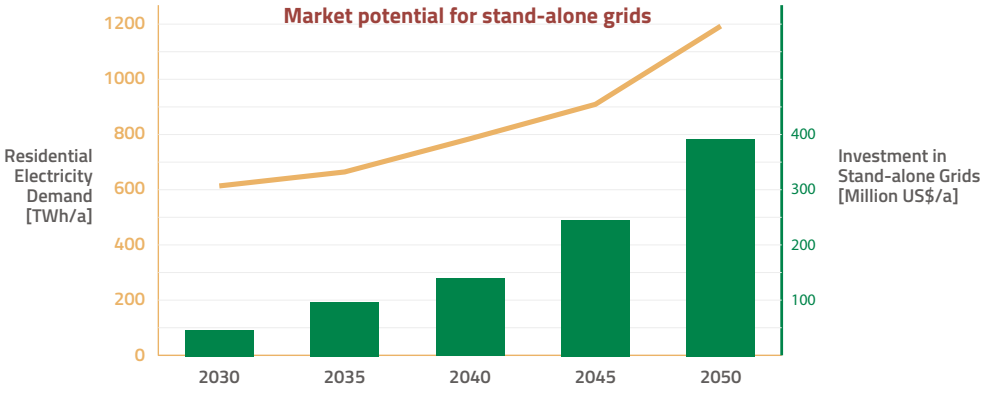


Stand-alone grids that can switch between stand-alone and grid operation represent a particularly interesting case. These stand-alone grids are distribution networks that can be developed using a bottom-up approach, such as home energy systems and off-grid systems that use local renewable energy sources to meet local demand. However, unlike these stand-alone systems, the power supply is more flexible and reliable, with the option to source from local or central generation depending on demand, availability and price. This allows cheap power to be sourced from the grid during periods of low demand, while local supply can be activated to meet local needs during power outages on the main grid. In addition, microgrids can help manage the balance between local supply and demand, helping to manage power quality and improve security of supply.

Energy Access Alternatives	Pros	Cons
Standalone Home Energy System (island)	» Lowest capital cost due to small unit size » No transmission or distribution lines need to be built » Fast and simple construction » No change in regulation required » Reliable supply can be sustained when grid is down	» Supply accessible to only one user » No benefit from economy of scale
Mini-grid system (island)	» No transmission lines need to be built » Supply can be shared between multiple users » No change in regulation required » Reliable supply can be sustained when grid is down » Can be installed fast	» Local distribution lines need to be built » Requires localized balancing control » Effective payment structure needs to be established » Mini-grid operator needs to be established
Microgrid system (island <->grid)	» Investment in transmission extension can be delayed until it can be economically justified » Supply can be shared between multiple users » Reliable supply can be sustained when grid is down » Supply from grid can be accessed when energy is cheaper and/or in case of local generation outage » Excess local supply can be fed to grid » Microgrid can support grid voltage and restarting grid after shutdown	» Distribution lines need to be built » Requires localized balancing control » Requires an effective independent payment structure until grid access is available » An operator of the island grid needs to be established until grid access is available » Requires communication and control equipment to switch between operation modes » Requires review of protection equipment and regulations
Grid extension with Distributed Generation (DG) (grid)	» Can achieve economies of scale » Access to centralized balancing control » No change in regulation required » No new payment structure needs to be developed for consumers	» Transmission and distribution lines need to be built » Reliability of supply is dependent on centralized system (small villages are unlikely to become high priority areas for maintaining delivery of quality and reliability of supply) » Prone to voltage problems
Distributed generation (grid)	» Supply can be shared between multiple users » Access to centralized balancing control » Can support grid voltage and black start operation » No new payment structure needs to be developed for consumers	» Highest capital cost because transmission and distribution lines need to be built as well as generation units » Reliability of supply is dependent on centralized system (small villages are unlikely to become high priority areas for maintaining delivery of quality and reliability of supply) » Requires review of regulations » Power purchase agreements need to be established

Table : Strengths and weaknesses of different energy access options.[26]

Given the potential for off-grid power generation, especially for accelerating electricity access, we have estimated the potential investment costs of developing stand-alone grid options to 2050.



		2020	2025	2030	2035	2040	2045	2050
Total Population	**[Mill.]**	1,361	1,530	1,711	1,899	2,093	2,290	2,485
No access to power grid	**[Mill.]**	720	811	736	627	481	298	12
Persons with no electr. Access	**[%]**	53%	53%	43%	33%	23%	13%	1%
Progress ratio	**[%/a]**			2.0%	2.0%	2.0%	2.0%	2.5%
Potential NEW Stand-alone Grid Customers	**[Mill.]**	0	0	75	184	329	513	798
Residential Electricity Demand	**[TWh/a]**	410	474	551	652	781	949	1,179
Average Residential Electricity Demand per person	**[kWh/a]**	640	659	565	512	484	476	477
Stand-alone Grid - supply	**[TWh/a]**			43	94	160	245	381
Average electricity costs - Stand-alone grids	**[US$ cent/ kWh]**	0.09	0.09	0.13	0.11	0.09	0.11	0.10
Total electricity value - stand-alone grids	**[Million US$/a]**	0	0	54	108	150	264	396
Investment in Stand-alone Grids	**[Million US$/a]**			51	103	142	250	376

The investment estimates are based on the assumption that stand-alone grids would progressively provide energy access to the population not served by other grid infrastructure, reaching to up to 800 million potential users by 2050, within a 100% renewable energy scenario.

