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Working Paper

Roadmap to Zero-Carbon Electrification of Africa by 2050:

The Green Energy Transition and the Role of the Natural Resource Sector (Minerals, Fossil Fuels, and Land)

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Prepared for the African Natural Resources Center of the African Development Bank[1]

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[1] The views in this working paper do not necessarily reflect the views of any organization, including the African Development Bank.
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Acronyms and Abbreviations

AC	Alternating current
AfDB	African Development Bank
ANRC	African Natural Resource Center
AU	African Union
AUC	African Union Commission
CCSI	Columbia Center on Sustainable Investment
CSP	Concentrated Solar Power
DC	Direct current
DFI	Development finance institution
DRC	Democratic Republic of Congo
ECOWAS	Economic Community of West African States
ESHIA	Environmental, social, and human rights impact assessment
EU	European Union
FPIC	Free, prior and informed consent
GEIDCO	Global Energy Interconnection Development and Cooperation Organization
HSGOC	Heads of State and Government Orientation Committee
IEA	International Energy Agency
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
LMCP	Last-Mile Connectivity Program
LUT	Lappeenranta-Lahti University of Technology

MapRE	Multi-Criteria Analysis for Planning Renewable Energy
MASEN	Moroccan Agency for Sustainable Energy
MDB	Multilateral development bank
MoU	Memorandum of Understanding
PICI	Presidential Infrastructure Champion Initiative
PPA	Power purchase agreement
PV	Photovoltaic
REC	Regional economic community
REmap	Renewable Energy Roadmaps program
SAPP	Southern African Power Pool
SDG	Sustainable Development Goal
SHS	Solar Home Systems
SDSN	Sustainable Development Solutions Network
SIEPAC	Central American Electrical Interconnection System
UHV	Ultra-high voltage
UN	United Nations
UNECA	United Nations Economic Commission for Africa
WAPP	West African Power Pool

Executive Summary

All Africans—whether living in urban or rural areas—need access to affordable, clean, efficient, reliable, climate-proof, and renewable energy for both residential and productive uses to achieve sustainable development objectives. This report sets out a comprehensive and actionable roadmap for Africa's zero-carbon energy transformation by 2050, with most advances achieved by 2030. Natural resource management in minerals, fossil fuels, and land sits at the core of the strategy.

The world is moving to decarbonization by 2050. This is the dominant geopolitical message of 2021, appearing, for example, in U.S. President Joe Biden's online summit with world leaders in April 2021 and in the new IEA Report on *Net Zero by 2050: A Roadmap for the Global Energy Sector*. Africa will be part of this global trend. Prospective oil and gas projects in Africa will no longer be pursued as overseas markets and financing will shrink. At the same time, Africa's vast renewable energy potential, in the solar and hydropower sectors especially, will engage increasingly bankable and highly attractive investments. In net terms, Africa has a huge amount to gain from a decisive build-up of renewable energy and the capacity to produce the minerals, hardware, and software of the new zero-carbon energy economy.

Starting from a simple and transparent model of the annual investment volumes needed to provide continent-wide access to electricity based on renewable sources (Section 2), the report addresses various imperatives and challenges regarding Africa's energy planning (Section 3) and financing (Section 4) and outlines recommendations for immediate implementation of the strategy from 2022 (Section 5).

There are four overarching ideas in our vision for Africa's energy future.

1. The world economy is truly going to decarbonize. The oil companies do not necessarily believe it today, but we are convinced that they will soon understand and act accordingly.[3] Many pending oil and gas projects in Africa will become un-bankable in the coming years as decarbonization proceeds.
2. Africa needs to frontload its investments in green electrification and digitalization. Our point is that Africa should borrow heavily, at very concessional rates, in order to build infrastructure and achieve other crucial SDGs (such as quality education for all children). Debt relief may also be helpful in increasing the fiscal space for green and digital investments.
3. The international community, guided by the African Union, should dramatically increase the capacity of the African Development Bank and other African banks to frontload investments in infrastructure.
4. Africa should use its vast continental resources (renewable energy, strategic minerals, biodiversity, and human skills) to develop African productive capacity at all points in the renewable energy supply chain, including a massive scaling up of strategic minerals mining and African supply chains for photovoltaics, electric batteries, hydrogen and other green fuels, electric vehicles (e.g., electric motorcycles), and digital services (e-education, e-health, e-payments, and others).

The main strategic recommendations are as follows:

1. Rapid socio-economic development in Africa will depend on the massive scaling-up of investment in three key areas: zero-carbon electrification, digital access, and education. These investments are necessary for, and supportive of, investments in other priorities, including transportation, water and sanitation, housing, and business development in general and in particular in the productive value chains of minerals *(Section 1)*.
2. Africa's scale-up of zero-carbon electrification should aim for 100% household coverage by 2030 in line with Sustainable Development Goal 7 (universal access to modern energy services), the United Nations Secretary-General's Roadmap for Digital Cooperation, and the African Union's Digitization Transformation Strategy, which will set it on track to achieve the African Union's Agenda 2063 *(Section 1)*.

[3] Even as we were finalizing this paper, three events were part of this rapid "learning." The Netherlands Supreme Court ordered Shell to cut its carbon emissions, including the scope 3 emissions of its hydrocarbon products. ExxonMobil's shareholders voted over management objections to place on the Board at least two directors committed to the company's decarbonization by 2050. Chevron's shareholders similarly voted to cut the company's scope 3 emissions.

3. Africa has very high stakes in pushing for the global success of stopping human-induced climate change. African countries should show a united front through continent-wide institutions, including the African Union and the African Development Bank, and urge developed and emerging economies to lead a rapid global transition to renewable energy and decarbonization. Africa's historical contribution to greenhouse gas emissions has been minuscule, and as such, the continent is incurring net damages from climate change that are hugely disproportionate to Africa's contribution. Africa has the right to receive significant international official financing for mitigating and adapting to climate change *(Sections 1, 3, and 4)*.
4. Investments in zero-carbon electrification (as well as digital access and education) should be frontloaded and supported by large-scale official concessional financing by development institutions (most importantly, the African Development Bank), private-sector investments, and debt relief where appropriate. *(Sections 2 and 4)*.
5. Urbanization will occur naturally as agricultural output per worker rises, which, in turn, will shift new jobs from agriculture to urban-based industry and services. African governments and continent-wide institutions should also promote urbanization as part of the overall African development strategy: it will dramatically lower the cost of providing electrification, digital access, education, and other services compared with rural areas while making cross-subsidization between urban and rural areas possible. However, existing and future slums associated with rapid urbanization could hinder these efficiency gains and, therefore, urbanization should be tackled with public policies for urban planning, housing, services, and jobs *(Sections 1 and 3)*.
6. Urbanization and education will accelerate Africa's demographic transition to lower mortality rates and lower fertility rates, which, in turn, will reduce the population growth rate and the youth dependency rate while increasing the proportion of the population at working age. The demographic transition will thereby create a "demographic dividend" of economic growth and poverty reduction *(Section 1)*.
7. The rapid scale-up of renewable energy will create millions of new jobs in Africa, directly through the construction of new energy facilities and indirectly through the jobs that electrification and digital access will induce. Africa should support its educational institutions to prepare the workforce for the new digital and renewable economy, leveraging the tremendous opportunities offered by digitization and stimulating a reverse talents diaspora *(Sections 1 and 3)*.
8. **Africa requires a vast increase in energy production and use, which should occur overwhelmingly through a massive increase in zero-carbon electricity from Africa's plentiful renewable energy sources**, including solar, hydropower, wind, and geothermal, with a complementary role for sustainable biomass and synthetic fuels (such as green hydrogen) in displacing fossil fuels. The three components of the proposed strategy for Africa's zero-carbon electrification are (1) centralized energy infrastructure, (2) decentralized energy infrastructure, and (3) the phase-out of fossil fuels on economic grounds *(Section 3)*. **Natural source management in minerals, fossil fuels, and land sits at the core of the strategy.**
9. **Centralized energy infrastructure** will be needed to meet the energy needs of urban populations, industrial users, and the transportation sector, whether directly (through electricity) or indirectly (through the production of synthetic fuels) *(Section 3.1)*.
    a. The trunk infrastructure will comprise mainly utility-scale solar, wind, and hydropower generation; smart electricity transmission and distribution networks through interconnection at national, regional, and international levels; and energy storage facilities *(Section 3.1.1)*.
    b. **Africa's zero-carbon energy transformation provides an opportunity for positive feedback loops between energy, mining, and industry**. The continent's mining sector tends to grow robustly, especially in the production of cobalt, copper, rare earth minerals, and other critical minerals for the renewable energy sectors. Mining, an energy-intensive activity, will provide anchor demand for a robust energy system. Nascent industries—such as the production of aluminum and cement—also tend to grow strongly and provide core demand for the scale-up of Africa's power sector. In turn, an increasingly robust energy system will support Africa's industrialization, including industrialization in markets that will further strengthen the zero-carbon energy system (e.g., the production of green hydrogen, the production and recycling of batteries, the making of solar panels and wind turbines, and the information and communications technology sector) *(Section 1 and Section 3.1.2)*.

c. **A prerequisite to this feedback loop, however, is an upgrade of the governance of the mineral sector and its value chain**, which includes a transparent and enforceable legal framework; a balanced, progressive, and administrable fiscal regime; and mechanisms to curb corruption and internalize social and environmental externalities by companies *(Section 3.1.2)*.

d. Other important elements of centralized energy infrastructure are increasingly digitized, strong, and flexible grids and networks of charging stations and other infrastructure needed for electric cargo vehicles to transport passengers and cargo *(Sections 3.1.3–3.1.5)*.

e. African governments must put in place high-quality electricity laws, policies, regulations, planning frameworks, and implementing institutions to ensure the social and environmental sustainability of renewable energy siting, the financial and operational health of power utilities, and the liberalization of the generation sector through the penetration of independent power producers *(Sections 3.1.6–3.1.7)*.

10. **Decentralized energy infrastructure** includes solar-based mini-grids and solar home systems for the continent's rural and other remote areas. They will be run by private companies. Economic, legal, and policy considerations in developing this component will include adopting a least-cost approach to mobilize the cost-effective technological solutions, ensuring energy justice through consultations, and ensuring the affordability and profitability of decentralized systems through the use of the appropriate regulatory and operational frameworks for the last-mile infrastructure *(Section 3.2)*.

11. Demand for land will increase as the climate changes and the roll-out of land-intensive climate and energy solutions accelerates. **Governments must undertake careful land-use and siting analyses that put people and the environment at the center** to avoid the uneven distribution of benefits and costs historically associated with large land-based projects. Consistent with the UN Sustainable Development Goals and states' human rights obligations, minimizing social, environmental, and human rights impacts is key to achieving successful project outcomes for all *(Sections 3.1.6 and 3.2.2)*.

12. Several African countries will continue to produce and export oil and gas by 2050. These export earnings are essential for Africa's growth and development. However, as the world transitions away from fossil fuels and toward zero-carbon energy, global prices for oil and gas are likely to remain low, opportunities for fossil fuel exports are likely to diminish, and more economic opportunities are likely to arise from the declining costs of zero-carbon energy. Besides scaling up investment in zero-carbon electrification, we strongly urge Africa to **phase out fossil fuel production and use by 2050, preparing for the decline in oil and gas export earnings and the global zero-carbon energy transition**. Africa's phase-out of fossil fuels will require action on several fronts, including the following *(Sections 1 and 3.3)*:

    a. Adopting legal and policy frameworks conducive to the phase-out of fossil fuels, with explicit energy transition strategies to provide market signals that Africa is determined to move away from fossil fuels in the long term.

    b. Structuring robust industrial and economic diversification policies so that Africa may secure a relevant role in zero-carbon energy markets (such as the production of green hydrogen and the production and recycling of batteries), ease its reliance on the collapsing fossil fuel industry, replace jobs lost, and ensure long-term government revenues.

    c. Redirecting oil and gas revenues toward diversification in the energy and industrial sectors that will support the zero-carbon transition while ensuring that the exploitation of remaining African fossil fuel resources provides meaningful development opportunities and a just transition for those dependent on the fossil fuel industry.

    d. Avoiding and minimizing locking in capital in coal, oil, and gas, as well as locking out zero-carbon alternatives: Africa should continue its operational fossil fuel production and exports on a diminishing basis. Investments in new hydrocarbons in Africa should be restricted to high-quality, low-cost reserves that can be profitably developed in the context of falling global demand and subdued prices, refraining from additional costly exploration and infrastructure expansions, particularly in coal and oil.

    e. Limiting investments in fossil gas and related infrastructure to those that minimize their LCOE, consistent with a phase-out by 2050.

f. Considering the potential role of green hydrogen and leveraging existing gas infrastructure to reduce stranded asset risks.

g. Removing USD 53.5 billion–worth of fossil fuel subsidies throughout the continent, investing instead in protecting vulnerable consumers and promoting zero-carbon energy infrastructure, research, and job training.

h. Repurposing national oil companies by redirecting their core activities toward the zero-carbon energy transition.

i. Cutting public financing for fossil fuel investment, making sure the lending policies of national and multilateral development banks and development finance institutions do not counter energy and climate policy goals.

13. The continent must also build local capabilities and operational means to progressively seed independence from foreign aid and shield against currency risk. In addition, they should not generate the power but rather orchestrate its generation, putting in place the necessary legal and regulatory frameworks for IPPs (including mini-grids, solar home systems, and large-scale units) and developing the core grid infrastructure. These efforts should target ministries of finance or planning and their capacity to prepare and plan for the investment, utilities and their capacity to run competitive auctions, ministries of mines and energy to leverage the vast mining sector investing in Africa as an anchor demand for investment, and the local financial sector (banks and institutional investors as well as the creation of a bond market) *(Section 4.2)*.

14. The African Development Bank should lead the overall financing effort, assisting African governments in this undertaking with *blended financing*, in which official financial institutions, especially the African Development Bank and other institutions, extend low-interest, long-term financing in conjunction with private-sector financing. The standards for blended financing should include capital adequacy provisions and other prudential standards for recipient entities seeking official financing for energy-sector scale-ups *(Section 4.1)*.

15. Africa-wide investments in renewable energy should be in the order of USD 136 billion per year, divided between power generation (USD 96 billion) and power transmission and distribution (USD 41 billion). While these are still rough numbers, they signal the approximate magnitudes that will be needed. Of the total outlays on the electricity system, roughly USD 377 billion, or 32% of the total between 2021 and 2030, should be for rural (off-grid) power generation, and USD 795 billion, or 68%, should be for urban and industrial (on-grid) power generation. Of the total new power generation, roughly 83% will be from solar power, 13% from hydropower, and 3% from wind power, reflecting the resource endowment of the continent. While significant, these new investments are affordable as they represent on average 2% of the continent's annual GDP. Taking the cost of the energy system for a household as measured by the Levelized Cost of Electricity, it represents 5% of annual GDP per capita. These findings, emerging from our simple and transparent model, represent rough estimates of the magnitude of investment needs, to be refined with deeper analysis *(Sections 2 and 4)*.

16. Africa's GDP can and should rise rapidly in the coming years, supported by frontloaded investments in energy, digital services, and education. We envision the growth of yearly GDP per capita between 2020 and 2050 at the following average rates: North Africa, 7%; Sub-Saharan Africa (other than the Republic of South Africa), 8.4%; and Republic of South Africa, 6%. **Because of rapid growth, Africa can absorb large amounts of low-interest, long-maturity debt in order to finance the rapid scale-up of power generation and power distribution** *(Section 4)*.

17. There is a need to increase annual climate finance mobilization for energy systems, from multilateral development banks as well as co-finance, by 10 to 20 times to achieve zero-carbon mass electrification by 2030. The African Development Bank should be the lead institution in Africa for supporting the large-scale financing of the renewable energy scale-up. For that reason, the African Development Bank's direct lending capacity for power generation and distribution should be scaled up to (at least) USD 20 billion per year. Other partner financing institutions (including the World Bank Group, the European Investment Bank, the Islamic Development Bank, the United States International Development Finance Corporation, the New Development Bank, the China Development Bank, and the Green Climate Fund) would be additional partners (*Sections 4.1.1–4.1.6*).

18. Though still covering a modest fraction of the continent's overall needs and potential, there are a few Africa-based large-scale energy development initiatives and projects worth monitoring closely for lessons learned to amplify and replicate the successful aspects of their design. Three case studies look into characteristics and success factors of the Desert to Power Initiative, the Lake Turkana project in Kenya, and the Benban Solar Park in Egypt (*Section 4.1.5*).

19. Key steps should be taken in 2022. We recommend that the African Development Bank, including the African Natural Resources Center, and the African Union convene a high-level international advisory group composed of the main institutions working on strategies for Africa's zero-carbon mass electrification leveraging integrated resource management. Such institutions include the International Energy Agency, the International Renewable Energy Agency, the Global Energy Interconnection Development and Cooperation Organization, the Lappeenranta-Lahti University of Technology, and the KTH Royal Institute of Technology, as well as the African Development Bank's Program for Infrastructure Development in Africa, the African Union's New Partnership for Africa's Development Agency, the infrastructure programs of the Regional Economic Communities, and the newly launched initiative by the United Nations Economic Commission for Africa, Team Energy.

20. With the support of this international group, the African Union and the African Development Bank, including the African Natural Resources Center, should undertake the following strategic planning tasks in the coming year:

    a. Drawing up a continental timeline and strategy to phase out fossil fuels and redirect national and international resources and incentives to zero-carbon energy investment while ensuring that current fossil fuel exploitation serves African countries' development needs.

    b. Setting up a working group to update the Africa Mining Vision in light of the opportunities offered by the energy transition. At its core should be skill development policies to seize the rising opportunities of the localization of value chains; the operating principles of shared use of mining-related infrastructure, in particular in zero-carbon electricity; and the importance of good governance to avoid missing the windfall of the energy transition for Africa's critical minerals.

    c. Assessing the skills to be developed throughout the continent to seize the opportunities of the energy transition.

    d. Identifying regional priority projects of the trunk infrastructure of the continent, namely, the utility-scale renewable energy projects (solar, hydro, wind, and geothermal) and the regional, continental, and international interconnections.

    e. Identifying the remaining steps to reform regional power pools.

    f. Developing principles of financing and bankability combining concessional finance, political risk, default, currency guarantees, and private capital, building on successful cases.

    g. Crafting a strategy to strengthen the planning, monitoring, and procurement capabilities of African utilities and support their financial and operational health.

    h. Drafting Africa-wide norms and standards on the siting policy for renewable energy and land-based solutions and codifying how to conduct genuine consultation processes in energy investment.

    i. Upgrading the policy and legal frameworks related to investment in information and communications technologies; investment by independent power producers in large-scale, mini-grid, or stand-alone generation; local bank lending to infrastructure projects; standards on electric vehicle charging stations; and standards on importing used internal combustion engine vehicles.

    j. Developing country-specific affordability analyses to understand what commercial models and subsidy levels to promote for under-the-grid and off-grid communities.

    k. Develop a communication program on the advantages of renewable energy solutions for the broad African citizenry.