Under the assumption that the average electricity demand per person supplied by stand-alone grids is similar to the grid connected areas and that electricity generation costs are within the same level as grid connected systems, stand-alone grids would reach an annual electricity supply market volume of just over US$ 375 billion by 2050.

A detailed investment plan to implement an African stand-alone power generation network was not within the scope of this research, but a high-level costs estimate suggests an investment requirement in power generation and stand-alone grid equipment of around US$ 6.2 billion between 2025 and 2050, or an annual average investment of US$ 250 million.

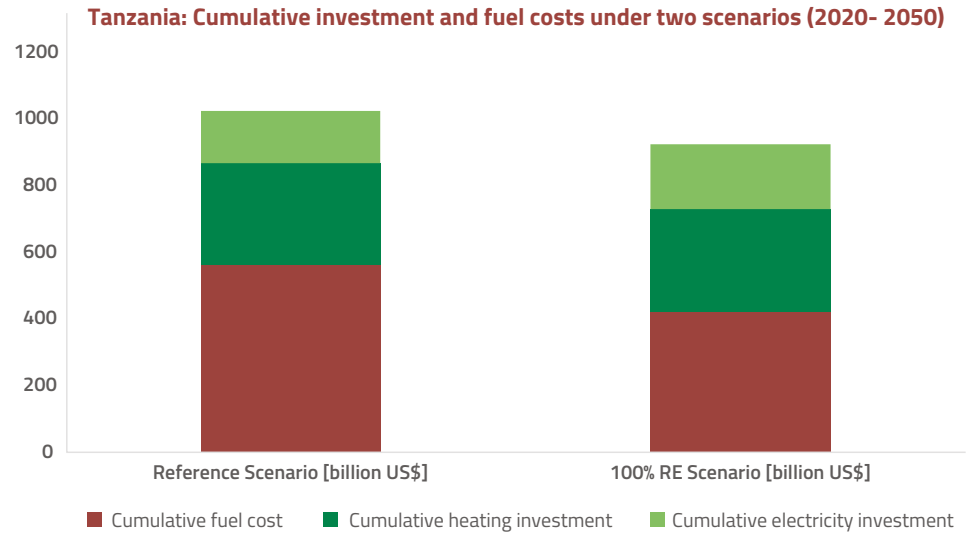
Case studies

Power Shift Africa and the University of Technology Sydney (UTS) have developed 100% renewable energy pathways for Tanzania, Rwanda, Kenya, Malawi, Senegal and Tunisia that are aligned with the Paris Climate Agreement goals. While the current report develops Africa-wide estimates on the requirements and scope for a full energy transition, the case studies allow for more detailed modelling and scenario planning.

The overall approach for the specific country cases is consistent with the continental approach already presented. To develop a projection for the residential electricity demand for the analysed Africa countries over the coming 30 years, a bottom-up electricity demand analysis was performed. The energy development plans aim to increase the access to energy—especially electricity—for all by 2050, while increasing the electrification and comfort standards to the levels of OECD countries. The growing economy requires a reliable power supply for small and medium businesses, industry, and the transport sector. It is assumed that households will use modern energy-efficient applications, according to the highest efficiency standards, to slow the growth of the power demand and to allow the parallel expansion of the energy infrastructure and the construction of renewable power plants. Electrification expansion was assumed through a new and innovative 'bottom-up' approach developed by UTS-ISF. The full case studies can be found at https://www.powershiftafrica.org/publications

The specific country cases also show that secure and accessible 100% renewable energy systems in Africa are both achievable and economically desirable. Investment costs for grid improvements, renewable energy systems build out, and storage requirements to achieve secure 100% renewable energy systems in all six countries would be more than paid for by the savings on substituted fuel costs.

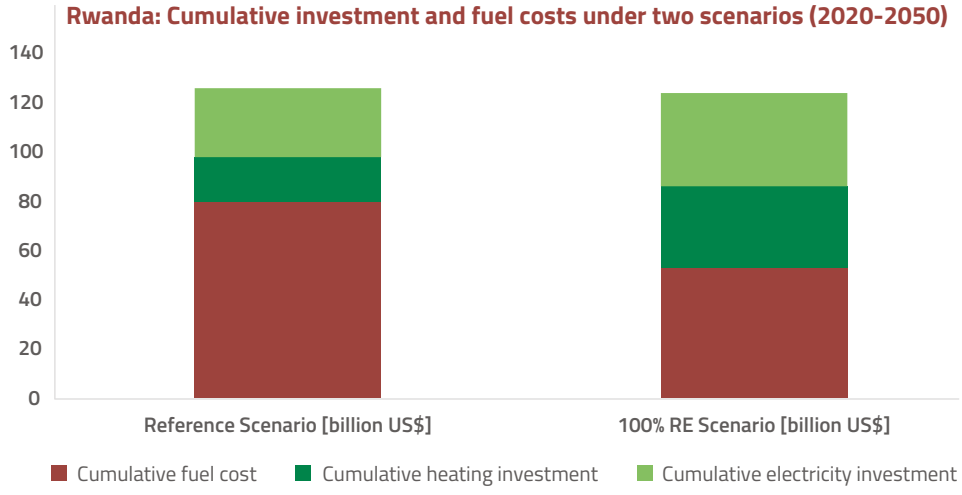
Tanzania



Tanzania can cost-effectively build a reliable electricity supply based on local power generation with a high proportion of solar and wind power. The potential for solar and wind power can not only reliably cover future electricity needs, but also allow renewable electricity to be exported to neighbouring countries.

Increased electrification will lead to higher investment costs in power generation and higher overall electricity supply costs for Tanzania. Under the most ambitious electrification strategy of the 100% renewable energy pathway, total investment in power generation will be 487 trillion TZS (US$ 195 billion). But across the entire scenario period, fuel cost savings under the 100% renewable energy scenario will be 355 trillion TZS (US$ 142 billion), more than 3 times higher than the additional investment in power generation until 2050. Whereas fuel cost predictions are subject to a great deal of uncertainty, the clear result makes the cost-effectiveness of electrification very clear.

Rwanda

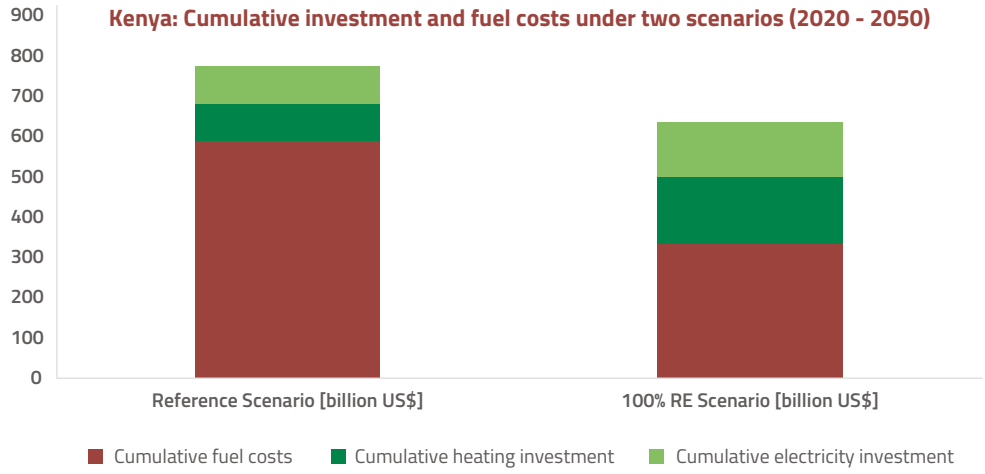


Rwanda can cost-effectively build a reliable electricity supply based on local power generation with a high proportion of solar and wind power. The potential for solar and wind power is sufficient to cover future electricity needs projected for 2050.

Increased electrification will lead to higher investment costs in power generation and higher overall electricity supply costs for the 100% renewable energy scenario. The 100% renewable energy scenario requires an investment in power generation of 38 trillion RWF (US$ 47 billion) and 30 trillion RWF (US$ 24 billion) in heat generation. The total investment in power and heat generation capacities therefore adds up to 68 trillion RWF (US$ 71 billion). Additional power generation investments will be compensated by fuel costs savings in the decade that they are made.

Across the entire scenario period, fuel cost savings under the 100% renewable energy scenario compared to the reference case will be 4.2 trillion RWF (US$ 27 billion), which would cover more than half of the total investment in generation capacities until 2050 - about 2.5 times the additional investment in comparison of the 100% renewables pathway. In countries with a high level of energy access, fuel cost savings almost always refinance the investment in new renewable energy generation. Rwanda, however, has a low energy access rate and therefore, additional investment in energy infrastructure is required in any case.

Kenya

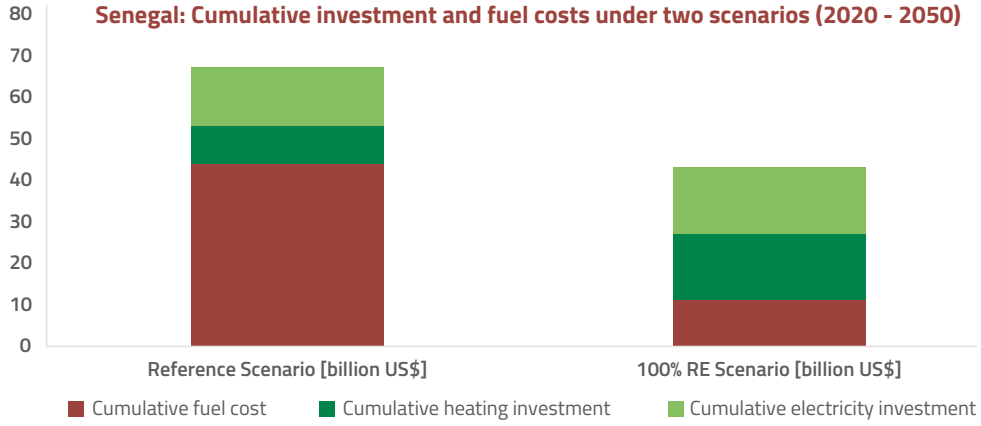


Increased electrification will lead to higher investment costs in power generation and higher overall electricity supply costs for Kenya. Table 55 shows all the accumulated fuel costs by sector and scenario and the calculated fuel cost savings in 10-year intervals between 2020 and 2050 in Kenyan Shilling and US Dollars. The 100% renewable energy scenario requires an investment in power generation of 21 trillion KES (US$ 135 billion) and 25 trillion KES (US$ 166 billion) in heat generation. The total investment in power and heat generation capacities therefore adds up to 46 trillion KES (US$ 301 billion).

Additional power generation investments will be compensated by fuel costs savings in the decade that they are made. Across the entire scenario period, fuel cost savings under the 100% renewable energy scenario compared to the reference case will be 91 trillion KES (US$ 590 billion) – about 2 times higher than the investment in generation capacities until 2050.