1. Introduction: A Vision for Africa's Energy and Economic Development

The United Nations' (UN) Sustainable Development Goal (SDG) 7,[4] to be achieved by 2030, includes targets to "ensure universal access to affordable, reliable, and modern energy services" and "increase substantially the share of renewable energy in the global energy mix."[5] The African Union's (AU) Agenda 2063 commits AU member states to speed up actions to build the energy infrastructure needed, "harnessing all African energy resources to ensure modern, efficient, reliable, cost-effective, renewable, and environmentally friendly energy to all African households, businesses, industries, and institutions."[6] The African Development Bank's (AfDB) High 5s set as development priorities for the Bank to "Light up and Power Africa; Feed Africa; Industrialize Africa; Integrate Africa; and Improve the Quality of Life for the People of Africa."[7]

Rapid socio-economic development in Africa will depend on the massive scaling-up of investment in three key areas: zero-carbon[8] electrification, digital access, and education. These investments are necessary for, and supportive of, investments in other priorities, including transportation, agriculture, water and sanitation, housing, and business development.

Electrification is a fundamental input to development. For far too long, much of Africa has lacked reliable access to electricity. This has been a major hindrance to development. Yet because of climate change, electrification will become even more important. Most new automobiles sold worldwide after 2030 will be electric vehicles (EVs), making access to electricity even more essential than in the past. Moreover, the world will increasingly require green (zero-carbon) electricity as part of the global transition to zero greenhouse gas (GHG) emissions by 2050. Africa, like the rest of the world, will be expected to have a power grid based on zero-carbon energy.

Achieving these goals and bringing zero-carbon electricity to every African is well within reach. Africa has a very high endowment of zero-carbon energy sources: tremendous solar technical potential spread throughout the continent[9] and considerable hydropower, wind, geothermal, and other sources, varying by region. Africa can achieve a high share of renewables in the continent's final energy consumption during 2030-2040, assuming a massive investment in the coming decade,[10] and increase that share to nearly 100% by 2050. Considering the ineluctable global transition to zero-carbon energy systems, Africa can reduce its domestic reliance on fossil fuels by 2030 and ultimately eliminate it by 2050. While achieving the goal of continent-wide electricity access by 2030 may initially mean low-level energy services[11] for many Africans living in rural areas, the level of these services will then improve across Africa by 2050 to meet growing energy use per person.

Four structural changes will shape Africa's energy transition and rising energy use:

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[4] With ramifications to many other SDGs (such as SDGs 6, 8, 10, 9, 13, 14, and 15).

[5] "Goal 7," Sustainable Development, United Nations Department of Economic and Social Affairs, 2020, *https://sdgs.un.org/goals/goal7*.

[6] African Union Commission, *Agenda 2063: The Africa We Want* (Addis Ababa: African Union Commission, 2015), 16, *https://au.int/sites/default/files/documents/36204-doc-agenda2063_popular_version_en.pdf*.

[7] "The High 5s," African Development Bank Group, African Development Bank, 2021, *https://www.afdb.org/en/high5s*.

[8] Throughout this report, we use the term "zero-carbon" rather than "low-carbon" to convey a higher decarbonization ambition through renewables-based electrification, even though acknowledging that "zero" may, in practice, mean "near-zero" or "net-zero." We note that the Intergovernmental Panel on Climate Change (IPCC) does not appear to define "zero-carbon energy" and "low-carbon energy" separately, merely noting: "Zero- and low-carbon energy supply includes renewables, nuclear energy and fossil energy with carbon dioxide capture and storage (CCS) or bioenergy with CCS (BECCS)." Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)] (Geneva: IPCC, 2014), 23, *https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf*.

[9] "Global Solar Atlas 2.0," Solargis, World Bank, 2020, *https://solargis.com/maps-and-gis-data/download*.

[10] International Renewable Energy Agency (IRENA), *Scaling up Renewable Energy Deployment in Africa: Impact of IRENA's Engagement* (Masdar City: IRENA, January 2019), *https://www.irena.org/-/media/Files/IRENA/Agency/Regional-Group/Africa/IRENA_Africa_impact_2019.pdf*.

[11] E.g., 365 kWh per capita per year, which is the target consumption for 2030 used in our model.

- **Urbanization**: The share of the population that is urban is expected to reach around 59% by 2050, up from 43% in 2020.[12] This increase is a result of both a significant rise in agricultural productivity and the promotion of urbanization as part of the overall African development strategy. Higher urbanization will greatly lower the unit costs of providing energy services and will facilitate electrification throughout the economy.
- **Demographic Transition**: Africa will experience a decline in the fertility rate[13] and mortality rate,[14] accelerated by urbanization and education, which will slow down the population growth rate while increasing the proportion of the population at working age, creating a demographic dividend of economic growth and poverty reduction.[15]
- **Industrialization**: Industry's share of GDP will rise,[16] supported by massive digital access and a skilled workforce prepared to seize the new digital and renewable economy opportunities.
- **Economic growth**: Annual growth in per capita GDP should reach at least 7% per decade, thereby doubling per capita income each decade (see Table 1). This growth rate is comparable to that achieved by China during 1980–2020 and should be based on the same principles of China's super-charged growth rate: high rates of investment in infrastructure, education, and business capital.

1.1. Africa's Energy Transformation Through Renewables-Based Electrification

To support this growing energy demand cost-effectively, we envision an energy transformation strategy for Africa that entails a rapid build-up of the renewable power supply and the replacement of fossil fuels in power, transport, and industry with zero-carbon electricity (to the extent possible) or with renewable and synthetic fuels. Higher levels of electrification will also result in energy efficiency gains across Africa.[17] Our focus on access to electricity rests on the assumption that, **by 2050, economy-wide energy demand—from households and the productive sector, including industry, transport, buildings, and cooking—will be overwhelmingly met with renewables-based electricity, and renewable and synthetic fuels will supply any remaining fuel demand, displacing fossil fuel use.**

During the period to 2050, several African countries will continue to be hydrocarbon exporters to world markets. These export earnings are essential for Africa's growth and development to 2050. Yet, we strongly urge that Africa prepare for a decline in these hydrocarbon export earnings as the entire world shifts to renewable energy. The first

[12] "World Urbanization Prospects 2018," United Nations Department of Economic and Social Affairs: Population Dynamics, United Nations, *https://population.un.org/wup*.

[13] Declining trend in sub-Saharan Africa since 2010: "Fertility rate, total (births per woman) – Sub-Saharan Africa," The World Bank, World Bank Group, 2019, *https://data.worldbank.org/indicator/SP.DYN.TFRT.IN?end=2019&locations=ZG&start=2010*.

[14] Declining trend in sub-Saharan Africa since 2010 for all mortality indicators, for instance infant mortality here: "Mortality rate, infant (per 1,000 live births) – Sub-Saharan Africa," The World Bank, World Bank Group, 2019, *https://data.worldbank.org/indicator/SP.DYN.IMRT.IN?end=2019&locations=ZG&start=2010*. This trend might be reversed for a couple of years in some countries due to Covid-2019 although overall Africa is less hit than other continents. See Yakubu Lawal, "Africa's low COVID-19 mortality rate: A paradox?," *International Journal of Infectious Diseases* 102, 2021: 118-122, ISSN 1201-9712, *https://www.sciencedirect.com/science/article/pii/S1201971220322426*.

[15] Covid-19 has undone gains in poverty reductions in many areas but in the longer term poverty will reduce. African Development Bank (AfDB), *African Economic Outlook 2021: From Debt Resolution to Growth: The Road Ahead for Africa* (AfDB, 2021), *https://www.afdb.org/en/knowledge/publications/african-economic-outlook*.

[16] "Industry (including construction), value added (% of GDP) - Middle East & North Africa (excluding high income)," The World Bank, World Bank Group, 2020, *https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?locations=XQ*; "Industry (including construction), value added (% of GDP) - Sub-Saharan Africa," The World Bank, World Bank Group, 2020, *https://data.worldbank.org/indicator/NV.IND.TOTL.ZS?locations=ZG*.

[17] According to research by the Lappeenranta-Lahti University of Technology (LUT): "The massive gain in energy efficiency is primarily due to a high level of electrification of more than 93% in 2050, saving nearly 7200 TWh compared to the continuation of current practices (low electrification)." LUT University and Energy Watch Group, *Global Energy System Based on 100% Renewable Energy: Power, Heat, Transport and Desalination Sectors,* (Lappeenranta, April 2019), 102, *http://energywatchgroup.org/wp-content/uploads/EWG_LUT_100RE_All_Sectors_Global_Report_2019.pdf*.

In addition to electrification, the IEA's Africa case includes strong energy efficiency policies when it comes to fuel economy standards for cars and two/three-wheelers (largely absent today), industrial processes, building codes, and home for appliances and cooling systems. Electrification and strong efficiency standards enable growth to be 4 times higher in the Africa case than in the Stated policies scenario while having a lower level of energy use. International Energy Agency (IEA), *Africa Energy Outlook 2019* (Paris: IEA, November 2019), *https://www.iea.org/reports/africa-energy-outlook-2019*.

six months of 2021 brought new evidence attesting to this impending global shift, such as U.S. President Joe Biden's online summit with world leaders in April 2021[18] and the May 2021 IEA Report on *Net Zero by 2050: A Roadmap for the Global Energy Sector.*[19] The beginning of 2021 also saw three other landmark events in May 2021 affecting oil companies: The Netherlands Supreme Court ordered Shell to cut its carbon emissions (including the scope 3 emissions of its hydrocarbon products),[20] ExxonMobil's shareholders voted over management objections to place on the Board at least two directors committed to the company's decarbonization by 2050,[21] and Chevron's shareholders similarly voted to cut the company's scope 3 emissions.[22]

The world prices for oil and gas are likely to remain low, and the opportunities for exports are likely to diminish, not to increase. Thus, we are arguing for a transformation built around three components: (1) an Africa-wide energy system based on renewable energy (solar, wind, hydro, geothermal, biomass); (2) a continuation of hydrocarbon exports on a diminishing basis; and (3) preparation for the global transition to renewable energy, including at least some opportunities for Africa to export green (zero-carbon) power and green hydrogen (hydrogen produced with green power) to Europe over long-distance transmission across the Mediterranean.

For Africa's growing **industry**, the shift toward zero-carbon electrification will mean increased reliance on grid-based power generated by zero-carbon sources and a diminishing reliance on off-grid diesel power. Africa's mining sector will be a key user of grid-based renewable power. The mining sector will grow robustly in future years, especially in the production of cobalt, copper, rare earth minerals, and other critical minerals for the energy transition. Mining will therefore provide a core demand for the scale-up of Africa's power sector. Other industries—metallurgy, batteries, solar PV, wind turbines—will also experience strong growth in the coming years, becoming major users of the expanded grid. This is also true for the telecommunications and Internet sectors. In short, the renewable power sector will provide the vital electricity for the expansion of African industry, and African industry will ensure the core market for expanded energy services (see Section 3.1.2).

Planning for continent-wide access to electricity across Africa must also entail mass electrification of **transport** in both urban and rural contexts. Starting with cities with existing grid connections, Africa must plan to electrify its fleets of light-duty vehicles—including two and three-wheelers, cars, utility vehicles, and small trucks—using renewable power sources and taking advantage of both improvements in range, cost, and market share of electric vehicles (EVs) as well as recent and expected achievements in battery technologies. For heavy-duty trucks, decarbonization efforts will focus on a range of options currently being explored, including battery EVs, green hydrogen, biofuels, and even electric long-distance highways using overhead lines to power trucks.[23]

The rapid scale-up of renewable energy will create millions of new, qualified **jobs** in Africa, including direct jobs through the construction of new energy facilities, indirect jobs along the electricity value chain, and induced jobs resulting from electrification and digital access[24] (further discussed below in Sections 3.1.2 and 3.3.5). African educational institutions should prepare the workforce for the new digital and renewable economy.

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[18] The While House, "President Biden Invites 40 World Leaders to Leaders Summit on Climate," Press release (March 26, 2021), *https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/26/president-biden-invites-40-world-leaders-to-leaders-summit-on-climate/f*.

[19] International Energy Agency (IEA), *Net Zero by 2050* (Paris: IEA, 2021), *https://www.iea.org/reports/net-zero-by-2050*.

[20] BBC News, "Shell: Netherlands Court Orders Oil Giant to Cut Emissions" (May 26, 2021), *https://www.bbc.com/news/world-europe-57257982*.

[21] Steven Mufson, "A Bad Day for Big Oil," *The Washington Post*, May 26, 2021, *https://www.washingtonpost.com/climate-environment/2021/05/26/exxonmobil-rebel-shareholders-win-board-seats*.

[22] Sergio Chapa and Caroline Hyde, "Chevron Investors Back Climate Proposal in Rebuke to C-Suite," *Bloomberg Green*, May 26, 2021, *https://www.bloomberg.com/news/articles/2021-05-26/chevron-investors-back-climate-proposal-in-rebuke-to-management*.

[23] International Renewable Energy Agency (IRENA), *Global Renewables Outlook: Energy Transformation 2050 (*Abu Dhabi, 2020), 183, *https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Apr/IRENA_Global_Renewables_Outlook_2020.pdf*.

[24] International Renewable Energy Agency (IRENA), *Global Renewables Outlook*, 100 et seq.

Pursuing this vision, and based on extensive policy analysis,[25] we set out a comprehensive and actionable roadmap for African governments—with coordination efforts by the AU and the AfDB and support from other stakeholders—to drive **Africa's zero-carbon energy development**. Starting from a simple and transparent model of the investment volumes needed for Africa to achieve zero-carbon continent-wide electrification by 2050 (Section 2), we address various imperatives and challenges regarding Africa's energy planning (Section 3) and financing (Section 4) and outline recommendations to implement the strategy starting from 2021 (Section 5).

[25] Superb recent analyses of Africa's energy prospects by the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the Global Energy Interconnection Development and Cooperation Organization (GEIDCO), the Lappeenranta-Lahti University of Technology (LUT), and other institutions have informed this report.

2. A Simple and Illustrative Model of Investment Needs

We deploy a simple and illustrative model of African electrification to illustrate the rough magnitudes involved between 2021 and 2050. Our purpose is not precision; that can best be achieved in further detailed engineering studies. Our purpose is to illustrate the general scale of energy use that should be targeted and assess the affordability of the transformation deemed necessary for the continent. We divide Africa into three geographic zones—North Africa, the Republic of South Africa, and Sub-Saharan Africa (not including the Republic of South Africa)—and consider the urban and rural sectors in each region, thus describing energy use in six regions:

- NA-U: North Africa – Urban
- NA-R: North Africa – Rural
- RSA-U: Republic of South Africa – Urban
- RSA-R: Republic of South Africa – Rural
- SSA-U: Sub-Saharan Africa (without the Republic of South Africa) – Urban
- SSA-R: Sub-Saharan Africa (without the Republic of South Africa) – Rural

For each of these groupings, we set reasonable normative targets for economic growth and electricity consumption for 2030 and 2050. Our assumption is for rapid economic growth to mid-century (Table 1), with a corresponding rapid increase in electricity consumption per capita (Table 2). We believe that Africa should aim for and plan for roughly 7% growth per annum in per capita GDP, an achievable rate that would close a significant part of the income gap with the rest of the world. The basis for such rapid growth is high investments in infrastructure, education, and business capital.

Table 1: Growth in GDP per capita by decade, 2020 to 2050 (USD in constant 2020 prices)

	2020	2030	2040	2050
NA-U				
GDP per capita	3,699	7,444	13,645	22,337
Annual growth over the previous decade		7%	6%	5%
NA-R				
GDP per capita	1,849	4,287	8,890	16,016
Annual growth over the previous decade		9%	8%	6%
RSA-U				
GDP per capita	7,431	12,974	21,003	31,219
Annual growth over the previous decade		6%	5%	4%
RSA-R				
GDP per capita	2,477	5,410	10,650	18,427
Annual growth over the previous decade		8%	7%	6%
SSA-U				
GDP per capita	2,158	4,848	9,781	17,248
Annual growth over the previous decade		8%	7%	6%
SSA-R				
GDP per capita	719	2,021	4,960	10,181
Annual growth over the previous decade		11%	9%	7%

Table 2: Electricity consumption targets by grouping, 2030 and 2050

	2019 – Baseline	2030		2050	
Groupings	**Consumption Level** (kWh per capita per year)	**Consumption Level** (kWh per capita per year)	**Service Level**	**Consumption Level** (kWh per capita per year)	**Service Level** (see note under the table)
NA-U	1,938	2,993	Level 5	4,000	European average today
NA-R	530	1,241	Level 4	2,993	Level 5
RSA-U	4,270	5,100	Similar to Spanish average today	6,400	Russian average today
RSA-R	1,908	2,993	Level 5	4,000	European average today
SSA-U	408	1,241	Level 3	2,993	Level 5
SSA-R	66	365	Level 4	1,241	Level 4

Source: Prepared by the authors on levels of electricity consumption per capita deemed sensibly achievable for each region. Note: See Figure 9 for explanations on service levels.[26]

Based on these normative targets for 2030 and 2050, we build an annual linear progression of electricity consumption per capita starting from the 2019 baseline.[27] Using UN population estimates, we calculate the total consumption time series by 2050. The time series also includes total generation, calculated based on the assumption of power transmission and distribution losses at 15%,[28] as well as installed capacity, assuming a renewable energy blended capacity factor of 30%.

[26] Level 3: Daily consumption per capita: Minimum 1000 Wh; Level 4: Daily consumption per capita: Minimum 3400 Wh; Level 5: Daily consumption per capita: Minimum 8200 Wh.

[27] For the 2019 baseline, we used IEA data on electricity consumption at country level and then applied a rough split of 4 to 1 between urban consumption and rural consumption. Source for this assumption: Manfred Hafner, Simone Tagliapietra, and Lucia de Strasser, "The Challenge of Energy Access in Africa," in *Energy in Africa*, SpringerBriefs in Energy (Springer, Cham, 2018), *https://doi.org/10.1007/978-3-319-92219-5_1*.

[28] Assuming a fixed percentage for the period, with that being an average rate from system losses dropping linearly from 25% to 10% by 2050.

Based on the time series of installed capacity, we calculate the installed capacity that will need to be added every year. We assume that all new installed capacity will be based on renewables; we also assume that the allocation of the new installed capacity to different types of renewables will reflect the energy potential[29] of each geodemographic grouping. To simplify, we assume the same breakdown between renewables throughout the time series (see Table 3).

Table 3: Breakdown of renewable energies for each grouping

Groupings	Utility-scale solar	Decentralized solar	Hydro	Onshore wind	Offshore wind	Geothermal	Biomass
NA-U	91%			5%	3%		1%
NA-R		100%					
RSA-U	85%		4%	5%	5%		1%
RSA-R		100%					
SSA-U + 55% of SSA – R (considered on-grid)	74%		21%	3%		1%	1%
45% of SSA-R		100%					
Share of the Africa-wide potential used by 2050, considering existing renewable plants and the development of new renewable plants as per our model	20% of solar potential		74% of hydro potential	97% of wind potential		99% of geothermal potential	19% of sustainable biomass potential

Source: Prepared by the authors based the rough breakdown of renewable potential between sources of each region.

[29] The renewable energy potential of the continent is provided by the AfDB ("Light Up and Power Africa – The New Deal on Energy for Africa," African Development Bank Group, African Development Bank, *https://www.afdb.org/en/the-high-5/light-up-and-power-africa-%E2%80%93-a-new-deal-on-energy-for-africa*) and the broad view of the potential for each geodemographic region by: Sebastian Hermann, Asami Miketa, and Nicolas Fichaux, "Estimating the Renewable Energy Potential in Africa: A GIS-based approach," (IRENA-KTH working paper, Abu Dhabi: International Renewable Energy Agency (IRENA)), 2014), *https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2014/IRENA_Africa_Resource_Potential_Aug2014.pdf*; and International Energy Agency (IEA), *Africa Energy Outlook 2019*.