In comparison to the reference case, the fuel cost saving of the 100% renewables pathway will cover about 6-times the additional investments required in power generation capacity. Whereas fuel cost predictions are subject to a great deal of uncertainty, the clear result makes the cost-effectiveness of electrification very clear.

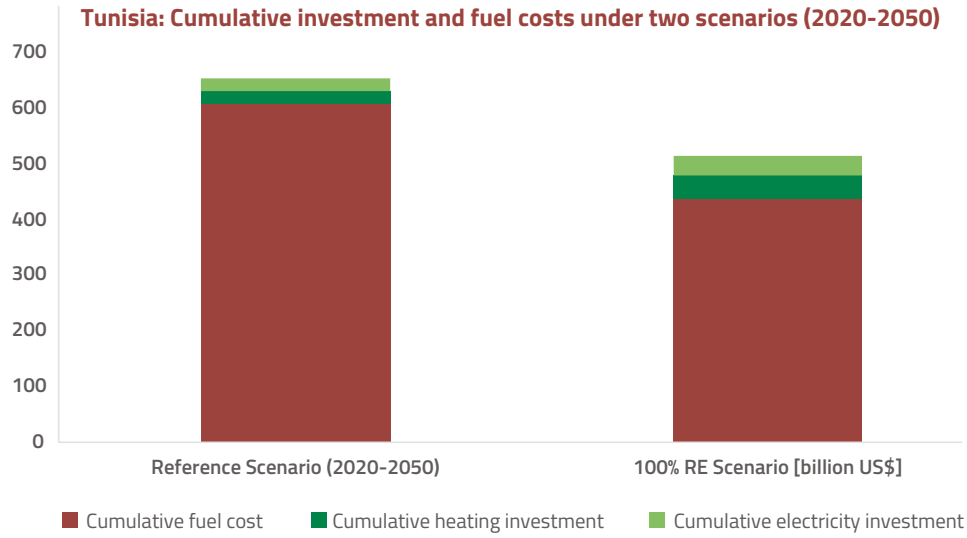
Senegal



Increased electrification will lead to higher investment costs in power generation and higher overall electricity supply costs for Senegal. Table 57 shows all the accumulated fuel costs by sector and scenario and the calculated fuel cost savings in 10-year intervals between 2020 and 2050 in Central African francs and US dollars. The 100% renewable energy scenario requires an investment of 16 trillion CFA (US$26 billion) in power generation and 10 trillion CFA (US$16 billion) in heat generation. Therefore, the total investment in power and heat generation capacities will sum to 25 trillion CFA (US$43 billion).

Across the entire scenario period, fuel cost savings under the 100% renewable energy scenario relative to the reference scenario will be 19.2 trillion CFA (US$32.6 billion) – and will cover the entire investment in new power generation capacities until 2050 - about 16 times the additional investment in comparison of the 100% renewable energy pathway. Although fuel cost predictions are subject to a great deal of uncertainty, the clear result makes the cost-effectiveness of electrification very clear.

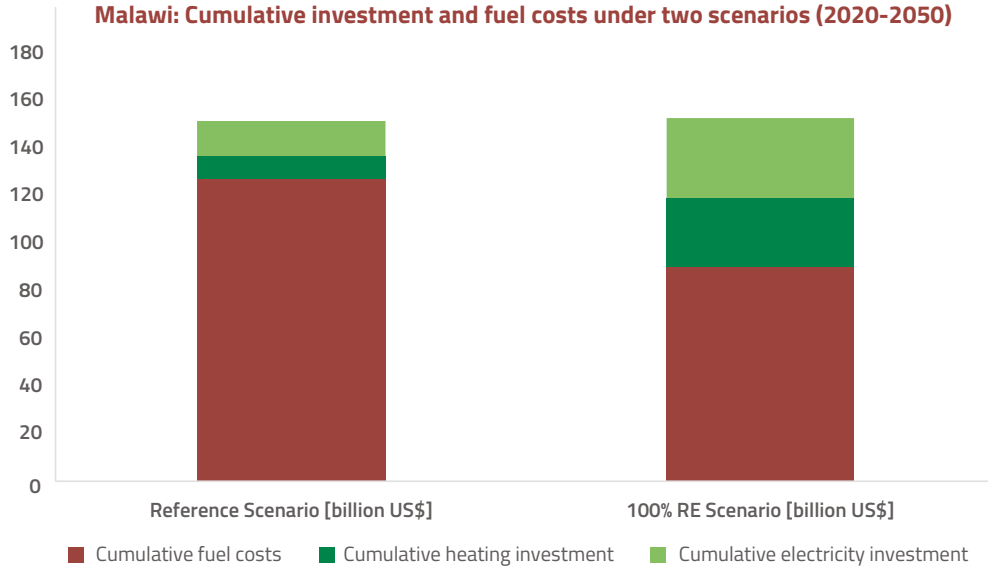
Tunisia



Increased electrification will lead to higher investment costs in power generation and higher overall electricity supply costs for Tunisia. The 100% renewable energy scenario requires an investment of 110 billion Tunisian dinar (trillion TND US$36 billion) in power generation and 129 billion trillion TND (US$42 billion) in heat generation. The total investment in power and heat generation capacities therefore sum to 239 billion trillion TND (US$78 billion). Additional power generation investments will be compensated by fuel costs savings in the decade in which they are made.