Each stock of new installed capacity is multiplied by a unit installation cost that includes a surcharge for batteries of 15%.[30] For grid infrastructure, we leveraged existing studies anticipating regional interconnections to estimate the surcharge, setting it at 30% of total cost.[31] The installation cost of solar, wind, and geothermal is divided by 1.5 in 2030 and again by 1.5 in 2050; [32] the installation cost of hydropower and biomass remains constant. We also assume that the mostly-fossil-fuel-based current installed capacity will have a useful life of 40 years and that the new installed capacity will not be replaced before its economic end of life in 2050.

On this basis, we estimate the annual investment needs for the whole electric system, which over the period averages USD 136 billion per year (in 2019 dollars), divided between power generation (USD 96 billion) and power transmission and distribution (USD 41 billion). Accordingly, to enable Africa to achieve SDG 7 by 2030 and set it on track to achieve Agenda 2063, USD 4.22 trillion (in 2019 dollars) must be invested by 2050. Of the total outlays on the power system, roughly USD 377 billion, or 32% of the total between 2021 and 2030, should be for rural (off-grid) power generation, and USD 795 billion, or 68%, should be for urban and industrial (on-grid) power generation. Of the total new power generation, roughly 83% will be from solar power, 13% from hydropower, and 3% from wind power.

We note that our estimate is higher than GEIDCO's (USD 90.6 billion per year) and IEA's (USD 120 billion per year). The main reason for differing from IEA's and GEIDCO's estimates is the level of electricity consumption that we consider that the various groupings within the continent should sensibly reach in 2030 and 2050. We reach an average level of consumption per capita for the continent in 2050 that is similar to that of Europe in 2020, whereas GEIDCO and IEA anticipate an average level of consumption per capita that is not enough to power home appliances such as a fridge in 2050 (assuming single-person households).

Our model also considers the extent to which these investment needs are affordable for the continent. While significant, these new investments are affordable as they represent on average 2% of the continent's annual GDP.

Moreover, we analyzed if these investments are affordable for the average household. Based on the energy mix for the new installed capacity mentioned above and on the current energy mix, which is based on fossil fuels, we assess a yearly cost of the system, taking into account the cost of the existing system and that corresponding to the new investment. The cost is established by multiplying the yearly LCOE by the yearly generation. The LCOE of each energy source takes into account installation costs, fixed and variable operating costs, and a hurdle rate corresponding to a concessional financing rate of 5% per year. The LCOE of the new investments (including grid and storage), exclusively based on renewables and assuming low-cost financing, remains low over the period, hovering between USD 0.09 per kWh (2020) and USD 0.04 per kWh (2050).

The yearly cost of the system is then divided by the yearly population to assess the per capita cost of the system. To estimate the affordability of the assumed electricity consumption per household, we then compare the per capita electricity costs with GDP per capita, assuming the growth rates of 7% for North Africa; 8.4% for Sub-Saharan Africa (other than the Republic of South Africa); and 6% for the Republic of South Africa.

We find that the assumed electricity costs, measured at the LCOE per kWh, averages around 5% of GDP per capita, a reasonable and affordable sum for energy outlays. Of course, the ultimate affordability depends on the availability of large-scale financing at low cost, as we emphasize throughout this report.

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[30] Estimate based on International Renewable Energy Agency (IRENA), *Utility-Scale Batteries: Innovation Landscape Brief* (Abu Dhabi: IRENA, 2019), *https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Sep/IRENA_Utility-scale-batteries_2019.pdf*.

[31] The Transformation Scenario of IRENA sets the grid cost at 18% of total cost (International Renewable Energy Agency (IRENA), *Global Renewables Outlook*) and GEIDCO sets it at 46% (Global Energy Interconnection Development and Co-operation Organization (GEIDCO), *Africa Energy Interconnection Planning Research Report* (Beijing: GEIDCO, 2018)).

[32] The sharp decline in cost of solar, wind and geothermal is in line with forecast by IRENA: International Renewable Energy Agency (IRENA), *Future of Solar Photovoltaic: Deployment, Investment, Technology, Grid Integration and Socio-Economic Aspects* (Abu Dhabi: IRENA, 2019), *https://irena.org/-/media/Files/IRENA/Agency/Publication/2019/Nov/IRENA_Future_of_Solar_PV_2019.pdf*; International Renewable Energy Agency (IRENA), *Electricity Storage and Renewables: Costs and Markets to 2030* (Abu Dhabi: IRENA, 2017), *https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Oct/IRENA_Electricity_Storage_Costs_2017.pdf*; International Renewable Energy Agency (IRENA), *Geothermal Power; Technology Brief* (Abu Dhabi: IRENA, 2017), *https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Aug/IRENA_Geothermal_Power_2017.pdf*.

3. Energy Planning Strategy

3.1. Centralized Energy Infrastructure

Africa must build the energy trunk infrastructure made of large, utility-scale hydropower, solar, and other large, utility-scale generation projects, synchronous regional power pools, and a high-voltage DC grid connecting these pools. While developing the trunk infrastructure will take the upcoming three decades to 2050, some tasks should be realized within the next five years:

- Developing all policies and action plans at the national level to implement the African Union's February 2020 Digital Transformation Strategy.
- Strengthening and starting the digitization of national grids and making the fossil fuel-based grid compatible with renewable energy.
- Preparing for the development of charging stations for electric cars and public transportation.
- Clarifying and strengthening the rules governing land-intensive investments in renewable energies in national investment laws and international instruments such as the Investment Protocol to the African Continental Free Trade Area Agreement (AfCFTA) under negotiation.
- Reestablishing the financial and operational health of utilities.

3.1.1. The Trunk Infrastructure

Grid interconnection in Africa is needed for several reasons. One is that while private investment in generation is booming, with Independent Power Producer (IPP) capacity doubling every five years since 1995, in the absence of parallel investment in the national and international grid, many projects are experiencing off-taker risks because either countries can't absorb the proposed capacity (by some estimates, Ethiopia, Kenya, Rwanda, Tanzania, and Uganda could together face overcapacity of 2,689 MW by 2022 and IPPs have been put on hold in Ghana and Kenya)[33] or the sole potential off-taker is the financially-ill utility.[34]

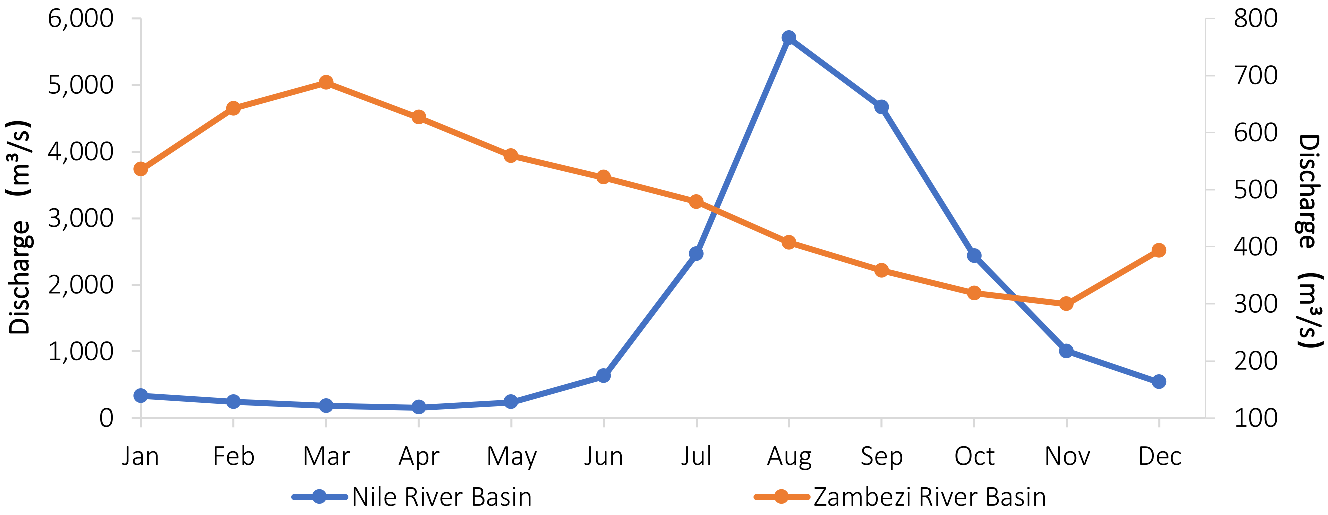
Another reason that grid interconnection is needed is that it enables the complementarity of renewable energy sources with different profiles (see Figure 1) and improves the stability of the energy supply. While these reasons have always been true, climate change adds one more reason. Some hydropower-rich countries will suffer from underperformance while others will over-perform; collaboration through interconnection between hydropower countries, solar- or wind-rich countries, and hydropower countries can mitigate inequality caused by climate change.[35]

[33] Benjamin Attia, "Big Solar Bankability & Utility Performance Can Benefit from Power Pools," *Energy For Growth Hub*, September 22, 2019, *https://www.energyforgrowth.org/memo/big-solar-bankability-utility-performance-can-benefit-from-power-pools*; Benjamin Xornam Glover, "400 MW Wind Power Project Stalls," *Graphic Online*, July 20, 2020, *https://www.graphic.com.gh/news/general-news/400mw-wind-power-project-stalls.html*.

[34] Green Climate Fund (GCF), "Desert to Power G5 Sahel Facility," (concept note, GCF, October 5, 2020), *https://www.greenclimate.fund/sites/default/files/document/25180-afdb-desert-power.pdf*. "A public–private partnership called Africa GreenCo is acting as a credit-worthy renewable energy intermediary, buying power from IPPs, and hedging the default risk of selling to utilities by selling on the SAPP market (in addition to selling to private off-takers)." "Our Mission," GreenCo: Africa GreenCo Group, 2021, *https://africagreenco.com/about-us*.

[35] "Country-specific data show that climate change will have significant impacts on most African countries, although the patterns of change may vary from one country to the other. For example, the hydropower capacity factor in Morocco, Zambia, Zimbabwe, the Democratic Republic of Congo, and Mozambique are projected to decline considerably, while the decrease would be offset by an increase in the hydropower capacity of the Nile basin countries, notably Egypt, Sudan, and Kenya." "Climate Impacts on African Hydropower," International Energy Agency (IEA), 2020, *https://www.iea.org/reports/climate-impacts-on-african-hydropower*.

Figure 1: Complementarity of water discharge between the Zambezi and Nile River Basins



Source: Global Energy Interconnection Development and Cooperation Organization (GEIDCO).[36]

Interconnection also leverages the comparative advantage of each region in large-scale energy potential through economies of scale (such as the Grand Inga project and the Desert to Power initiative). Once this interconnection is built, the transformation of the energy production system towards 100% renewable energy can happen faster and more cost-effectively. For instance, Angola, Burundi, the Democratic Republic of Congo (DRC), and Rwanda lack sufficient high-quality wind resources, while some of their neighboring countries (Namibia, Tanzania, and Zambia) have wind resources that exceed their projected demand.[37] Instead of developing unreliable and expensive wind generation sources, countries lacking resources would buy from countries with excess capacity under functioning power pools.

According to SAPP, interconnection in the Southern African region will lead to savings in generation and transmission infrastructure of USD 1.6 billion per year,[38] while savings could reach USD 5 to 8 billion per year in the WAPP according to the World Bank.[39]

When the interconnection is over long distances, the optimization is even higher. Therefore, the roadmap should likely include the progressive construction of asynchronous long-distance high-voltage DC links connecting the AC regional power grids, as proposed by the Chinese NGO and think-tank, GEIDCO. An Ultra High Voltage (UHV) grid that would enable the cost-effective transmission of very high-power capacity (up to 10 GW) over longer distances with low losses should be actively considered as it will enable Africa to leverage load centers or excess energy in Europe and West Asia (Arabian Peninsula) to stabilize its grid.[40]

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[36] Global Energy Interconnection Development and Co-operation Organization (GEIDCO), *Africa Energy Interconnection Planning Research Report*.

[37] Lawrence Berkeley National Laboratory (LBNL), "MapRe: Multi-criteria Analysis for Planning Renewable Energy," Berkeley Lab: MapRE Multi-criteria Analysis for Planning Renewable Energy, U.S. Department of Energy and University of California, Berkeley, *https://mapre.lbl.gov*.

[38] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

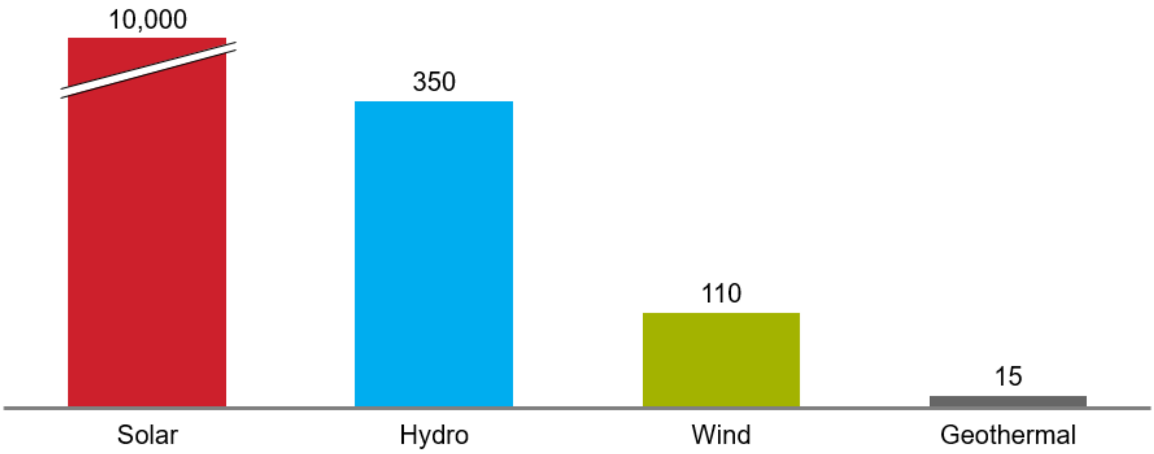
[39] World Bank, "Regional Power Trade in West Africa Offers Promise of Affordable, Reliable Electricity," *The World Bank News,* April 20, 2018, *https://www.worldbank.org/en/news/feature/2018/04/20/regional-power-trade-west-africa-offers-promise-affordable-reliable-electricity*.

[40] Global Energy Interconnection Development and Co-operation Organization (GEIDCO), *Africa Energy Interconnection Planning Research Report.*

Interestingly, with strong interconnection links, GEIDCO anticipates an installed capacity of 1130 GW in 2050;[41] without taking interconnection into account, LUT anticipates that Africa would reach 3059 GW of installed capacity by 2050 while recognizing that interconnection would lower this amount. [42]

An interconnection system would, therefore, enable Africa to tap into the full renewable energy potential of the continent (see Figure 2).

Figure 2: Africa's estimated renewable energy resources, GW



Source: African Development Bank (AfDB).[43]

This continental-scale system would entail connecting the following potential developments in large-scale renewable energy:

- Main hydropower bases (above 2 GW) in the basins of the Congo (Central Africa), Nile (East Africa), Niger (West Africa), and Zambezi Rivers (Southern Africa).
- High-irradiation areas suitable for large-scale solar power (above 50 GW) in the Sahara Desert (North Africa), the Atlantic coastal areas in Southern Africa, and some inland areas in East Africa.
- Main areas suitable for wind development (above 10 GW) in the coastal regions of North Africa, East Africa, and Southern Africa (Algeria, Egypt, South Africa, Somalia, and Sudan), with the best offshore wind energy potential located off the coasts of Angola, Madagascar, Mozambique, South Africa, and Tanzania.[44]
- Geothermal power in the East Africa Rift System.

The International Renewable Energy Agency's (IRENA) Renewable Energy Roadmaps (REmap) program could usefully refine the exact mapping of the renewable energy potential in each country, [45] while the Multi-Criteria Analysis for Planning Renewable Energy (MapRE) initiative could help balance sustainability considerations with energy potential considerations (see further discussion in Section 3.1.6 below).

3.1.2. Feedback Loop Between Mining, Industrialization, and Energy Development

Load centers that already exist through mining activities in West Africa, Central Africa, and Southern Africa and high urbanization in North Africa will make large-scale power generation and long-distance interconnection viable. With the industrialization of the continent through more intensive agriculture, light industry, and some heavy industry, as

[41] Global Energy Interconnection Development and Co-operation Organization (GEIDCO), *Africa Energy Interconnection Planning Research Report.*

[42] LUT University and Energy Watch Group, *Global Energy System Based on 100% Renewable Energy*.

[43] "Light Up and Power Africa — The New Deal on Energy for Africa," African Development Bank Group, African Development Bank, *https://www.afdb.org/en/the-high-5/light-up-and-power-africa-%E2%80%93-a-new-deal-on-energy-for-africa*.

[44] Hermann, Miketa, and Fichaux, "Estimating the Renewable Energy Potential in Africa: A GIS-Based Approach."

[45] "Remap – Renewable Energy Roadmaps," International Renewable Energy Agency (IRENA), IRENA, *https://www.irena.org/remap*.

well urbanization (bringing higher incomes, lower connection costs, and more home appliances and cooling systems), the load centers will become more widespread, enabling the further deployment of the trunk infrastructure. As GEIDCO expresses, the co-development model of “electricity-mining-metallurgy-manufacturing-trade” can effectively solve the dilemma of large hydropower development (such as the Grand Inga dam) or any other utility-scale development or grid extension that has not appeared bankable for any actor, MDB, DFI, or private over time.

Cleaning the Governance of the Mining Sector as a Pre-requisite

Table 4 presents estimates of the percentages of world reserves of critical minerals found in African countries, along with the 2050 projected annual demand of those minerals from energy technologies as a percentage of their production in 2018. Though African governments should read these demand projections prudently and not as grounds for overly optimistic expectations and plans,[46] the demand for critical minerals for the global zero-carbon energy transition in the coming decades tends to boost mining activities in resource-rich African countries.

Table 4: Percentage of world reserves of critical minerals in Africa and projected demand increase

	Percentage of world reserves											
Mineral / Country	DR Congo	Gabon	Ghana	Guinea	Madagascar	Morocco	Mozambique	South Africa	Tanzania	Zambia	Zimbabwe	2050 projected global annual demand from energy technologies as percent of 2018 global annual production
Aluminum (bauxite)				**24.7**								9%
Chromium								**35.1**				1%
Cobalt	**50.7**				1.4	0.2		0.5				460%
Copper	2.2									2.4		7%
Graphite					8.1		7.8		5.3			494%
Iron ore								0.1				1%
Lithium											1.0	488%
Manganese		4.7	1.0					**40.0**				4%
Titanium					3.1		3.5	5.6				0%
Vanadium								**15.9**				189%

Source: Prepared by the authors based on World Bank data on 2050 projected annual demand for 17 critical minerals,[47] and on USGS data on global reserves.[48] Note: USGS MCS 2021 did not list African countries with reserves of indium, lead, molybdenum, neodymium, nickel, silver, or zinc.

[46] Perrine Toledano, Martin Dietrich Brauch, Solina Kennedy, and Howard Mann, *Don’t Throw Caution to the Wind: In the Green Energy Transition: Not All Critical Minerals Will Be Goldmines* (New York: CCSI, May 2020), *https://ccsi.columbia.edu/sites/default/files/content/docs/Dont%20Throw%20Caution%20to%20the%20Wind_0.pdf*.

[47] Kirsten Hund, Daniele La Porta, Thao P. Fabregas, Tim Laing, and John Drexhage, *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition* (Washington, DC: World Bank Group, 2020), *http://pubdocs.worldbank.org/en/961711588875536384/Minerals-for-Climate-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf*.

[48] U.S. Geological Survey (USGS) and U.S. Department of the Interior, *Mineral Commodity Summaries 2021* (Reston: U.S. Geological Survey, January 2021), *https://pubs.usgs.gov/periodicals/mcs2021/mcs2021.pdf*.

In this context of opportunities, countries must significantly improve mining sector governance. A predictable, durable, and equitable legal framework, implemented by strong institutions, is the foundation of a mutually beneficial, thriving mining sector that can support further industrialization. "When the rules for compan[ies], government[s], and citizens are widely known, investments can operate smoothly, governments can manage them effectively, and citizens can monitor how the benefits of the investment—fiscal and non-fiscal—are allocated."[49] Africa's mineral resources can and should generate substantial fiscal revenues to expand state budgets, necessary for the provision of essential public services to Africans, including zero-carbon electrification and industrialization. Since mineral resources are non-renewable, they should be translated into long-lasting public investments through a fair and transparent collection of revenues. Moreover, countries and the private sector should leverage mining for upskilling the workforce through stringent training requirements and partnerships with local institutions[50] and developing energy and other types of infrastructure, as discussed below.[51] In light of the automation of mines, local content requirements should shift away from targets for local procurement and employment toward targets for training in transferable skills and infrastructure development.[52]

The expected rise in mineral demand, including in so far underexploited minerals, gives Africa a second chance to get the governance right. While governments are responsible for the appropriate administration over the mining sector, company behavior can undermine their objectives. African governments should accordingly select international companies that are ready to act as corporate citizens in their countries and support the achievement of the SDGs rather than undermining them.[53] The Democratic Republic of Congo (DRC), where at least 50% of the world reserves of much-needed cobalt are located, is a case in point (see Box 1).

Box 1: The DRC's journey toward reaping the benefits of cobalt for its communities

Cobalt is a critical mineral for electric car batteries, computers, and cell phones, and the demand for cobalt from batteries is expected to grow by a factor of four by 2030.[54] This could represent an incredible windfall for the DRC, given that the country's cobalt production makes up more than 63% of global production.[55] However, since the boom has started, the DRC has failed to reap its benefits and is still one of the poorest countries. It ranks 176 out of 188 countries in the most recent Human Development Report, and 77% of its population lives below the poverty line.[56] But the situation might yet change due to recently reformed policies.

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[49] Lisa Sachs and Perrine Toledano, with Susan Maples, *Resource-Based Sustainable Development in the Lower Zambezi Basin: A Draft for Consultation* (Columbia Center on Sustainable Investment (CCSI), June 2011), *https://ccsi.columbia.edu/sites/default/files/content/docs/publications/zambezi.pdf*.

[50] Nicolas Maennling and Perrine Toledano, *Linkages to the Mining Sector in Colombia* (Columbia Center on Sustainable Investment (CCSI), Ministry of Mines and Energy of the Republic of Colombia, and GIZ, October 2019), *https://ccsi.columbia.edu/sites/default/files/content/docs/publications/Linkages-to-the-mining-sector-in-Colombia-CCSI-2019.pdf*.

[51] "Leveraging Mining-Related Infrastructure Investments for Development (Rails, Port, Power, Water and ICT)," Columbia Center on Sustainable Investment, *http://ccsi.columbia.edu/work/projects/leveraging-infrastructure-investments-for-development*.

[52] Aaron Cosbey, Howard Mann, Nicolas Maennling, Perrine Toledano, Jeff Geipel, and Martin Dietrich Brauch, *Mining a Mirage? Reassessing the shared-value paradigm in light of the technological advances in the mining sector* (New York: Columbia Center on Sustainable Investment (CCSI) and International Institute for Sustainable Development (IISD), 2016), *https://ccsi.columbia.edu/sites/default/files/content/docs/publications/mining-a-mirage-CCSI-IISD-EWB-2016.pdf*.

[53] Columbia Center on Sustainable Investment (CCSI) and Responsible Mining Foundation (RMF), *Mining and the SDGs: A 2020 Status Update* (CCSI and RMF, September 2020), *https://www.responsibleminingfoundation.org/app/uploads/RMF_CCSI_Mining_and_SDGs_EN_Sept2020.pdf*.

[54] Martin Brudermüller, Benedikt Sobotka, and Dominic Waughray, *A Vision for a Sustainable Battery Value Chain in 2030: Unlocking the Full Potential to Power Sustainable Development and Climate Change Mitigation* (Geneva: Global Battery Alliance and World Economic Forum, September 2019), *http://www3.weforum.org/docs/WEF_A_Vision_for_a_Sustainable_Battery_Value_Chain_in_2030_Report.pdf*.

[55] "New Initiative to Support Artisanal Cobalt Mining in the DRC," *The Mining Review: Africa*, April 1, 2021, *https://www.miningreview.com/battery-metals/new-initiative-to-support-artisanal-cobalt-mining-in-the-drc*.

[56] Ben Radley, "The DRC Is Revisiting Its Mining Code. Why Reform Is Long Overdue," *The Conversation*, June 28, 2017, *https://theconversation.com/the-drc-is-revisiting-its-mining-code-why-reform-is-long-overdue-79937*.

The first problem has been that artisanal and small-scale mining (ASM) accounts for about 20% of the DRC's cobalt production and is interwoven with the cobalt supply chains.[57] This ASM activity has been associated with "child labor, fatal accidents, and violent clashes between artisanal miners and security personnel of large mining firms."[58] Tech companies have been denounced for overlooking human rights abuses in their supply chains, and Panasonic, Tesla's battery supplier, is researching how to avoid the use of cobalt in battery making.[59]

The second problem is that, until its 2018 reform, the DRC's 2002 mining code—prepared with guidance from the World Bank—aimed at attracting private investment into the mining sector following the 1996 and 2003 Congo Wars. To make the country attractive, the reform focused on a generous fiscal package. As a result, the 21% government take was well below the recommended average government tax by the World Bank (46%), and, between 2011 and 2014, total mining resource revenues for the state treasury were not more than 6% of the total revenues of the mining sector.[60] In addition, contracts—including their social and environmental clauses—were stabilized for ten years. Mining in the DRC was highly lucrative for multinationals, in particular, since, on top of the fiscal incentives, the geology is excellent and the operational cost is lower than the regional average.[61]

The DRC has decided to reform both aspects. In 2018, it promulgated the Revised Code amending the 2002 Mining Code and published the Revised Decree amending and supplementing the 2003 Mining Decree.[62] The 2018 amended mining code[63] stipulates many tax changes, including a 50% tax on "super profits"; an increase in state equity in new projects from 5% to 10%; an increase in royalties from 2% to 3.5% for non-ferrous metals and 10% for strategic minerals, including cobalt; and a reduction of stabilization clauses from ten years to five years, only applicable to fiscal terms.[64] Though multinational mining companies balked at the changes, they only bring the DRC back to the regional average. [65]

In addition, the Government of the DRC established the Entreprise Générale du Cobalt (EGC) in November 2019, and its first activities were officially launched in 2021. EGC will support "the commercialization of responsibly sourced artisanal cobalt [by establishing] safe and strictly controlled artisanal cobalt mining zones [following its] Responsible Sourcing Standards."[66] It will purchase all the country's ASM cobalt ore before taking responsibility for processing and marketing. To this end, EGC signed a trading agreement with Trafigura to finance and develop traceability

[57] "New Initiative to Support Artisanal Cobalt Mining in the DRC," *The Mining Review: Africa*.

[58] Dorothée Baumann-Pauly, "Why Cobalt Mining in the DRC Needs Urgent Attention," *Council on Foreign Relations* (blog), October 29, 2020, *https://www.cfr.org/blog/why-cobalt-mining-drc-needs-urgent-attention*.

[59] Anna Kucirkova, "The High Human Cost of Cobalt Mining," *The Mining Review: Africa*, January 7, 2019, *https://www.miningreview.com/top-stories/human-cost-cobalt-mining*.

[60] Ben Radley, "The DRC Is Revisiting Its Mining Code. Why Reform Is Long Overdue."

[61] Thomas Lassourd, David Manley, Jean-Pierre Okenda, and Amir Shafaie, *Sortir de l'mpasse fiscale : comment sauver la réforme du code minier en République Démocratique du Congo* (National Resource Governance Institute, September 2016) *https://resourcegovernance.org/sites/default/files/documents/nrgi-sortir-de-impasse-fiscale-rdc.pdf*.

[62] *The Mining Review: Africa*, "Unpacking the Revised and Annotated DRC Mining Code," September 1, 2020, *https://www.miningreview.com/gold/unpacking-the-revised-and-annotated-drc-mining-code*.

[63] Cabinet du Président de la République, *Loi n°18/001 du 09 mars 2018 modifiant et complétant la Loi n° 007/2002 du 11 juillet 2002 portant Code minier*, Exposé des motifs, Journal Official de la République Démocratique du Congo, March 28, 2018, *https://eiti.org/files/documents/j_o_ndeg_speicial_du_28_mars_2018_code_minier.pdf*.

[64] "The Democratic Republic of Congo's Revised Mining Code," Herbert Smith Freehills, April 25, 2018, *https://www.herbertsmithfreehills.com/the-democratic-republic-of-congos-revised-mining-code.*

[65] Ben Radley, "The DRC Is Revisiting Its Mining Code. Why Reform Is Long Overdue."

[66] Pact, "EGC Releases Responsible Sourcing Standard for Artisanal Cobalt from DRC," News release (March 31, 2021), *https://www.pactworld.org/news/egc-releases-responsible-sourcing-standard-artisanal-cobalt-drc*.

systems and identify industrial buyers. The NGO PACT[67] will be in charge of training stakeholders and ASM miners and monitoring the implementation of the EGC Standards to ensure the constant improvement of ASM conditions.[68]

Despite this considerable progress, the revised mining code could have done much more to curb corruption[69] and address mining's social and environmental externalities.[70] New regulations to support these matters are still needed.

Feedback Loop Between Mining and Energy Development

With falling ore grades and rising mineral demand induced by the energy transition, energy demand is expected to increase by 36% by 2035. Electricity demand is likely to grow at an even faster rate, given the trend toward electrification of mines.[71]

Over the years, African governments have not sufficiently taken advantage of the opportunity presented by energy-intensive mining operations to develop a robust energy system. For instance, in 2013, the World Bank[72] and CCSI[73] assessed that self-generation was the dominant power sourcing arrangement for years to come. In 2019, CCSI could only find few African case studies of mining projects integrating renewable energies outside of South Africa (see Box 2 on Burkina Faso).[74]

Box 2: Solar plant at mine sites in Burkina Faso

Iamgold's Essakane mine started operating in 2009 and is the largest known gold deposit in Burkina Faso with 2.65 million ounces of recoverable gold reserves and an expected 8.6-year mine life, which could extend past 2030 with further exploration. In March 2018, Iamgold commissioned a 15 MW solar project from solar IPPs Eren RE and Africa Energy Management Platform (AEMP)[75] that obtained a USD 16.5 million loan from BNP Paribas subsidiary Banque Internationale pour le Commerce, l'Industrie et l'Artisanat du Burkina. Iamgold entered into a 15-year power purchase agreement with the developers. The solar plant will connect with the mine's existing 57 MW diesel generators to cover up to 8% of the mine's energy needs. While the mine's motivation for the project stemmed from the desire to save on expensive fuel costs (6 million liters annually) and hedge against oil price volatility and supply risk, the mine and the Government of Burkina Faso also coordinated and together envisioned leaving the fully

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67 Ibid.

68 "Official Launch of Entreprise Générale Du Cobalt in the Democratic Republic of the Congo," Entreprise Générale Du Cobalt, March 31, 2021, *https://www.egcobalt-rdc.com/official-launch-of-entreprise-generale-du-cobalt-in-the-democratic-republic-of-the-congo*.

69 Global Witness, "Democratic Republic of Congo Plans to Water down Laws against Mining Corruption," Press release, (October 15, 2015), *https://www.globalwitness.org/en/press-releases/democratic-republic-congo-plans-water-down-laws-against-mining-corruption*; World Politics Review, "Congo's New Mining Code Opens the Door to Litigation and More Corruption," March 20, 2018, *https://www.worldpoliticsreview.com/trend-lines/24400/congo-s-new-mining-code-opens-the-door-to-litigation-and-more-corruption*.

70 "Propositions D'amendements de la Société Civile au Projet de Révision du Code Minier," *Congo Mines*, June 2017, *http ://congomines.org/reports/1247-propositions-d-amandements-de-la-societe-civile-au-projet-de-revision-du-code-minier*.

71 Nicolas Maennling and Perrine Toledano, *The Renewable Power of the Mine: Accelerating Renewable Energy Integration* (New York: CCSI, December 2018), 17, *https://ccsi.columbia.edu/sites/default/files/content/docs/publications/CCSI_2018_-_The_Renewable_Power_of_The_Mine__mr_.pdf*.

72 Sudeshna Ghosh Banerjee, Zayra Romo, Gary McMahon, Perrine Toledano, Peter Robinson, and Inés Pérez Arroyo, *The Power of the Mine: A Transformative Opportunity for Sub-Saharan Africa*, Directions in Development—Energy and Mining (Washington, DC: World Bank, 2015), *https://openknowledge.worldbank.org/handle/10986/21402*.

73 Perrine Toledano, Sophie Thomashausen, Nicolas Maennling, and Alpa Shah, *A Framework to Approach Shared Use of Mining-Related Infrastructure* (New York: CCSI, March 2014), *http://ccsi.columbia.edu/files/2014/05/A-Framework-for-Shared-use_March-2014.pdf*.

74 Maennling and Toledano, *The Renewable Power of the Mine*, 17.

75 AEMP is an Africa based renewable and hybrid independent Power Producer and equity investor in renewable energy

amortized project to the community post-closure. To enable such an arrangement, the closure and reclamation regulations need to be adjusted to exclude the power plant from the requirements to dismantle the mine's assets.[76]

Ministries of mines and energy should be aware that the lack of integration and co-development between the mining sector and renewable energy systems often results in missed opportunities.. "From the situation where mines have to self-generate due to a lack of or an unreliable national generation and transmission infrastructure to one where mines can source power from a large-scale grid, there exists the potential for mining companies to help develop the national power sector"[77] (see Figure 3).

Figure 3: Spectrum of power-sourcing arrangements for the mine

		Intermediate options						
	Self-supply	*Self-supply + CSR*	*Self-supply + sell to the grid*	*Grid supply + self-supply backup*	*Mines sell collectively to the grid*	*Mines invest in the grid*	*Mines serve as anchor demand for IPP*	*Grid supply*
Description	Mine produces its own power for its own needs	Mine provides power to community through mini-grids or off-grid solutions	Mine produces its own power and sells excess power to the grid	The mine is first connected to the grid and is moving into own-generation when more economical	Coordinated investment by a group of mines, producers, and users in one large power plant off-site connected to the grid	Mine invests with government in new, or in the upgrading of, power assets under different arrangements	Mine buys power from an IPP and serves as an anchor customer	Mine does not produce any power, but buys 100% from the grid

Source: World Bank.[78]

The model proposed by the World Bank is not new (see Figure 4), but not enough has yet been done. The ministries of mines and energy should immediately start to integrate the mining sector's power demand in broader energy planning as well as amend the legal framework for mining. The goal of these measures is to ensure that mines systematically adopt renewable energies to power their needs and enable sharing with the broader consumer base in the country. Sharing can happen through on-grid or off-grid solutions benefiting surrounding communities. Figure 4 presents the questions to address to ensure that the power demand of the mining sector is leveraged for broader development needs.

[76] Maennling and Toledano, *The Renewable Power of the Mine*, 37.

[77] Toledano et al., *A Framework to Approach Shared Use of Mining-Related Infrastructure*.

78 Banerjee et al., *The Power of the Mine*.

Figure 4: Guidance on questions to address for each power supply arrangement

Arrangement	Questions
Mines Supplies Communities	• Parties to be involved (government, utility, donors, NGOs)? • Responsibilities of each party? • Provisions for post-mine closure?
Mine Sells Excess Power to Grid	• Scope for coordination among mines? • Terms of the PPA between mine and utility company? • Quality of the utility? Are extra guarantees necessary? • Responsibility for transmission?
Mine Serves as Anchor for IPP	• Role of mine i.e. off-taker or joint venture partner? • Alignment of timing ? Provision for delays? • Terms of the PPA? • Quality of the utility/company? Extra guarantees necessary? • Responsibility for transmission of power?
Mine Sources Power from Grid	• Commercial arrangement for transmission infrastructure? • Ownership of transmission infrastructure? • Design for smaller users to tap into grid supply? • How to avoid saturation of the grid?

Source: Authors based on CCSI's A Framework to Approach Shared Use of Mining-Related Infrastructure.[79]

Box 3: Leveraging the mining sector to develop power infrastructure: examples

- In Ghana in 1966–1996, the Volta Aluminum Company Limited (VALCO) smelter was the anchor customer for the Akosombo Dam, which supplied most of the country's, as well as some of the neighboring countries', energy needs.[80]
- In the Lao People's Democratic Republic, in 2009, the Nam Theun II hydropower plant was designed with a capacity of 1070 MW with 995 MW dedicated for export to the Thai utility under a 25-year power purchase agreement and 75 MW allocated to domestic consumption. The revenue generated with a credit-worthy off-taker (the Thai utility) provided enough security to finance of the deal.[81]
- In 2015, in Australia, the Weipa Solar Plant was developed to serve the need of Rio Tinto and 20% of the demand of the township's daytime demand. Rio Tinto is in a 15-year PPA with the IPP First Solar.[82]

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[79] Extensive guidance is included in: Toledano et al., *Framework to Approach Shared Use of Mining-Related Infrastructure*.

[80] Banerjee et al., *The Power of the Mine.*

[81] Ibid.

[82] Maennling and Toledano, *The Renewable Power of the Mine,* 17.

The same logic mentioned above would apply to any existing pockets of energy-intensive industries (for example, large-scale cement and aluminum in West Africa, steel in Southern Africa,[83] and Internet exchange points in Kenya and Nigeria[84]) and mechanized agriculture.[85]

Upstream and Downstream Linkages from Mining and Energy Feedback Loop

Nascent or potential new industries could support energy development, which would, in turn, support industrialization. The African mining sector can anchor demand for energy infrastructure development and, at the same time, provide the mineral inputs needed for the manufacturing of zero-carbon energy technologies in the continent. These technologies can be used domestically to support the goal of continent-wide zero-carbon electrification or for export to strengthen African countries' industrial base, reduce their dependence on commodities, and improve their balance of payments. Opportunities exist in the production and recycling of batteries, the production of solar panels and wind turbines, and the production of green hydrogen, as discussed below.