Across the entire scenario period, fuel cost savings under the 100% renewables scenario relative to the reference scenario will be 170 billion TND (US$56 billion) – about 4 times higher than the additional investment in power generation capacities until 2050. Although fuel cost predictions are subject to a great deal of uncertainty, this clear result makes the cost-effectiveness of electrification very clear.

Malawi



Increased electrification will lead to higher investment costs in power generation and higher overall electricity supply costs for Malawi. The 100% renewable energy scenario requires an investment of 57 trillion Malawian kwacha (MWK; US$33.5 billion) in power generation and 29 trillion MWK (US$41 billion) in heat generation. Therefore, the total investment in power and heat generation capacities will sum to MWK 86 trillion (US$74 billion) Additional power generation investments will be compensated by fuel cost savings in the decade in which they are made.

Across the entire scenario period, fuel cost savings under the 100% renewable energy scenario – relative to the reference case – will be MWK 322.4 trillion (US$189.7 billion). Additional investment in power and heat generation (including cooking) under the 100% renewable energy scenario would be more than paid for by fuel cost savings.



PART III: IMPLEMENTING AND FINANCING THE TRANSFORMATION TO 100% RENEWABLE ENERGY

Key principles and approaches for a new Africa energy vision

The transition to renewable energy in Africa presents an opportunity to address the continent's energy and development challenges in ways that are equitable, sustainable, and inclusive.

To implement a fully renewable energy system while enhancing energy access, Africa will need to move away from outmoded models based on centralised infrastructure towards more modern, integrated energy solutions. The new system should embody a number of key principles and approaches that underpin a new African energy vision – as outlined and elaborated in the Independent Expert Group on Just Transition and Development report and the LDC REEEI Framework. These include:

- **Ensuring African ownership and agency in energy initiatives and plans.** Africa's energy transition must firmly establish African voices and leadership, ensuring that energy policies and actions are informed by local realities and aligned with the continent's broader development objectives. External initiatives often dominate the landscape, shaped by powerful interests that fail to fully reflect African priorities. To assert its agency, Africa must lead the formulation of questions about its energy and development challenges and identify solutions that emerge from inclusive, continent-wide deliberations. This shift requires robust institutional frameworks that foster transparency, accountability, and collaboration among African nations. Additionally, this principle demands the creation of mechanisms that enable African countries to resist external pressures and chart a path toward self-determined, sustainable energy solutions.
- **Integrating energy systems design into wider development objectives and planning.** Africa has the unique opportunity to design energy systems that are agile and capable of adapting to evolving social and technological realities. For countries with limited infrastructure, the focus must be on leapfrogging directly to advanced renewable systems, bypassing outdated technologies, analogous to the continent's rapid adoption of mobile telecommunications. In nations with considerable existing infrastructure, transitioning from fossil fuels to renewables will require careful planning to phase out obsolete systems in an equitable manner. The transition must also consider distributed energy models that cater to rural and urban areas while minimizing environmental impact.
- **Establishing clear policy priorities** that phase out fossil fuels and prioritise renewable energy while continuing to grow African economies and investing in new forms of people-centered and sustainable industrialization. African governments should promote policies that actively prioritize greater participation in the manufacturing and high-value segments of the renewables industry over harmful resource extraction. Key items promoted by active industrial policies should begin with renewable energy products (e.g LED lights, solar panels, wind turbines, heat pumps, ventilation equipment). Policies should also promote stringent safeguards, compliance mechanisms, and precautionary approaches to minimize environmental and social harm.

- **Prioritising and sequencing strategic investments to achieve energy sovereignty.** Energy sovereignty is critical to breaking Africa's dependence on costly fossil fuels and raw material exports. Prioritizing local manufacturing of renewable technologies allows African nations to move up the value chain, fostering economic independence and meaningful industrialization. This approach stimulates domestic economies, creates jobs, and strengthens tax bases while reducing reliance on foreign currencies. Building African markets requires the development of critical infrastructure, logistics, finance, insurance, supply chains systems, investment in workforce development, and stringent environmental safeguards across the continent. Pan-African collaboration to build regional markets would help to achieve economies of scale and ensure efficient access to critical resources, breaking the pattern of extractivism and securing for Africans a greater share of the economic benefits and employment opportunities of an energy transition.
- **Fostering energy democratization, including diversification of energy generation and ownership**, and support for the transition to electrification of cooking. Africa's energy transition offers an opportunity to reimagine energy systems as inclusive, participatory, and equitable. Future energy systems should emphasize cooperative approaches, including shared standards, innovative grid designs, and strategies for managing demand. Ownership models that engage producers and consumers alike can democratize access to energy, fostering social equity and economic opportunity. Multi-directional energy flows, localized storage, and decentralized grids can enhance efficiency and resilience. Governments should establish policies, regulations, and support systems conducive to community energy projects, ensuring that these initiatives serve as a backbone for democratized energy systems. Overall, the transformation must prioritize inclusivity, community empowerment, and adaptability, ensuring equitable access to energy resources and a sustainable future for all. Public utilities need to play an important role and be regulated, resourced and mandated to promote the renewable energy systems of the future. In parallel - the diversification of ownership will see a huge number of new actors involved in energy production – households, farmers, community organisations, cooperatives, SMEs, schools, hospitals and universities.
- **Ensuring stakeholder participation, equity and sufficiency** in terms of energy use. The renewable energy transition holds great potential to decentralize power and enhance equity, but these outcomes are not guaranteed. To avoid negative equity impacts, deliberate measures must integrate distributional fairness into energy and development policies. Energy governance must undergo radical democratization, with robust institutional frameworks enabling wide stakeholder participation. Moreover, these strategies must connect energy goals with broader social policies to foster equity, reduce poverty, and strengthen resilience against external shocks.