Building on Africa's comparative advantage in critical mineral resources for the battery industry, the development of a strong battery sector in Africa would provide technologies to support Africa's zero-carbon electrification and, at the same time, benefit from the renewables-based electricity generated in the continent as a market outlet. Batteries will be essential in increasing solar and wind power reliability. The continent's own battery demand is forecast to increase from 2 GW in 2015 to 15 GW by 2030 based on extrapolations of current trends and could increase to more than 30 GW assuming continent-wide access to electricity by 2030.[86] Globally, battery demand is expected to increase more than nine times between 2020 and 2030, mostly due to the increased use of batteries for electric mobility. Thus, the growth of battery demand both within the continent and globally could represent an opportunity for investment in battery production and recycling in Africa.[87]

The same is true for the production of solar panels and wind turbines. The Integrated Energy Plan of South Africa interrogated the value chains of energy generation technologies. The report isolates those inputs available in South Africa and assesses the localization potential for those inputs not immediately available. They find a localization potential of 45% and 49%, respectively, for solar PV and wind.[88] They also assessed that it was relatively "easy" to localize the entire solar PV value chain, while only 3% of the wind value chain was likely to remain imported.[89] The Department of Trade and Industry in South Africa also released a wind energy localization roadmap and a PV localization roadmap.[90] Another study found that the local tower producers are more likely to enter the global value chain closer to the location of deployment, as towers are bulky and difficult to transport. Comparatively, since blades and nacelle components both require high technical skill, it may be challenging to switch their production location as well.[91] The participation of the continent in the production of solar panels is also visible outside of South Africa in

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[83] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[84] Joseph Cotterill, "Cabling Africa: The Great Data Race to Serve the 'Last Billion,'" *Financial Times,* January 30, 2021, *https://www.ft.com/content/adb1130e-2844-4051-b1df-a691fc8a19b8*.

[85] According to the UN, 12 African countries including Ethiopia, Malawi, Mali, Morocco, Rwanda, Tanzania, and Zambia are showing strong growth in mechanized agriculture. Busani Bafawa, "Mechanizing Agriculture Is Key To Food Security," *Africa Renewal*, April 9, 2019, *https://www.un.org/africarenewal/magazine/april-2019-july-2019/mechanizing-agriculture-key-food-security*.

[86] Brudermüller, Sobotka, and Waughray, *A Vision for a Sustainable Battery Value Chain in 2030*, 4.

[87] Ibid., 11.

[88] Department of Energy of the Republic of South Africa, "Integrated Energy Plan," *Staatskoerant*, November 25, 2016, *http://www.energy.gov.za/files/IEP/2016/Integrated-Energy-Plan-Report.pdf*.

[89] Tobias Bischof-Niemz and Terence Creamer, *South Africa's Energy Transition: A Roadmap to a Decarbonised, Low-Cost and Job-Rich Future*, 1st ed. (London: Routledge, 2018), *https://doi.org/10.4324/9780429463303*.

[90] Escience Associates, Urban-Econ Development Economists, and Chris Ahlfeldt, *Photovolaic Electricity: The Localization potential of Photovoltaics and a Strategy to Support the Large Scale Roll-out in South Africa* (2013), *https://resources.solarbusinesshub.com/images/reports/42.pdf*.

[91] Thomas Hebo Larsen and Ulrich Elmer Hansen, "Sustainable Industrialization in Africa: The Localization of Wind-Turbine Component Production in South Africa," *Innovation and Development* (January 27, 2020): 1–20, *https://doi.org/10.1080/2157930x.2020.1720937*.

Algeria, Egypt, Ethiopia, Kenya, Nigeria, Senegal, Ugandan, Tunisia, and Tanzania, with a total annual production capacity of around 650 MW across 20 assembly plants. Plants to make local wind-turbine components are also present outside of South Africa in Egypt, Kenya, Morocco. [92] The localization potential of the value chain is further induced by the rise in carbon costs that make fragmented global value chains, as currently operated, expensive because of the GHG emissions of transportation and waste.[93] This is another opportunity of the energy transition that provides industrialization opportunities.

Another example is the development of a green hydrogen market in Africa. Green hydrogen is hydrogen produced using renewable energy, typically through electrolysis (splitting H_2O into hydrogen and oxygen). The costs of producing green hydrogen are decreasing, and in North Africa, for example, they "are expected to be two to three times lower than in most of Europe or Japan." Leveraging both its renewable energy potential and its domestic fuel demand for transportation and industry, Africa could develop a strategy to produce green hydrogen. In exactly this way, for example, the Minerals Council in South Africa is advocating for a national hydrogen strategy, combined with the build-up of the South African platinum sector, to establish a domestic fuel cell industry.[94] South Africa's Department of Science and Technology (DST) developed the National Hydrogen and Fuel Cell Technologies Research, Development, and Innovation Strategy (Hydrogen South Africa, HySA) to support the development of the hydrogen and fuel cell value chain in the country.[95] In addition to stimulating the demand for minerals and metals, investment in green hydrogen can provide African countries opportunities to create jobs throughout the value chain, develop specialized skills, and reduce energy costs.[96] In addition to meeting domestic industrial and transportation needs, African countries producing green hydrogen could increasingly export it to meet growing global demand, particularly in Europe.[97] In fact, the EU's 2020 Hydrogen Strategy highlights Africa as a potential supplier of cost-competitive green hydrogen to the EU.[98]

In sum, current and future energy-intensive industries cannot survive in Africa without inexpensive and reliable power. At the same time, they can anchor demand to make the investment in inexpensive, clean, and reliable energy infrastructure viable. Mining can, in addition to constituting anchor demand, provide the necessary mineral inputs for low carbon technologies, provided that public policies are in place to guarantee good governance and high-quality education for workers.[99]

Africa can and should leverage both existing and nascent industries to make the energy system more robust; in turn, an increasingly stronger energy system will support faster industrialization, thus creating a feedback loop between

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[92] Ibid.

[93] Perrine Toledano, Martin Dietrich Brauch, Karan Bhuwalka, and Kojo Busia, *The Case for a Climate-Smart Update of the Africa Mining Vision* (New York: Columbia Center on Sustainable Investment (CCSI), April 2021), *https://ccsi.columbia.edu/sites/default/files/content/docs/The-Case-for-a-Climate-Smart-Update-of-the-African-Mining-Vision.pdf*.

[94] Halima Frost, "S Africa can lead Platinum-fueled Hydrogen Economy," *Creamer Media's Mining Weekly,* September 20, 2019, *https://www.miningweekly.com/article/s-africa-can-lead-platinum-fuelled-hydrogen-economy-2019-09-20-1*.

[95] "HySA Infrastructure: Hydrogen South Africa," *https://hysainfrastructure.com*; Martin Creamer, "Sasol Able to Produce Green Hydrogen within 24 Months – CEO," *Creamer Media's Engineering news,* June 17, 2021, *https://www.engineeringnews.co.za/article/sasol-able-to-produce-green-hydrogen-within-24-months-ceo-2021-06-17*.

[96] Jonathan Metcalfe, Le Riche Burger, and James Mackay, *Unlocking South Africa's Hydrogen Potential* (PwC, October 2020), *https://www.pwc.co.za/en/assets/pdf/unlocking-south-africas-hydrogen-potential.pdf*.

[97] International Energy Agency (IEA), *The Future of Hydrogen: Seizing Today's Opportunities* (Paris: IEA, June 2019), *https://www.iea.org/reports/the-future-of-hydrogen*; "Hydrogen could be a €120 Billion+ Industry in Europe by 2050, with Germany Emerging as one of the Most Favorable Markets for Electrolysis," Aurora Energy Research, November 3, 2020, *https://www.auroraer.com/insight/hydrogen-could-be-120-billion-industry-in-europe-by-2050*; IEA, "Global Hydrogen Demand by Sector in the Sustainable Development Scenario, 2019-2070" (Paris: IEA, Last updated September 9 2020), *https://www.iea.org/data-and-statistics/charts/global-hydrogen-demand-by-sector-in-the-sustainable-development-scenario-2019-2070*.

[98] European Commission, *Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions* (Brussels: European Commission, July 2020), *https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf*.

[99] "The Right Way for Africa to Promote Manufacturing: the Prospects Are Better than Previously Thought," *The Economist*, March 20, 2021, *https://www.economist.com/leaders/2021/03/20/the-right-way-for-africa-to-promote-manufacturing*.

industrialization and energy. Strategies should include revising the Africa Mining Vision in light of opportunities arising from climate change policy and the global energy transition.[100]

3.1.3. National Digitization Transformation Strategy

In February 2020, the AU released an ambitious yet feasible digitization transformation strategy for the continent aiming at building a Digital Single Market in Africa by 2030, equipping all people with safe and secure access to least 6 Mbps all the time at an affordable price, establishing and improving digital networks, implementing policies and regulations required to stimulate and accelerate digital transformation for national, regional, and continental development (such as local data protection regulations to encourage the formation of local data centers that enable internet speed[101]), among other goals.[102] Realizing this vision at a national and regional level is critical to modernizing the grid, as discussed below. Countries should embark on this mission immediately. Thanks to forward-looking ICT policies, Kenya is Sub-Saharan Africa's fastest-growing ICT market, with ICTs having increased productivity throughout the economy and contributing to raising Kenyans' standards of living,[103] thereby evidencing that AU's Digitization Transformation Strategy is feasible.

3.1.4. Strong, Flexible, and Digitized Grids

The construction, reinforcement, and upgrade of the transmission grid in parallel with, and in anticipation of, the build-up of generation is fundamental to decrease the risk of renewable energy investment. The Lake Turkana wind project in Kenya illustrates the difficulty of investing in a utility-scale project when the transmission infrastructure is not yet in place. Project commissioning, which was due at the end of 2017, was delayed by 15 months due to the prolonged construction of the 428-km transmission line to the power grid.[104] In 2017, the Kenyan government agreed to pay the wind farm developers EUR 46 million in capacity charges in compensation for the delay as well as a monthly surcharge to be passed on to consumers.[105]

Moreover, many national grids are not ready for renewable energy integration and are operating close to their voltage limit with frequent load-shedding, "thus lacking a uniform base-frequency which enables injection of solar power in a distributed manner."[106] Bringing the necessary upgrade will imply considering "several technical factors such as voltage variations, power plants reactions under faulted systems, interactions with protection systems, and the overall operational flexibility for dispatch centers."[107]

To this end, it is necessary to plan for a switch to digitization, enabling smart grids that integrate smart operation and control, multi-renewable energy complement, storage, contingency and flexibility reserves, and efficient utilization. Where the broadband network is sufficiently developed, this investment should be immediately undertaken for a full roll-out within five years. In countries where broadband deployment is still weak, digitization will take more time and should be prioritized. While this is a heavy lump-sum investment, it will deliver significant savings down the road (see Box 4).

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[100] Toledano et al., *The Case for a Climate-Smart Update of the Africa Mining Vision*.

[101] Cotterill, "Cabling Africa."

[102] African Union, *The Digital Transformation Strategy for Africa (2020 – 2030)* (Addis Ababa: African Union, May 2020), *https://au.int/sites/default/files/documents/38507-doc-dts-english.pdf*.

[103] International Trade Administration (ITA), "Kenya – Country Commercial Guide," International Trade Administration, last published September 13, 2020, *https://www.trade.gov/knowledge-product/kenya-information-communications-and-technology-ict*.

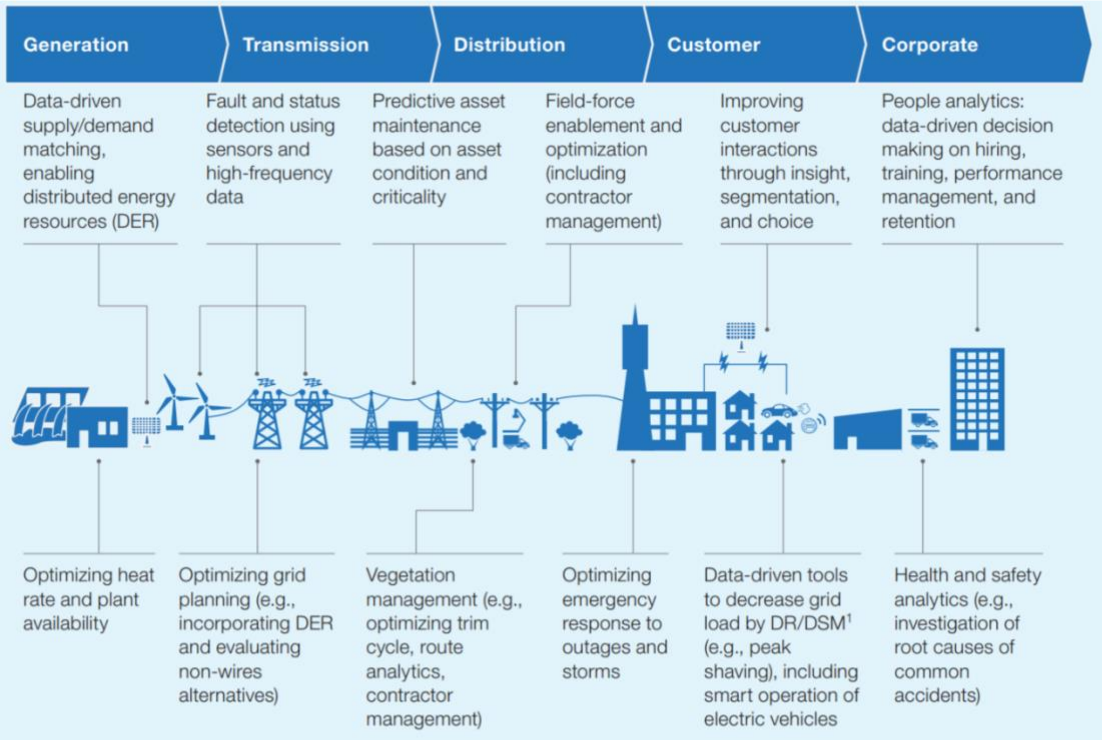
[104] Vaselina Petrova, "Google Backs out from Lake Turkana Wind Farm Stake Buy – Report," *Renewables Now,* February 11, 2020, *https://renewablesnow.com/news/google-backs-out-from-lake-turkana-wind-farm-stake-buy-report-686760*.

[105] Constant Munda, "Sh1.16bn Payment to Turkana Wind Power Averts Sovereign Default Crisis," *Business Daily,* June 24, 2019, *https://www.businessdailyafrica.com/news/payment-to-Turkana-Wind-Power-averts-sovereign/539546-5169434-68iw0xz/index.html*.

[106] Green Climate Fund (GCF), "Desert to Power G5 Sahel Facility."

[107] Ibid.

Box 4: Digitalization of the utility's value chain



Source: McKinsey.[108]

When it comes to storage, the combination of smart grids and interconnection will enable the regulation of supply and demand of power and help rationalize storage technologies, balancing out the intermittency of renewable energy.

LUT's energy model for Africa, which does not include the potential benefits of interconnection, provides an upper boundary on how much of the electricity demand should be covered by storage throughout 2050. Given the recent and upcoming massive cost reduction of battery technology (see Figure 17), LUT anticipates it as being the technology of choice for *electricity* storage (85% of the storage output by 2050) while thermal energy storage becomes the most prevalent *heat* storage technology with around 57% of heat storage output by 2050, following the expected drop in cost of Concentrated Solar Power (CSP) technology, which is already gaining ground in South Africa.[109]

Moreover, East Africa has the advantage of being endowed with strong solar and wind potential (as well as geothermal). Both interconnection and the hybridization of renewable energy load profiles within national borders will help the rationalization of investment in battery storage. For example, the construction of an 80 MW solar–wind–battery hybrid facility is expected to start in 2021 in Kenya. Signed with Australian and Japanese developers and costing USD 150 million, the project will have 20 wind turbines and 40,000 solar panels, in addition to sufficient battery capacity to store the latent energy for after-hour use. This project is significant as Africa's largest hybrid project to include battery storage in the project scope.[110] Similar opportunities should be carefully mapped out.

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[108] Marcus Braun, Eelco de Jong, Alfonso Encina, and Tim Kniker, *Fueling Utility Innovation Through Analytics* (McKinsey, June 2018), *https://www.mckinsey.com/~/media/McKinsey/Industries/Electric%20Power%20and%20Natural%20Gas/Our%20Insights/The%20Digital%20Utility/The%20Digital%20Utility.pdf*.

[109] Mordor Intelligence, "Africa Thermal Energy Storage Market – Growth Trends, COVID-19 Impact, and Forecasts" (Mordor Intelligence), *https://www.mordorintelligence.com/industry-reports/africa-thermal-energy-storage-market*.

[110] Cecilia Keating, "Africa's 'largest' solar-plus-wind-plus-storage project unveiled," *PV-Tech,* September 2, 2019, *https://www.pv-tech.org/news/largest-solar-plus-wind-plus-storage-project-in-africa-unveiled-in-japan*.

3.1.5. Preparation to Electrify Transportation

As discussed in Section 1, for light-duty vehicles (cars, sport-utility vehicles, and small trucks), the improvement of EVs in cost is such that the path forward is clear.[111] EVs will be in growing circulation in Africa within 10 years, especially if limits are put on the age of imported vehicles.[112] Half of the African countries do not currently place any restrictions on the import of used vehicles.[113] An Africa-wide policy to phase out ICEs and phase in EVs is therefore warranted. A master plan for charging stations should be developed along with the supporting policies needed to operationalize it. South Africa demonstrates a set of forward-looking policy tools that could be emulated.

Box 5: South Africa' strategy to develop EV charging stations

In 2013, South Africa set up the uYilo Programme within the Green Transport Strategy of the national Department of Transport to promote the introduction of electric and hybrid-electric vehicles. It brings together higher education institutions, science councils, and companies to accelerate the development of new technologies to support the flourishing of the EV industry in South Africa.[114] In 2014, a collaboration began between BMW, Nissan, the South African National Energy Development Institute (SANEDI), Gridcars (a private company), and the Technology Innovation Agency's uYilo e-mobility program to provide advice and recommendations on charging station standards. From this partnership, three main standards were enacted as regulations for EV charging within South Africa.[115]

As of 2019, there were 137 charging stations throughout South Africa, mainly dotted along major highways[116] and primarily supplied by international equipment manufacturers. To support the development of the local industry in charging station manufacturing, South Africa developed the uYilo Kick Start fund to make grants to local suppliers.[117]

The uYilo project also includes a smart grid facility to "provide a live-testing environment for electric vehicle fleets and the related infrastructure ecosystem." It tests technologies such as "solar EV charging, second-life EV battery storage systems, BackOffice management, AC charge points, DC fast chargers, and the leading Vehicle-to-Grid technology."[118]

3.1.6. Social and Environmental Sustainability of Renewable Energy Siting and Nature-Based Solutions for Climate Change Mitigation and Adaptation

Demand for land will increase as the climate changes and the roll-out of land-intensive climate and energy solutions accelerates. Indeed, renewables are estimated to be 15 to 500 times more land-intensive than fossil fuels.[119] As such, the construction of solar, hydropower, and wind projects, as well as the development of transmission infrastructure, could significantly impact ecosystems and nearby communities. Therefore, there is a need to review the rules

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[111] Price parity could be reached in 2026-2027. Nic Lutsey and Michael Nicholas, "Update on Electric Vehicle Costs in the United States Through 2030" (ICCT working paper 2019-06, The International Council on Clean Transportation (ICCT), April 2019), *https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf*.

[112] For instance, Egypt, South Africa, Sudan, and Morocco ban used vehicle imports; Gambia, Ghana, Mali, Cote d'Ivoire, and Cape Verde have adopted punitive taxation/ penalties for used vehicle imports beyond a certain age; Algeria imposes an internal consumption tax and Uganda an environmental levy. UN Environment, "Used Vehicles: A Global Overview," (UN Environment and UNECE, 2017), *https://unece.org/fileadmin/DAM/trans/doc/2017/itc/UNEP-ITC_Background_Paper-Used_Vehicle_Global_Overview.pdf*.

[113] UN Environment, "Used Vehicles: A Global Overview."

[114] "SA Unveils Funding Scheme to Drive EV Charging Infrastructure," *ESI Africa*, March 1, 2019, *https://www.esi-africa.com/news/sa-unveils-funding-scheme-to-drive-ev-charging-infrastructure*.

[115] Global Environment Facility (GEF), *Global Programme to Support Countries with the Shift to Electric Mobility Child Projects Annex – 2nd Phase* (GEF, 2020), *https://www.thegef.org/sites/default/files/web-documents/10544_CC_PFD_child_projects.pdf*.

[116] Sibahle Malinga, "Electric Vehicle Charging Station Map Goes Live," *ITWeb*, December 9, 2019, *https://www.itweb.co.za/content/WnxpE74DJQR7V8XL*.

[117] "SA Unveils Funding Scheme to Drive EV Charging Infrastructure," *ESI Africa*.

[118] Ibid.

[119] Maennling and Toledano, *The Renewable Power of the Mine,* 17.

governing land-intensive investment in renewable energies in national laws and international instruments, including the Investment Protocol to the African Continental Free Trade Area Agreement (AfCFTA) under negotiation, and update them if necessary.

Hydropower projects have long been mired in controversy due to their potential for disastrous impacts on people and the environment. In 2000 the World Commission on Dams estimated that in the preceding 50 years, 40 to 80 million people worldwide had been displaced due to dams.[120] Communities who live on or near lands affected by reservoir flooding are most acutely affected, though communities downstream from a project may also suffer detrimental impacts due to changes in river flow.[121] Hydropower projects may also result in biodiversity loss, deforestation, and harm to species in the reservoir area as well as species that live in or use rivers. While potentially avoiding some of the human impacts of large-scale hydro, smaller scale and run-of-river hydro projects are not guaranteed to result in less significant environmental impacts.[122]

More recently, wind projects have come into the spotlight due to land and human rights concerns.[123] In Kenya, the Kinangop Wind Park project was canceled due to land-related disputes,[124] and communities affected by the Lake Turkana Wind Power project sued the Government of Kenya over the lack of community participation in the land allocation process for the project.[125]

Similarly, solar parks in semi-arid regions of India and Egypt have affected grazing rights and increased water stress.[126]

These impacts have important implications for renewable energy project planning: governments must undertake careful land-use and siting analyses that put people and the environment at the center. Consistent with the UN SDGs and states' human rights obligations, minimizing social, environmental, and human rights impacts is key to achieving successful project outcomes. To avoid the uneven distribution of benefits and costs that have historically been associated with large development projects, governments should take several measures listed as follows.

Institutionalize Strategic Environmental Assessment (SEA). An SEA "informs planners, decision-makers, and affected public on the sustainability of strategic decisions, facilitates the search for the best alternative, and ensures a democratic decision-making process," thereby "enhance[ing] the credibility of decisions and lead[ing] to more cost-

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[120] Michelle Hay, Jamie Skinner and Andrew Norton, *Dam-Induced Displacement and Resettlement: A Literature Review* (FutureDAMS working paper 004, Manchester: University of Manchester, 2019), *https://hummedia.manchester.ac.uk/institutes/gdi/publications/workingpapers/futuredams/futuredams-working-paper-004-hay-skinner-notron.pdf*.

[121] Hay, Skinner, and Norton, *Dam-Induced Displacement and Resettlement*; Kwadwo Owusu, Alex Boakye Asiedu, Paul William Kojo Yankson, and Yaw Agyeman Boafo, "Impacts of Ghana's Bui Dam Hydroelectricity Project on the Livelihood of Downstream Non-Resettled Communities," *Journal of Sustainability Science* 14 (March 2019): 487–499, *https://doi.org/10.1007/s11625-018-0588-8*.

[122] IUCN Water, "The Future of Dams: Viable Options or Stranded Assets," International Union for Conservation of Nature (IUCN), assessed March 1, 2021, *https://digital.iucn.org/water/the-future-of-dams*; Jeff Opperman, "Crocodiles Are Not Geckos: The Realities Of Run-Of-River Hydropower," *Forbes,* June 6, 2019, *https://www.forbes.com/sites/jeffopperman/2019/06/06/crocodiles-are-not-geckos-the-realities-of-run-of-river-hydropower/?sh=77d41cdd6371#394718376371*.

[123] Soledad Mills, Sebastian Perez, and Josh Garett, *Defining and Addressing Community Opposition to Wind Development in Oaxaca* (case study, Equitable Origins, January 2016), *https://d2oc0ihd6a5bt.cloudfront.net/wp-content/uploads/sites/1738/2016/05/Equitable_Origin_Case_Study_Wind_Development_in_Oaxaca_JAN_2016_1.pdf*.

[124] "Kenya: Kinangop Wind Park Impacts Communities in Nyandarua," Business & Human Rights Resource Center, *https://old.business-humanrights.org/en/kenya-kinangop-wind-park-impacts-communities-in-nyandarua#*.

[125] Ilse Renkens, *The Impact of Renewable Energy Projects on Indigenous Communities in Kenya* (Denmark: International Work Group for Indigenous Affairs, December 2019), *https://www.iwgia.org/images/publications/new-publications/IWGIA_report_28_The_impact_of_renewable_energy_projects_on_Indigenous_communities_in_Kenya_Dec_2019.pdf*; Duncan E Omondi Gubam and Guyo Chepe Turi, "Kenya's ambitious wind turbines battle community land crosswinds," *ISS Today*, March 16, 2020, *https://issafrica.org/iss-today/kenyas-ambitious-wind-turbines-battle-community-land-crosswinds;* Zoe Cormack, "Kenya's huge wind power project might be great for the environment but not for local communities," *Quartz Africa,* September 3, 2019, *https://qz.com/africa/1700925/kenyas-huge-wind-power-project-in-turkana-hurts-local-people*; Danwatch, "Prostitution, alcoholism and a lawsuit on illegal land acquisition in the Lake Turkana Wind Power project," (Danwatch, 2016), *https://old.danwatch.dk/wp-content/uploads/2016/05/Danwatch_report_A-PEOPLE-IN-THE-WAY-OF-PROGRESS-2016_web.pdf*.

[126] Peter Fairley, "The Pros and Cons of the World's Biggest Solar Park," *IEEE Spectrum*, January, 22, 2020, *https://spectrum.ieee.org/energy/renewables/the-pros-and-cons-of-the-worlds-biggest-solar-park*.

and time-effective EIAs [Environmental Impact Assessments] at the project level."[127] An SEA process involves predicting and analyzing the potential direct, indirect, and cumulative negative and positive effects of the proposed project, minimizing direct, indirect, and cumulative negative social and environmental impacts to maximize positive impacts and opportunities, building the data collection capacity necessary to inform and monitor design and implementation, integrating the views of civil society, particularly affected communities, and enabling their influence in the development of plan and policies.[128] An SEA process makes it easier to envision and plan for sustainable siting and technology alternatives to reach a specific objective, such as equipping the country with large-scale power generation.

Identify and mitigate risks at the project level. Rigorous environmental, social, and human rights impact assessments (ESHIAs) should inform and influence siting and licensing decisions. These impact assessments must be produced by independent and credible experts, the findings should be consulted on widely with affected parties, and both the findings of the assessments and the consultations should inform and meaningfully influence government decision making. In addition, impacts, as well as the adherence to mitigation measures and management plans, must be continually and systematically monitored throughout a project's life cycle. Given that political realities may result in governments deprioritizing ESHIA results in their decision-making processes (see Box 6), civil society, financiers, and development partners have an important role in calling on governments to uphold rigorous ESHIA standards and always look for the most sustainable alternative when building infrastructure.

Box 6: The politics of ESHIAs: the Stiegler's Gorge Dam in Tanzania

The Tanzanian government's decision to move ahead with the controversial Stiegler's Gorge Dam demonstrates the importance of the timing and quality of impact assessments and the influence of those assessments on the ultimate decisions taken by governments. The environmental impact assessment that was carried out in the Stiegler's Gorge Dam case was deemed inadequate by independent reviewers, and despite the concerns raised by domestic and international actors over the dam's potential impact on fragile ecosystems, the government is moving ahead with a project expected to result in the deforestation of nearly 1000 km^2 of the Selous Game Reserve, a UNESCO World Heritage site.[129]

Recognize and respect legitimate tenure rights. The Africa-owned Guidelines on Large Scale Land Based Investments[130] and the Voluntary Guidelines on the Responsible Governance of Tenure both call on governments to respect the rights of legitimate tenure holders in the context of land-based investments. Without such recognition, the rights of people who do not have a formal title to land or whose rights may not be immediately visible (such as the rights of pastoralists) may not be accounted for in renewable energy project consultations and any resettlement planning and compensation process.

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[127] International Association for Impact Assessment (IAIA), "Strategic Environmental Assessment Performance Criteria," IAIA Special Publication Series 1 (IAIA, 2002), *https://iaia.org/uploads/pdf/sp1.pdf*.

[128] Perrine Toledano and Martin Dietrich Brauch, "Carajás Corridor in Brazil: Could an SEA Have Reconciled Shared-Use Infrastructure and Environmental Protection?" in Jonathan Hobbs and Diego Juffe-Bignoli, eds., *Impact Assessment for Corridors: From Infrastructure to Development Corridors* (Development Corridors Partnership, forthcoming 2021). See also: Organisation for Economic Cooperation and Development (OECD), *Applying Strategic Environmental Assessment: Good Practice Guidance for Development Cooperation*, DAC Guielines and Reference Series (OECD, 2006), 70, *https://www.oecd.org/environment/environment-development/37353858.pdf*.

[129] Mike Mwenda, "Tanzania to Build Stiegler's Gorge Dam in a Wildlife Reserve and Unesco Site," *Lifegate*, January 9, 2020, *https://www.lifegate.com/stieglers-gorge-dam-tanzania*; International Union for Conservation of Nature (IUCN), *Technical Review of the Environmental Impact Assessment for the Rufiji Hydropower Project in Selous Game Reserve, Tanzania* (Gland: International Union for Conservation of Nature, 2019), *https://portals.iucn.org/library/node/48425*; Patrick Mulyungi, "Tanzania to Commence Construction Stiegler's Gorge Hydropower Dam," *Construction Review Online,* May 2, 2019, *https://constructionreviewonline.com/news/tanzania/tanzania-to-commence-construction-stieglers-gorge-hydropower-dam*; Funmbuka Ng'wanakilala, "Tanzania Makes $310 Million Advance Payment for Dam on Heritage Site," *Reuters,* April 24, 2019, *https://www.reuters.com/article/us-tanzania-hydropower/tanzania-makes-310-million-advance-payment-for-dam-on-heritage-site-idUSKCN1S02BX*.

[130] Developed by the African Union, African Development Bank, and UN Economic Commission for Africa.

Consult affected communities and obtain their consent. Various conventions, decisions, and guidelines mandate participation by affected communities in decisions that affect them and their lands.[131] In the case of Indigenous communities, their free, prior and informed consent (FPIC) is required.[132] Integral to the concept of FPIC is the community's right to withhold consent to a project. In the context of large-scale energy projects that would have a major impact on Indigenous territories, and especially in situations involving relocation, absent the community's consent, the project should not go ahead.[133]

Avoid resettlement. Resettlement of communities for renewables projects should be avoided. A recent review of dam-induced resettlement literature concludes that "we are still collectively a long way off being able to devise effective approaches to resettlement that can achieve good outcomes."[134] Examples abound of poorly designed and executed resettlement plans. In some such examples, communities resettled in the context of Ethiopia's Grand Renaissance Dam have complained that they have been relocated to land with no access to natural water sources,[135] and communities resettled in the context of the Olkaria geothermal plant in Kenya have complained about the exclusion of women, orphans, and elders from compensation arrangements.[136]

Where strictly necessary, any resettlement should be conducted in accordance with all relevant laws, including human rights laws. At a fundamental level, a resettlement framework should require:

- Comprehensive, fair, and adequate compensation to be paid to restore the resettled individual or community to the same or better quality of land and living standards as prior to resettlement. Livelihood restoration should be a central goal.
- Close and regular consultation and collaboration with all segments of the affected community throughout the process, including to inform socio-economic baseline studies that assess the impacts of resettlement at the household level. This community involvement is important to ensure that resettlement plans are designed appropriately and with the benefit of community input and knowledge.

Given the potential externalities involved in developing large-scale energy projects, energy development planning should be accompanied by a siting framework that allows anticipation of possible:

- Land-use **requirements** of energy infrastructure with **maximization of co-location** between renewable energy sources to minimize land use for both generation and transmission
- Land-use **impacts** of energy infrastructure
- Land-use **constraints** on energy infrastructure.[137]

Tools are now being developed to assist energy planners and policymakers in this undertaking. For instance, the Africa Clean Energy Corridor (ACEC) is an IRENA initiative aiming to accelerate the expansion of renewable energy in the Eastern and Southern African power pools that was signed in January 2014 by nineteen Ministers of Energy and

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[131] African Union, African Convention on the Conservation of Nature and Natural Resources (Revised Version), art. XVI(1)(c), A.U. Doc. CAB/LEG/24.1 (July 11, 2003); Centre for Minority Rights Development (Kenya) and Minority Rights Group International on behalf of Endorois Welfare Council v Kenya, 276 / 2003; African Commission on Human and People's Rights, Resolution on a Human Rights-Based Approach to Natural Resources Governance, A.U. Doc. ACHPR/Res.224 (May 2, 2012); International Labor Organization (ILO), Indigenous and Tribal Peoples Convention, 1989 (No. 169); United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP); Guidelines on Responsible Land Based Investment; Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT); International Finance Corporation (IFC) Performance Standards.

[132] United Nations, General Assembly Human Rights Council, *Report of the Special Rapporteur on the rights of indigenous peoples, James Anaya,* UN Doc. A/HRC/24/41 (July 1, 2013), para. 24, 27, *https://www.ohchr.org/EN/HRBodies/HRC/RegularSessions/Session24/Documents/A-HRC-24-41_en.pdf*.

[133] United Nations, *United Nations Declaration on the Rights of Indigenous peoples*, (2007), art. 10, art. 29(2), *https://www.un.org/development/desa/indigenouspeoples/wp-content/uploads/sites/19/2018/11/UNDRIP_E_web.pdf*.

[134] Hay, Skinner, and Norton, *Dam-Induced Displacement and Resettlement*.

[135] Ibid.

[136] European Investment Bank Complaints Mechanism, *Initial Assessment Report Complaint SG/E/2014/07, Complaint SG/E/2014/08,* (2015), *https://www.eib.org/attachments/complaints/sg-e-2014-07-and-08-initial-assessment-report.pdf*.

[137] Grace C. Wu, *Spatial Planning of Low-Carbon Transitions* (Sustainable Development Solutions Network, 2020), *https://www.jstor.org/stable/resrep25836?seq=1#metadata_info_tab_contents*.

heads of delegations. ACEC developed an interactive interface to identify "cost-effective, equitable, and environmentally sustainable wind, solar [PV], [CSP], and geothermal energy zones to facilitate the planning effort of the initiative.[138] It leverages the multi-criteria analysis developed by the MapRE initiative, which includes environmental protection criteria in addition to the traditional planning criteria.[139] A more complete multi-criteria analysis would also include social criteria.

There is also the SAVi tool developed by the International Institute for Sustainable Development (IISD) to equip policy-makers and investors with an assessment of the costs of economic, social, and environmental risks as well as positive and negative externalities.[140] For hydropower, for instance, it includes various cost factors that are often ignored in traditional cost-benefit analyses and asset valuations, such as sediment transport, dredging needs, and costs associated with lost agriculture production and lost tourism opportunities.[141]

When implementing nature-based solutions (NBS) for climate change mitigation or adaptation, design and implement legal and policy safeguards so that the NBS benefit both people and the environment. The International Union for Conservation of Nature (IUCN) loosely defines nature-based solutions (NBS) as "actions to protect, sustainably manage, and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide both human well-being and biodiversity benefits."[142] NBS cover a range of interventions that include approaches to adapt to and mitigate climate change. There is a growing sentiment globally and on the continent support ingNBS:[143] the IPCC's report on Climate Change and Land considers the role of NBS in removing and storing carbon, for instance, and UNECA and the AfDB have championed the potential of NBS to respond to climate change and improve livelihoods on the continent.[144]

Despite support for NBS by key actors and institutions, some approaches that fall under this "umbrella concept"[145] are controversial. The IPCC Climate and Land report warns that some approaches to mitigation, applied on a large-scale, risk increasing competition for land, for instance. This includes afforestation, reforestation, and bioenergy with carbon capture and storage,[146] each of which may have serious implications for food security, land rights, biodiversity, and water security.[147] For example, afforestation efforts have, in some instances, resulted in the growth of low biodiversity value monoculture plantations that only capture a fraction of the carbon compared with natural

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[138] Lawrence Berkeley National Laboratory (LBNL), Africa Clean Energy Corridor (ACEC), and International Renewable Energy Agency (IRENA), "SEAREZ (Southern and Eastern Africa Renewable Energy Zones)," Berkeley Lab: MapRE Multi-criteria Analysis for Planning Renewable Energy, U.S. Department of Energy and University of California, Berkeley, *https://mapre.lbl.gov/rez/searez*.

[139] Lawrence Berkeley National Laboratory (LBNL), "What is MapRE?" Berkeley Lab: MapRE Multi-criteria Analysis for Planning Renewable Energy, U.S. Department of Energy and University of California, Berkeley, *https://mapre.lbl.gov*.

[140] "Sustainable Asset Valuation (SAVi)," International Institute for Sustainable Development (IISD), *https://www.iisd.org/projects/sustainable-asset-valuation-savi*.

[141] Laurin Wuennenberg and Qendresa Rugova, "Why Albania Should Shift Away from Hydropower and Preserve the Last Free-flowing River in Europe" (International Institute for Sustainable Development (IISD), Sustainable Asset Valuation (SAVi), and MAVA), *https://cf.iisd.net/savi/story/why-albania-should-shift-away-from-hydropower-and-preserve-the-last-free-flowing-river-in-europe*.

[142] International Union for Conservation of Nature (IUCN), "Nature-based Solutions," IUCN, *https://www.iucn.org/theme/nature-based-solutions/about#:~:text=Defining%20Nature%2Dbased%20Solutions,well%2Dbeing%20and%20biodiversity%20benefits*.

[143] Clarisse Marsac, Nathaniah Jacobs, and Tehtena Mebratu-Tsegaye, *COVID-19 and Land-based Investment: Changing Landscapes* (New York: Columbia Center on Sustainable Investment (CCSI) and International Institute for Environment and Development (IIED), May 2021), *https://ccsi.columbia.edu/sites/default/files/content/docs/publications/Covid-19%20and%20Land-based%20Investment%20-%20Changing%20Landscapes%20-%20FINAL.pdf*.