Renewable energy as part of an economy-wide transformation

As outlined in the *Just Transition report*, African countries can and must break away from current entrapments with international debts and prescriptions that only aggravate unhealthy dependencies. This calls for a deep, structural transformation

of African economies, to diversify and prioritize energy and food sovereignty on the path to a more inclusive, people-centred model of development that achieves universal energy access while keeping in line with a 1.5°C climate target. This transformation would cut across many sectors of the economy, including:

- **Electricity.** The traditional electricity market has been developed for central suppliers mostly operating 'base-load' fossil-fuel power plants. But the electricity markets of the future will be dominated by variable generation, with no marginal or fuel costs. There should be no new investment in new oil, coal, and gas projects, and existing coal power generation needs to be phased out by 2040. At the same time, renewables capacity (especially solar) needs to be increased as the bedrock of a distributed (decentralised) system. This offers distinct advantages in terms of both rural electricity access and overcoming reliability problems. The power system will also require the build-up and economic operation of a combination of dispatch generation, storage, and other system services, supported by renewable electricity feed-in laws and guarantees.
- **Industry.** At a technical level, fossil fuel-based process heat needs to be replaced by renewable energy or electrical systems. Non-energy process emissions from cement and steel manufacture can be reduced by altering or optimizing manufacturing processes. More broadly, Africa should pursue an industrial model that allows the continent to produce and retain most of the value-added content of manufactured goods to secure a greater share of revenues and benefits.
- **Agriculture.** Africans can achieve food sovereignty by shifting away from export-oriented, cash-crop, industrial agriculture towards community-based agro-ecological systems that provide nutritious food, sustained yields, secure livelihoods, and climate resilience. A just transition should provide social protection and economic opportunities for smallholder farmers and rural communities, in pursuit of a sustainable food system that reduces deforestation and protects biodiversity.
- **Transport.** All fossil-fuel-based vehicles must be phased out by 2050 to achieve the terms of the Paris Climate Agreement, and all new vehicles with internal combustion engines should be phased out across Africa by 2040 at the very latest (with appropriate policy and support frameworks this should be possible even earlier). Just as importantly, this should be accompanied by policies and planning processes that avoid or reduce the need to travel and encourage shifts to more efficient transport modes, including vastly improved public transport and electrified rail for freight.
- **Buildings.** The construction of new energy-efficient buildings should follow stringent building codes that require a high level of energy performance. Building certification and labelling, technology transfer, training of building specialists, and financial incentives are also needed.
- **Energy efficiency.** A just transition should be underpinned by incentives, regulations, standards and policies to incentivize the efficient use of energy across sectors, including utilities, industry, and buildings as well as lighting, appliances and electrical equipment. This should include the development and harmonization of minimum energy performance standards and labeling, alongside financial assistance for utilities and industry to upgrade equipment and rationalize processes.

Financing a just energy transition

While renewable energy development is by far the cheapest option to 2050, new financing mechanisms are needed to help meet the significant upfront investment costs in a context of limited access to finance. Feed-in tariffs and payment guarantees are tried and tested policy measures that can help to bridge the financing gap. Funding for these policies should come through a mix of domestic and international sources, with measures to expand domestic fiscal capacity, cancel debt and remove other barriers to ensuring that African countries have sufficient capacity to invest in a renewable energy transition. African governments should prioritize an economic model that actively seeks to avoid capital extraction and increase domestic tax revenues to help expand fiscal spending capacity over time.



Expanding domestic fiscal capacity

African countries can expand their fiscal capacity to finance the energy transition by addressing key domestic constraints, particularly the risks of inflation tied to productive capacity and market conditions. Inflation, as the ultimate constraint on government spending, can arise when budget deficits increase consumer demand beyond domestic productive capacity, driving up imports and straining exchange rates. This, in turn, leads to currency depreciation, imported inflation, and potentially greater external debt burdens if governments resort to borrowing or subsidies to prevent social unrest. Enhancing productive capacity—through investments in skilled labor, infrastructure, supply chains, and critical industries such as agriculture and renewable energy—can mitigate this risk. By reducing dependency on imports, such strategic investments can also create jobs, stabilize exchange rates, and decrease external debt over time.

Market concentration and abusive price-setting behaviors by monopolistic companies further exacerbate inflationary pressures. These practices often involve exploiting resources, subsidies, or exclusive licenses for personal gain, hindering domestic productivity and exacerbating external debt. For instance, companies controlling essential imports or exports, such as food and fuel, may use their economic and political power to

maintain monopolies, drive up prices, and discourage domestic competition. To counter this, African governments must prioritize economic democratization, enforce antitrust regulations, and combat corruption. This ensures fair resource allocation, incentivizes domestic production, and creates a more equitable and robust economic framework.

The deliberate enhancement of productive capacity is a particularly promising avenue for mitigating these issues and enabling transformative change. Investments in strategic sectors, including renewable energy, housing, transportation, and agroecology, can build resilience in domestic economies by reducing reliance on costly imports and creating a foundation for industrialization. These initiatives would not only meet immediate development needs but also contribute to stabilizing exchange rates, lowering external debt, and reducing inflationary risks over time. Strengthened domestic production capabilities could serve as a cornerstone for sustainable growth while addressing pressing climate and energy needs.

Moreover, unlocking fiscal capacity through targeted interventions in productive sectors must be accompanied by efforts to foster inclusive economic development. By aligning public investments with social and environmental priorities, governments can ensure that these investments cater to real community needs, reduce inequality, and stimulate local economies. Empowering small businesses, cooperatives, and community-driven projects, particularly in renewable energy, ensures that the benefits of enhanced productive capacity reach all levels of society. This, in turn, amplifies the social and economic returns of these investments, creating a virtuous cycle of growth and sustainability.

Building an economy that can drive an energy transition means escaping the post-colonial trap of prioritising extractive industries, assembly-line manufacturing and low-value-added exports. To secure a greater share of benefits and revenue, regional or Pan-African approaches to industrial policy are needed that takes advantage of economies of scale, expands internal markets, and prioritises strategic investments in key sectors including renewable energy and agriculture. This will require strategic targets and partnerships to foster research and development, build technical capacity, and develop new trade relationships that benefit Africa rather than reproducing structural debt traps and economic dependency.

Addressing domestic factors effectively equips African countries to finance their energy transitions without exacerbating debt or inflation risks. Strategic investments that boost productivity, coupled with reforms to combat market concentration and corruption, lay the groundwork for a resilient and inclusive economic future. These measures are essential for advancing development priorities while safeguarding financial stability and promoting energy and climate justice across the continent.

International finance

African countries face significant external challenges in financing their energy transitions, particularly the burden of crippling external debts. This requires the systematic cancellation of unfair and illegitimate debts, alongside improved regulation of transnational corporations and tax evasion.

The energy transition also underscores the need for transformative external financing. International climate and development finance must be scaled up to support Africa's energy transition. Alongside existing multilateral climate funds, further financial transfers are needed from a variety of financial sources such as financial transaction taxes, redirection of subsidies and special drawing rights (SDRs).

Multilateral financing

Multilateral financing remains a cornerstone for addressing Africa's climate, energy, and development challenges. A proposed Global Renewable Energy and Energy Access Transformation (GREEEAT) initiative can serve as a platform to pool resources from bilateral and multilateral donors, providing a foundation for affordable and sustainable energy access.[27] Establishing predictable investment conditions, such as feed-in tariffs for renewables, can spur private and public investment while ensuring long-term energy security. Beyond energy, multilateral finance should support economic diversification strategies, enabling African nations to transition from fossil fuel dependency to sectors like agriculture, manufacturing, and renewable technologies. Social protection programs, like those advocated by the International Labour Organization's Global Accelerator on Jobs and Social Protection, can buffer communities during economic transitions and promote inclusive development.

Climate-specific multilateral financing

The scale of Africa's climate financing needs calls for a significant expansion of dedicated multilateral climate finance mechanisms like the Green Climate Fund (GCF). To address systemic gaps, reforms are necessary to prioritize adaptation funding and fair compensation for loss and damage. Africa initiated and controlled mechanisms should be scaled up to deliver immediate, targeted solutions to climate impacts across the continent. A variety of financial sources, such as a global financial transaction tax, reallocation of fossil fuel subsidies, and leveraging IMF Special Drawing Rights (SDRs), offer opportunities to generate substantial, predictable funding without increasing debt burdens.

Debt management and cancellation

Tackling Africa's unsustainable debt levels is essential for enabling effective climate and development financing. Comprehensive audits to identify and cancel illegitimate debts—those associated with corrupt practices or detrimental projects—should be prioritized. The "odious debt" doctrine, which challenges the legitimacy of exploitative financial obligations, offers a legal basis for such cancellations. Moving forward, structural reforms must address the root causes of debt dependency, including unsustainable borrowing practices and inequitable trade relationships, to ensure long-term fiscal sustainability and resilience.

Tax justice and regulation of transnational corporations (TNCs)

Combating tax evasion, profit shifting, and illicit financial flows is critical to unlocking Africa's revenue potential. A United Nations Tax Convention could create a global framework to enforce transparency measures, such as public registries of beneficial ownership and mandatory country-by-country financial reporting by multinational

corporations. Africa also requires legally binding agreements to hold TNCs accountable for human rights abuses and environmental harm, particularly in resource extraction industries. Robust tax and regulatory measures can reclaim vital public revenues for reinvestment in social and economic development priorities.

Trade, investment, and technology access

Reform of global trade and investment policies is necessary to foster equitable economic growth in Africa. Intellectual property regimes under agreements like TRIPS should be overhauled to facilitate access to essential technologies, including renewable energy systems and pharmaceuticals, enabling local production and reducing dependence on imports. Investor-State Dispute Settlement mechanisms, which often favor corporations over governments, should be redesigned to safeguard public interests and democratic governance. Regional economic integration, coupled with resilience-focused trade policies, can strengthen Africa's domestic economies and mitigate vulnerabilities to global market fluctuations.

South-south cooperation

Strengthening South-South cooperation offers transformative potential for Africa's development. Collaborative initiatives can reduce costs and improve access to essential goods, such as food, medicine, and renewable energy technologies, through shared procurement and manufacturing strategies. Local currency swap arrangements among African nations can minimize dependence on volatile global currencies like the US dollar and euro. Regional collaboration can also address shared challenges, from climate adaptation to inflation control, while fostering innovation in infrastructure and renewable energy. Enhanced cooperation among Global South nations builds collective resilience and amplifies Africa's influence in global economic and political arenas.