[144] Intergovernmental Panel on Climate Change (IPCC), "Climate Change and Land" (special report, IPCC, January 2020), *https://www.ipcc.ch/srccl*; United Nations Economic Commission for Africa, *Building Forward for an African Green Recovery* (Addis Ababa: United Nations Economic Commission for Africa, 2021), *https://repository.uneca.org/bitstream/handle/10855/43948/b11990399.pdf*; "Are Nature Based Solutions the Key to Africa's Climate Response?" African Development Bank, December 6, 2019, *https://www.afdb.org/en/news-and-events/are-nature-based-solutions-key-africas-climate-response-33090*.

[145] Nathalie Seddon, Alexandre Chausson, Pam Berry, Cécile A. J. Girardin, Alison Smith, and Beth Turner, "Understanding the Value and Limits of Nature-based Solutions to Climate Change and Other Global Challenges," *Philosophical Transgressions of the Royal Society B: Biological Sciences* 375, no. 1794 (January 2020), *https://royalsocietypublishing.org/doi/10.1098/rstb.2019.0120*.

[146] Intergovernmental Panel on Climate Change (IPCC), *Climate Change and Land*.

[147] Ibid.

forests over the long term. [148] REDD+, an initiative to prevent deforestation and forest degradation, has also come under scrutiny: its efficacy in reducing emissions has been questioned,[149] and numerous projects are associated with human rights abuses, including displacement of Indigenous and local communities.[150] In addition, some warn that NBS linked to carbon markets and offsetting schemes allow wealthy countries and companies to continue unsustainable consumption and pollution rather than incentivize the drastic emissions reductions that are urgently needed.[151]

Soundly designed NBS must be gender-sensitive;[152] promote, not worsen, food security; and avoid measures that may result in increased emissions or decreased biodiversity in the long term. [153] If NBS are planned for land belonging to or customarily used by Indigenous or local communities, they should be "designed, implemented, managed, and monitored by or in partnership with Indigenous peoples and local communities through a process that fully respects and champions local rights and knowledge and generates local benefits" (NBS Guidelines).[154] Finally, climate finance should be directed to communities that are the stewards of the land that is the site of an NBS and local level adaptation efforts.[155]

3.1.7. Financial and Operational Health of Power Utilities

A World Bank study on the financial health of utilities has estimated the scope for reducing utility deficits through increased operational efficiency. [156] Of the 39 countries studied, only the Seychelles and Uganda fully recover their operation and capital costs (see Figure 5). The problem with inefficient utilities in Africa boils down to high costs and low revenues. The issues with low revenue collection are that utilities suffer shortages and power outages, which, in turn, incentivize customers to not pay their bills or connect to the grid illegally.

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148 Fred Pearce, "Why Green Pledges Will Not Create the Natural Forests We Need," *Yale Environment 360*, April 16, 2019, *https://e360.yale.edu/features/why-green-pledges-will-not-create-the-natural-forests-we-need*; Nathalie Seddon et al., "Understanding the Value and Limits of Nature-based Solutions to Climate Change and Other Global Challenges."

149 Global Forest Coalition, *15 Years of REDD+: Has the Money Been Worth it?* September, 2020, *https://globalforestcoalition.org/wp-content/uploads/2020/09/REDD-briefing.pdf*.

150 Ibid.

151 Forest Peoples Programme, *Re-thinking nature-based solutions: seeking transformative change through culture and rights* (Forest Peoples Programme, 2021), *https://www.forestpeoples.org/sites/default/files/documents/Re-thinking%20nature-based%20solutions_Seeking%20transformative%20change%20through%20culture%20and%20rights.pdf*; Nathalie Seddon et al., "Understanding the Value and Limits of Nature-based Solutions to Climate Change and Other Global Challenges."

152 Intergovernmental Panel on Climate Change (IPCC), *Climate Change and Land*.

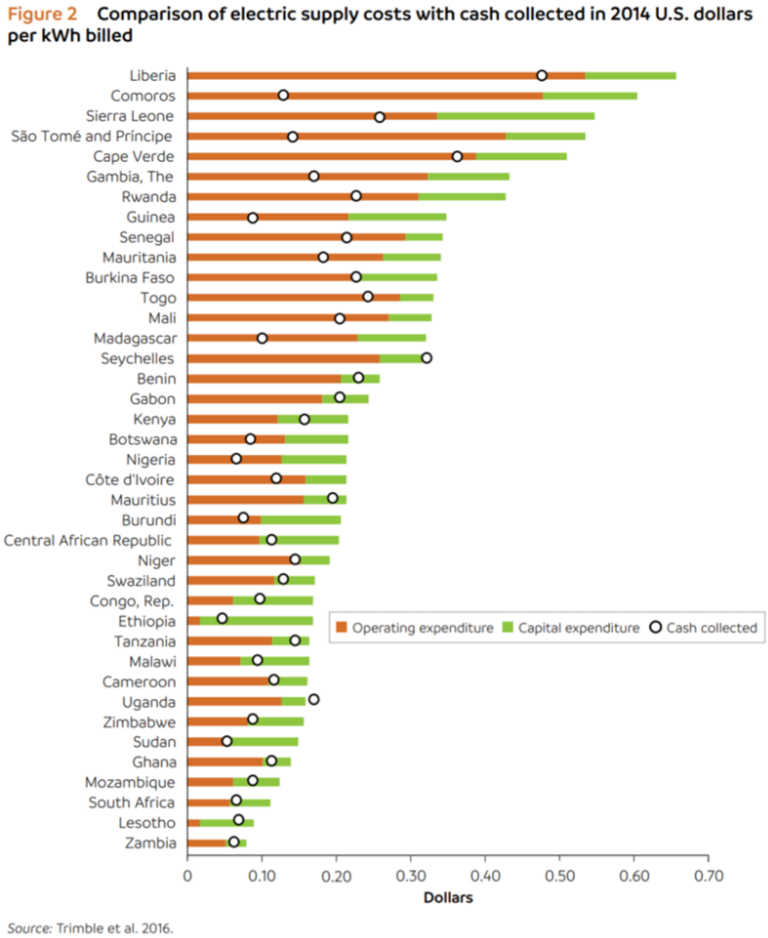
153 Kelly Levin, "How Effective Is Land At Removing Carbon Pollution? The IPCC Weighs In," *World Resources Institute*, August 8, 2019, *https://www.wri.org/insights/how-effective-land-removing-carbon-pollution-ipcc-weighs*. (E.g., where forests are cut down to make space to grow crops to produce bioenergy; or mono-culture afforestation efforts that reduce biodiversity or compete with other land uses.)

154 "Nature-based Solutions to Climate Change Key Messages for Decision Makers in 2021 and beyond," Nature-based Solutions Initiative, The Four Guidelines for Nature-based Solutions, February 2020, *https://nbsguidelines.info*.

155 Florence Crick, "Local Climate Finance Mechanism Helping to Fund Community-prioritised Adaptation," International Institute for Environment and Development (IIED), *https://www.iied.org/local-climate-finance-mechanism-helping-fund-community-prioritised-adaptation*.

156 Masami Kojima and Chris Trimble, *Making Power Affordable for Africa and Viable for Its Utilities* (Washington, DC: World Bank, 2016), *https://openknowledge.worldbank.org/bitstream/handle/10986/25091/108555.pdf?sequence=10&isAllowed=y*.

Figure 5: Comparison of electric supply costs with cash collected in 2014 USD per kWh billed



Source: World Bank.[157]

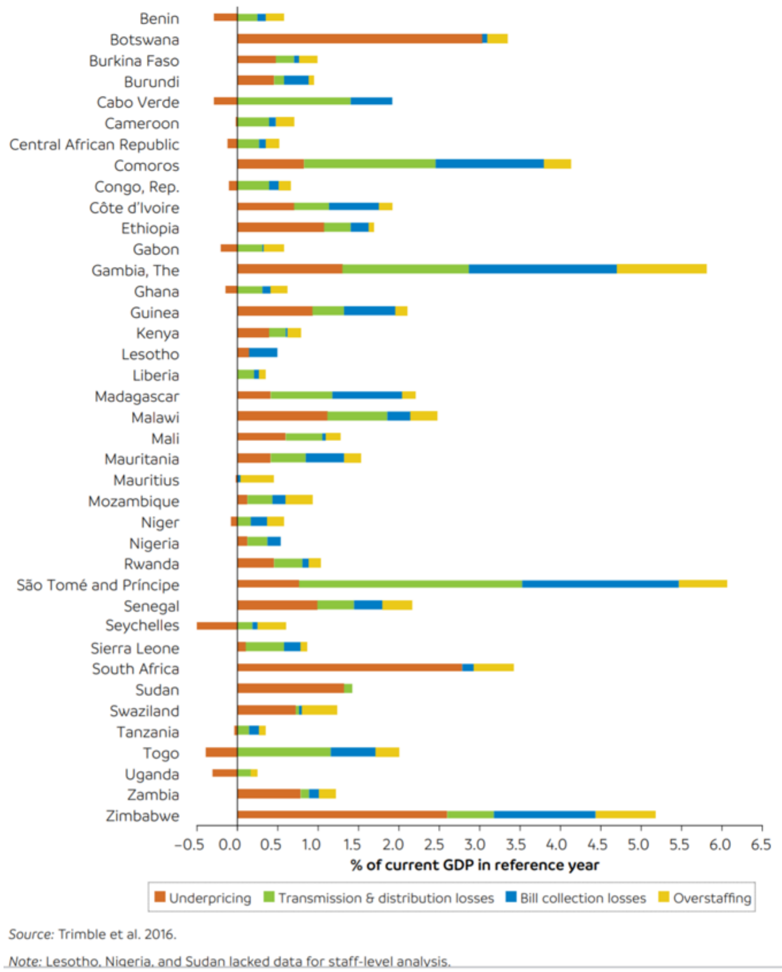
The impact of the four most common drivers of revenue loss—underpricing of tariff rates, transmission and distribution losses, bill collection losses, and overstaffing on utilities—is shown in Figure 6. For some utilities, inefficiency and mismanagement are particularly acute. Transmission, distribution, and bill collection losses combined make up more than half of the quasi-deficits[158] in 21 utilities and more than three-quarters in 13 utilities.[159]

[157] Ibid.

[158] Difference between the net revenue of an efficient electricity sector covering operational and capital costs and the net cash collected by the utilities.

[159] Kojima and Trimble, *Making Power Affordable for Africa and Viable for Its Utilities*.

Figure 6: Decomposition of quasi-fiscal deficits in Africa in 2016



Source: World Bank.[160]

Continent-wide zero-carbon electrification cannot happen without healthy and strong utilities, including the entry of new private utility companies with robust balance sheets. A massive pan-African program is needed to help strengthen utilities and regulate the entry of new utility companies.

Restoring electricity quickly and making it easier to pay bills

Reforms of existing utilities could start with increasing service quality in the short term through restoring electricity quickly and taking advantage of the advances in paying bills easily (through mobile phones, automatic teller machines, supermarkets, and other easily accessible locations with extended hours of service). Such improvement in services will require the development of an information system to collect complaints and the systematic measurement of service quality.[161] Additionally, a tailored strategy is needed to tackle the issue that slums account for 60% of Africa's urban population, and, for this reason, "many African cities are not set up to take advantage of the productivity and efficiency opportunities" from having a growing concentrated and urban population.[162]

[160] Ibid.

[161] Ibid.

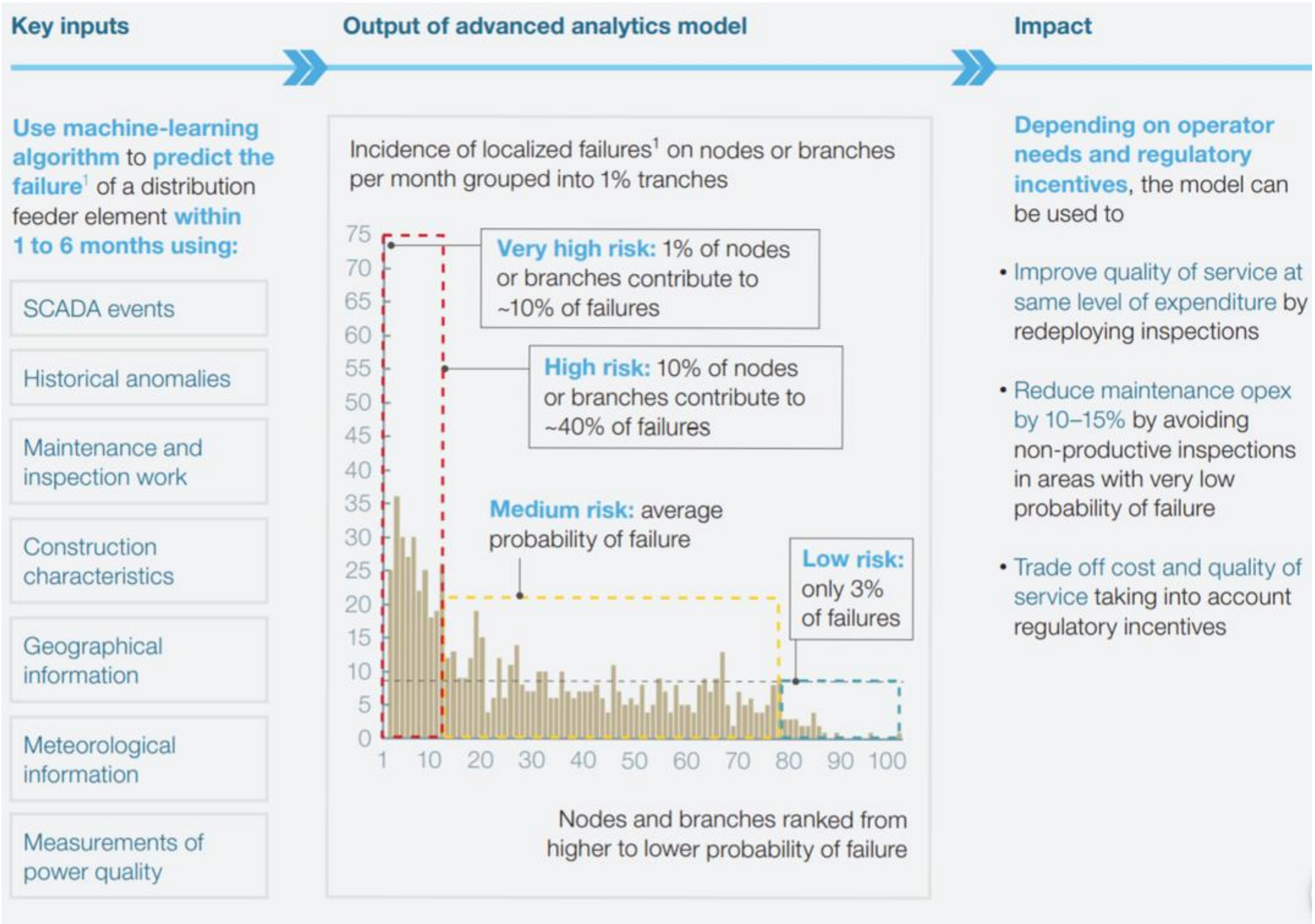
[162] Jonathan D. Moyer, David K. Bohl, Taylor Hanna, Ibrahim Mayaki, Martin Bwalya, *Africa's path to 2063: Choice in the Face of Great Transformation* (Denver, CO and Midrand, Johannesburg: Frederick S. Pardee Center for International Futures and NEPAD Planning and Coordinating Agency, 2018), 19, *https://www.nepad.org/publication/africas-path-2063-choice-face-of-great-transformation*.

Reducing technical and non-technical losses through digitization

In addition, a program to bring transmission and distribution losses down to 10% should be implemented. Here the latest progress in digitization should help utilities in Africa leapfrog and lead to considerable savings after the lump-sum investment.

Based on a variety of inputs—such as geographical information, historical anomalies, and meteorological information—utilities can predict the likelihood of system failure at different points along the value chain. Using predictive modeling in this way can help utilities to forecast failures before they happen and strategize funding to modernize equipment before failures occur. Figure 7 highlights how predictive failure modeling can work.

Figure 7: Predictive failure modeling

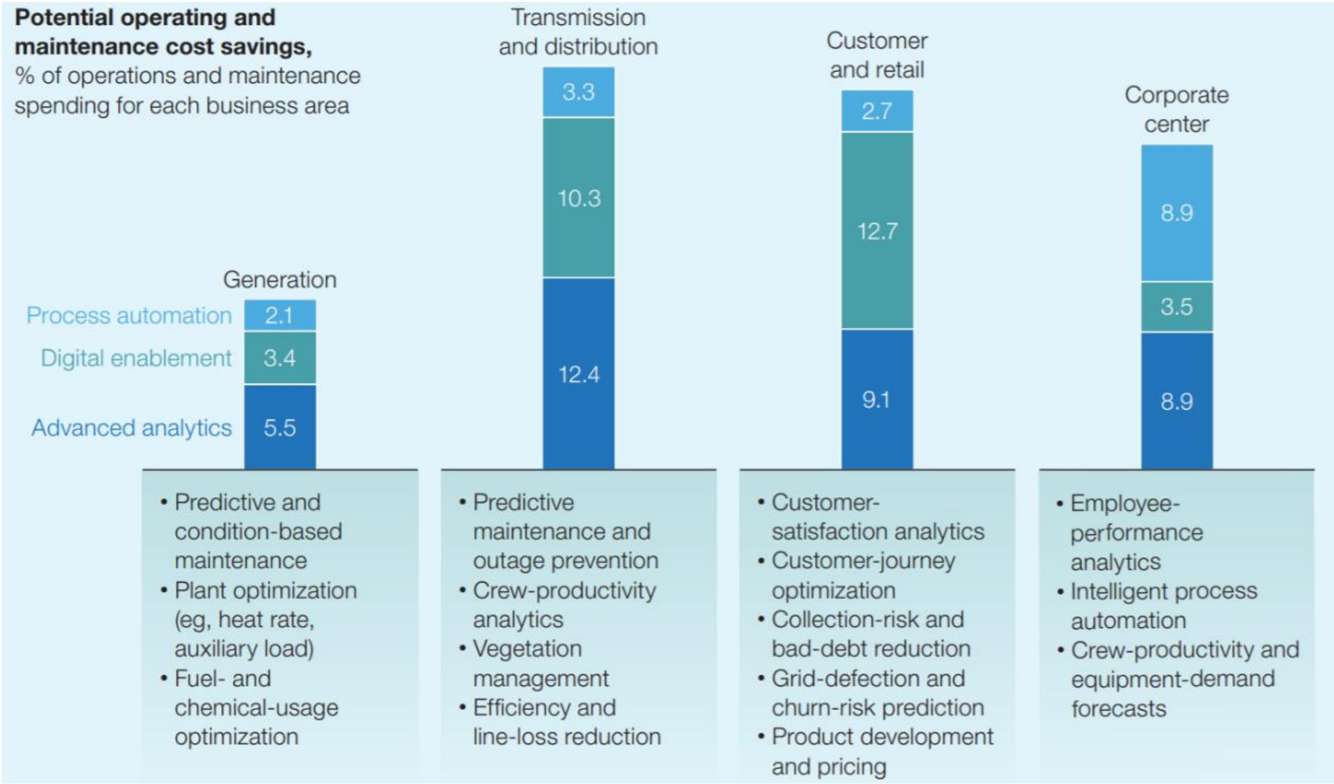


Source: McKinsey.[163]

When digitization is applied not only in a particular area of a utility's supply chain but throughout, it brings significant savings potential. While the greatest potential savings are from improvements in the transmission, distribution, and customer interface areas, generation and corporate administration also stand to gain (see Figure 5).