The path to sustainable development for Africa lies in equitable, innovative, and people-centered financing solutions. This also holds true for other regions, and country groups such as the LDCs. By combining multilateral efforts, systemic reforms, and strengthened regional cooperation, Africa can achieve its climate, energy, and development goals. International financing must align with Africa's unique contexts and priorities, empowering the continent to build a resilient, inclusive, and self-reliant future.

Conclusion

Africa has an unprecedented opportunity to leapfrog the dirty and obsolete energy systems of the past towards more modern, people-centred, decentralised renewable energy systems. This is also the path to a future where global warming is limited to below 1.5°C. This report has shown that developing a fully renewable energy system in Africa by 2050 is both technically feasible and economically desirable.

Investing in a 100% renewable energy system would be considerably cheaper than a business-as-usual approach to continued fossil fuel use, saving $3-5tn by 2050 (averaging approximately US$150 billion per year) and producing fuel cost savings of more than double (2.2x) the additional investment required to achieve 100% renewable energy.

Africa has large untapped potential for renewable energy, particularly solar, that could more than meet the continent's needs. Renewable energy development consistent with a 1.5°C warming limit requires installed capacity of about 3,500 GW by 2050, less than 1% of the technical potential. This would mostly come from solar photovoltaics (2,600 GW) and assumes that the continent continues on a path of sustainable industrialisation and growth, while electrifying and decarbonizing key sectors and activities including transport, buildings (heating/cooling), cooking and heavy industry.

Although Africa faces many structural challenges, it has two distinct advantages in reaching for a fully renewable energy future. First, as Africa's currently existing fossil fuel infrastructure is relatively small it can leapfrog directly into a renewable energy supply system without leaving a trail of stranded assets. New renewables capacity is the fastest and cheapest way for Africa to increase its energy supply to a per capita level similar to OECD countries.

Africa can achieve a fully renewable energy supply alongside improved living standards and universal energy access. We estimate that approximately 720 million Africans (around half of the total population) currently live over 10 km from existing transmission lines, most of whom lack affordable and reliable access to electricity. Building off-grid renewable generation and storage support should be prioritized to widen energy access. This can best be achieved by moving away from outmoded models based on centralised infrastructure, towards a more inclusive, people-centred energy system. This should emphasize cooperative approaches, including shared standards, innovative grid designs, and strategies for managing demand. Ownership models that engage producers and consumers alike can democratize access to energy, fostering social equity and economic opportunity.

A renewable energy transition will also accelerate job creation. 2.2 million extra jobs would be created by following a pathway towards a 100% renewable energy system. Business-as-usual would add around 3.2 million jobs in the energy sector (2.1 million

in renewables), whereas a full renewables transition would see 5.4 million additional energy sector jobs by 2050 – almost double the reference scenario.

The scope for African agency in achieving a renewable energy transition goal must not be underestimated. It should be integrated into a broader effort to grow African economies and achieve energy sovereignty through investing in sustainable industrialization. Prioritizing local manufacturing of renewable technologies allows African nations to move up the value chain, stimulates domestic economies, creating jobs, and strengthening the tax base while reducing reliance on foreign currencies. Pan-African collaboration to build regional markets would help to achieve economies of scale and ensure efficient access to critical resources, breaking the pattern of extractivism and securing for Africans a greater share of the economic benefits and employment opportunities of the energy transition.

While renewable energy development is by far the cheapest option to 2050, new financing mechanisms are needed to help meet the significant upfront investment costs in a context of limited access to finance. Feed-in tariffs and payment guarantees are tried and tested policy measures that can help to bridge the financing gap. Funding should come through a mix of domestic and international sources, with measures to expand domestic fiscal capacity, cancel debt and remove other barriers to ensuring that African countries have sufficient capacity to invest in a renewable energy transition. African governments should prioritize an economic model that actively seeks to avoid capital extraction and increase domestic tax revenues to help expand fiscal spending capacity over time. The remaining investment needs must be made possible through scaled up international public climate and development finance, in accordance with principles of equity and fair shares.

A 100% renewable energy future is not only possible but beneficial for Africa, protecting the environment while securing energy access and a truly sustainable path to development.



A 100% renewable energy future is not only possible but beneficial for Africa, protecting the environment while securing energy access and a truly sustainable path to development.

End notes

1 Teske, S. et al. (2025) Africa: Energy Development Plan to decarbonize the Continent, prepared by University Technology Sydney, Institute for Sustainable Futures. Forthcoming: https://www.powershiftafrica.org The 100% renewable energy scenario is referred to in that report as the AF-1.5°C scenario. A third Africa-Pledges (AF-Pledges) scenario is also presented in that report but excluded here for reasons of space. The AF-Pledges models what would happen if all national energy and climate targets made by governments, including net-zero goals, are met in full and on time.

2 Sokona et al. (2023) Just Transition: A Climate, Energy and Development Vision for Africa, https://www.powershiftafrica.org/publications/just-transition-a-climate-energy-and-development-vision-for-africa

3 Teske et al. (2025) https://www.powershiftafrica.org

4 For a more detailed description of this methodology, see Teske, S. et al. (2019). Methodology. In: Teske, S. (eds) Achieving the Paris Climate Agreement Goals Springer, https://doi.org/10.1007/978-3-030-05843-2_3

5 See the CSO Equity Review reports, https://www.equityreview.org, for a clear account of each country's 'fair share' and the need for international support from rich countries to African and other developing countries to enable the just transition.

6 For a more detailed account of cost projections see, Teske et al. (2025), pp.40-46 and Teske et al. (2019).

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