[163] Rui de Sousa, David Gonzalez, Jesus Rodriguez Gonzalez, and Humayun Tai, "*Harnessing the Power of Advanced Analytics in Transmission and Distribution Asset Management* (McKinsey, June 2018), 24–32, *https://www.mckinsey.com/~/media/McKinsey/Industries/Electric%20Power%20and%20Natural%20Gas/Our%20Insights/The%20Digital%20Utility/The%20Digital%20Utility.pdf*.

Figure 8: Potential cost savings by utility sector



Source: McKinsey.[164]

Deploying smart meters

The residual practice of shared meters should be addressed by replacing shared meters with individual smart meters on every connection. These smart meters will allow for a more accurate understanding of individual consumption, helping tariffs better target purchasing power. Illegal connections and meter tempering should continue to be sanctioned. Prepaid meters are already a solution for both low-income households and utilities in some countries, provided that the electricity is actually delivered. Prepaid meters can be paid for in small increments and they help households avoid reconnection fees when electricity is cut due to delayed payments; additionally, for the utility, prepaid meters improve revenue collection.[165]

Increasing transparency of tariffs of medium- to large-size consumers

Alongside service quality improvements, tariffs should increase to cost-recovery level. Importantly, the burden of this increase should be shouldered by those that have the ability to pay, such as large- to medium-size consumers and more energy-intensive businesses. If tariffs increase with no service quality improvement, their political feasibility might be threatened. In addition, tariff increases should be incremental, and the trajectory of the increases should be transparently communicated.[166]

Targeting unbundling but strengthening IPP and planning framework first

When discussing how to strengthen the health of utilities and improve the efficiency of the energy sector, the question of energy reform and unbundling of services arises. One of the main reasons for unbundling is to remove the conflicts of interest that arise within state-owned vertically integrated utilities. The generation and self-purchase of power causes a departure from least-cost planning and procurement methods within the company, negatively affecting the public. Working instead to establish an independent generation, transmission, and distribution system

[164] Ibid.

[165] Kojima and Trimble, *Making Power Affordable for Africa and Viable for Its Utilities*.

[166] Ibid.

will create competition by allowing for privately funded companies to get much more extensively involved. In Africa, only 10 out of 54 countries have vertically unbundled utilities.[167]

While the World Bank has a standard model for utility unbundling, which provides nine clear steps to achieving a clearly unbundled power sector (see Box 7), the World Bank's Doing Business database displays a low correlation between unbundling and operational efficiency.[168]

The World Bank has noted that more important than full unbundling is the ability to recover costs through tariffs (as discussed above), the operation efficiency grounded in sound least-cost planning (see Section 3.2.1), competitive procurement (see Section 4.2.2), and the ability to give IPP the rights and obligations associated with discrete investments in generation.[169] These should be the priorities of a program of utility strengthening.

Box 7: World Bank's standard model for unbundling

The nine steps in the World Bank's standard model for unbundling the power sector are:

1) corporatization, transforming of the power utility company into a separate legal entity with associated rights and obligations;
2) commercialization, introducing pricing and metering improvements to improve cost-recovery;
3) requisite legislation, passing laws that provide a legal mandate for private industry to enter the energy sector;
4) independent regulators, establishing regulatory bodies that can manage the newly competitive sector;
5) sector restructuring, unbundling state-owned utilities vertically into separate companies;
6) independent power producers, securing new investment from the private sector with long-term PPA;
7) divestiture of generation assets, divesting state ownership of generation assets;
8) divestiture of distribution assets, divesting state ownership of distribution assets; and
9) competition, introducing wholesale and retail markets.

Source: Development Bank of Southern Africa, "Briefing note: Unbundling practices and opportunities for private sector engagement in energy transmission in Africa." [170]

3.2. Decentralized Energy Infrastructure

Because Africa's population and its electricity demand continue to grow, exacerbating the electrification gap, achieving 100% access by 2030[171] even at low electricity levels will require connecting on average 60 million people per year, with roughly half of those being through off-grid solutions.[172]

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[167] Development Bank of Southern Africa (DBSA), "Briefing note: Unbundling Practices and Opportunities for Private Sector Engagement in Energy Transmission in Africa" (DBSA, September 2019), *https://www.dbsa.org/sites/default/files/media/documents/2021-03/Briefing%20note%20Unbundling%20in%20the%20Energy%20Sector%20in%20Africa%20-%20July%202019.pdf*.

[168] "The Big Question: Unbundling of State-Owned Utilities," *ESI Africa*, February 26, 2019, *https://www.esi-africa.com/industry-sectors/generation/the-big-question-unbundling-of-state-owned-utilities*.

[169] Ibid.

[170] Development Bank of Southern Africa (DBSA), "Briefing note: Unbundling Practices and Opportunities for Private Sector Engagement in Energy Transmission in Africa."

[171] A good number of countries in the region have set targets that are earlier than 2030: for example, Kenya's electrification plan will seek to achieve full electrification by 2022, Rwanda's by 2024, Cote d'Ivoire's, Ethiopia's and Senegal's by 2025. International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[172] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

Such an ambitious target will only be achievable with a structured roadmap that should be put in place in 2022 with the following principles:[173]

- Exploitation of the maturity and flexibility of solar technology and integration of all technological approaches and delivery models, from centralized electricity grids to decentralized solutions such as mini-grids and SHS, following the least-cost approach (see Section 3.2.1).
- Consideration of access to electricity in the context of human needs and energy justice with consultations and energy education at its core (see Section 3.2.2).
- Incorporation of policies that ensure affordability for low-income populations while enabling private sector investment in both stand-alone SHS and mini-grids (see Sections 3.2.3 and 3.2.4).
- Sponsorship by governments across all levels and adoption by all relevant stakeholders and designed to survive political transitions.
- Regular review and assessment to draw lessons learned from previous phases.

The first three principles are reviewed in subsequent sub-sections, while the last two are illustrated by the case studies in Ghana (Box 8) and Morocco (Box 9), two countries whose governments showed unwavering commitment to increasing access rates over the years while regularly adjusting plans to mobilize the best-fit technological solutions.

Box 8: Ghana's continued progress on the National Electrification Scheme from 1989 to 2019

In 1989, Ghana had a growing electricity crisis: only 15 - 20% of its population had access to the grid.[174] A blueprint called the National Electrification Scheme (NES) was developed to provide electricity to all settlements with an adult population of over 500 (4200 communities) within 30 years. The plan aimed to use electricity to drive industrialization, wealth creation, and improvements in the standard of living across the country.[175]

This plan involved 69 projects to be carried out in six 5-year phases.[176] The plan was based on a two-year National Electrification Planning Study and recommended the use of main grid (for communities with a population of more than 500), mini-grid, and renewable stand-alone systems depending on the suitability of each area.[177] The first phase of the NES involved electrifying the district capitals and the towns en route to them, with other phases focused on extending the grid to other regions depending on economic, political, historical, and cultural criteria. A related program called the Self-Help Electrification Program has been accelerating grid connections for communities within 20km of the grid so long as they provide the poles for the low voltage lines (typically wooden poles from felled trees) and have a minimum of 30% of the houses in the community wired. [178] The government's responsibility, then, is to provide the conductors, pole-top arrangements, transformers, and other installation costs.[179]

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173 Adapted from Sustainable Energy for All, *Integrated Electrification Pathways for Universal Access to Electricity: A Primer* (Sustainable Energy for All (SEforALL), May 2019), *https://www.seforall.org/system/files/2019-06/SEforALL_IEP_2019.pdf*.

174 George Adu, John Bosco Dramani, and Eric Fosu Oteng-Abayie, *Powering the Powerless: Economic Impact of Rural Electrification in Ghana* (International Growth Center, July 2018), *https://www.theigc.org/wp-content/uploads/2018/02/adu-et-al-policy-brief-july-2018.pdf*.

175 Ministry of Energy, *National Electrification Scheme (NES): Master Plan Review (2011-2020): Draft Report*, vol. 1 of *National Electrification Scheme (NES): Master Plan Review (2011-2020): Main Report* (Arthur Energy Advisors, July 2010), *https://mida.gov.gh/pages/view/111/NES_Master_Plan_Review_Executive_Summary_Main_Report.pdf*.

176 Francis Kemausuor and Emmanuel Ackom, "Toward Universal Electrification in Ghana," *WIREs: Energy and Environment* 6, no. 1 (September 2016): e225, *https://doi.org/10.1002/wene.225*.

177 Ministry of Energy, *National Electrification Scheme (NES): Master Plan Review (2011-2020): Draft Report*.

178 Ebenezer Nyako Kumi, "The Electricity Situation in Ghana: Challenges and Opportunities," CGD Policy Paper 109 (Washington, DC: Center for Global Development, September 2017), *https://www.cgdev.org/sites/default/files/electricity-situation-ghana-challenges-and-opportunities.pdf*.

179 Energy Commission Ghana, *Ghana: Sustainable Energy For All Action Plan* (United Nations Ghana, Sustainable Energy for All, Republic of Ghana, and Energy Commission Ghana, June 2012), *http://energycom.gov.gh/files/SE4ALL-GHANA%20ACTION%20PLAN.pdf*.

By 2009, the twentieth year and fourth phase of the project, the access rate had grown to 67%.[180] To catalyze achieving the targets of the NES in the next decade, the government passed the National Energy Policy in 2010 and set the goal to increase generation from 2,000 MW to 5,000MW and electricity access from 67% to 100% by 2020. To provide a safe and reliable electricity transmission grid, the government planned to support the mobilization of new funding for transmission infrastructure development, enforce technical regulations and operational standards, and provide support for the maintenance of existing transmission infrastructure. In addition to grid electricity, the National Energy Policy intends to promote the development of solar and other renewable forms of energy through favorable regulatory and fiscal regimes and by partnering with local universities to research opportunities to reduce the cost of solar and wind energy.[181]

By 2018, the electricity rate further increased to 84.3%, with 11,000 communities connected to the national grid at a total cost of USD 2 billion.[182]

Financing for the NES came from three sources: grants, soft loans and credit facilities, and taxes and government revenues. It is important to note that despite changes in government over the 30-year period, implementation progress on the NES and NEP was unwavering. The NES/ NEP strategies have been regularly reviewed over time to always reevaluate the least cost technology option depending on the off-grid context and the investment options available.[183]

3.2.1. A Least-Cost Approach to Mobilize Technological Solutions

Electrification roadmaps developed by countries need to apply the least-cost approach, leverage the existing open-source data and tools, and mobilize all technological solutions (grid extension, mini-grids, and solar).

The least-cost approach uses geospatial data to map the least expensive pathway to achieve full electrification per country. By inputting the population density, growth rate, projected electricity demand, the generation depending on the technology, transmission and distribution costs depending on the distance from the grid, as well as the lifetime of assets to be used for electricity delivery, the least-cost model determines the added electricity capacity, the investment requirement, and the best-fit electrification approach for each community.[184] Projecting electricity demand as mentioned above will entail determining the service level best served by each technology (see Figure 9).

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180 Ing. Sulemana Abubakari, "Achieving Universal Access and Options for Financing," (PowerPoint presentation, Ghana Ministry of Energy, June 2019), *https://atainsights.com/wp-content/uploads/2019/06/0.-Sulemana-Abubakari-Ministry-of-Energy.pdf*.

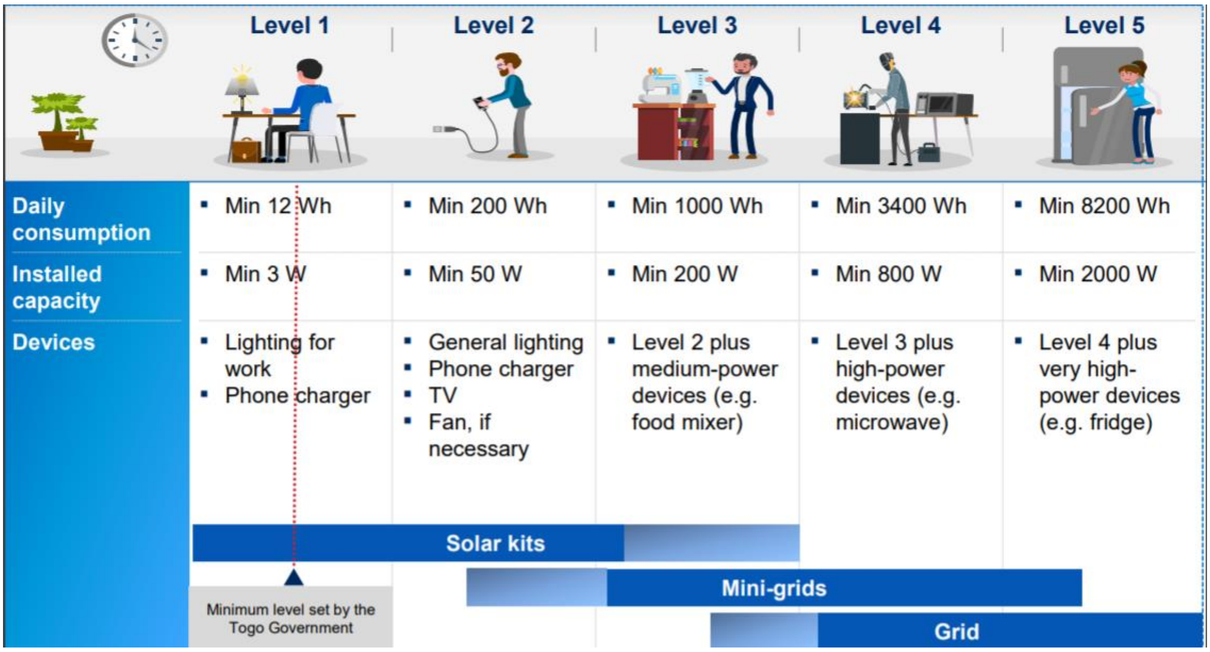
181 Ghana Ministry of Energy, *National Energy Policy*, (Ghana Ministry of Energy, February 2010), *http://www.ecowrex.org/system/files/repository/2010_national-energy-policy_ministry-of-energy.pdf*.

182 Ing. Sulemana Abubakari, "Achieving Universal Access and Options for Financing."

183 Ibid.

184 Benjamin Stewart, Nicolina Lindblad, and Gabriela R.A. Doyle, "Shedding Light on Least-Cost Electrification Strategies: the Global Electrification Platform," *World Bank Blogs* (blog), Data Blogs, January 21, 2020, *https://blogs.worldbank.org/opendata/shedding-light-least-cost-electrification-strategies-global-electrification-platform*.

Figure 9: Service level and suitable electrification technology



Source: Lighting Global.[185]

With this type of tool, government and power sector actors can plan how to meet a particular electrification objective and evaluate multiple scenarios to optimize the electrification process. Optimizing from a cost and demand perspective is critical where tariffs are too high for many households and may be below cost-recovery levels for an investor, degrading their willingness to invest. This optimization strategy has enabled Morocco to reach a 100% access rate within less than 20 years (see Box 9).

Box 9: Morocco's experience in least-cost planning

Morocco's rural electrification program (PERG) has achieved a 100% electrification rate, with 2.1 million households connected to the grid and 71,000 connected to decentralized systems. Some of the key success factors in Morocco's rural electrification program were the following:

i. Grid extension was based on the least-cost optimization principle, although political interference drew electrification slightly toward more expensive grid connections (at the expense of least-cost off-grid solutions). The first phase of the program involved connecting only households with extension costs lower than MAD 10,000 (EUR 890). This limit was progressively increased to MAD 14,000 in 2002, MAD 20,000 in 2004, and MAD 27,000 in 2006. Customers for whom grid extension costs exceeded these set-points were allocated individual SHS or mini-grids.

ii. PERG was able to improve project economics through cost efficiency, e.g. initiatives such as shorter low-voltage (LV) poles (20% reduction on poles cost) and transformers on poles (35% cost reductions for transformers).

iii. PERG also provided options tailored to consumption for individual customers, who were able to choose from:

   a. A 50 Wp PV capacity system that provided only household lighting.

   b. A 75 Wp and 100 Wp PV capacity system for household lighting and electronic media such as TVs.

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[185] Lighting Global, *Togo Electrification Strategy,* (PowerPoint presentation, Washington DC: World Bank, June 2018), *https://www.lightingglobal.org/wp-content/uploads/2018/12/Togo-Electrification-Strategy-Short-EN-Final.pdf.*

c. A 200 Wp PV capacity system that, in addition to lighting and audio-visual, was also able to provide refrigeration service.[186]

Throughout the years, PERG followed clear indicators relative to electrification costs, levels of demand, and ability to pay to adjust the technical option for electrification (e.g., grid versus SHS). The program was divided into five stages, and the utility, ONEE, leveraged its increasing experience from one phase to the next to optimize the electrification costs.[187]

Open-access tools are now available to assist stakeholders in this undertaking and should be relied on to plan for electrification. First, there is the Global Electrification Platform,[188] a tool developed by ESMAP, World Bank, and KTH Royal Institute of Technology, which makes publicly available geospatial data from 59 countries[189] and provides the best-fit electrification pathway for a particular geographical area as granular as 1 km^2.[190] This tool leverages the interactive Open-Source Spatial Electrification Tool (OnSSET),[191] a dynamic GIS-based tool that can be customized and updated as needed. Enriching the OnSSET results with additional data such as diesel cost, geographic adaptability, distance to the closest city or road, and resource availability will improve the accuracy of results.

Using this approach, the IEA in its African case (AC), based on the AU's African 2063 agenda, anticipates that for full electrification access by 2030, the energy deployment should be based on grid electrification and densification for most urban areas and one-third of rural areas.[192] Mini-grids have a role to play in both urban areas where the grid has not arrived yet and rural areas that are sufficiently dense. Building on the expected unit cost decrease of mini-grids by two-thirds by 2030, the World Bank sees the mini-grid share in all new installed capacity growing to 40%.[193]

Results vary a lot according to the characteristics of countries. In Togo, a country targeting full electrification by 2030, planners using GIS-based LCOE analysis have concluded that the split will be heavily targeted towards last-mile grid extension (i.e., electrifying households in localities already connected to the grid), with mini-grids only making up 4.5% of the new installed capacity (see Figure 10).

[186] Ivan Nygaard and Touria Dafrallah, "Utility Led Rural Electrification in Morocco: Combining Grid Extension, Mini-Grids, and Solar Home Systems," *WIREs: Energy and Environment* 5, no. 2 (March 2015): 155–168, *https://doi.org/10.1002/wene.165*.

[187] Gregoire Jacquot, Ignacio Perez-Arriaga, Divyam Nagpal, and Robert J. Stoner, *Reaching Universal Energy Access in Morocco: A Successful Experience in Solar Concessions* (MIT Energy Initiative working paper, Cambridge, MA: MIT Energy Initiative, May 2020), *http://energy.mit.edu/wp-content/uploads/2020/05/MITEI-WP-2020-03.pdf*.

[188] "Global Electrification Platform," Energy Sector Management Assistance Program (ESMAP) and World Bank Group, *https://electrifynow.energydata.info*.

[189] "Open Data and Analytics for a Sustainable Energy Future," EnergyData.Info, World Bank Group, *https://energydata.info*.

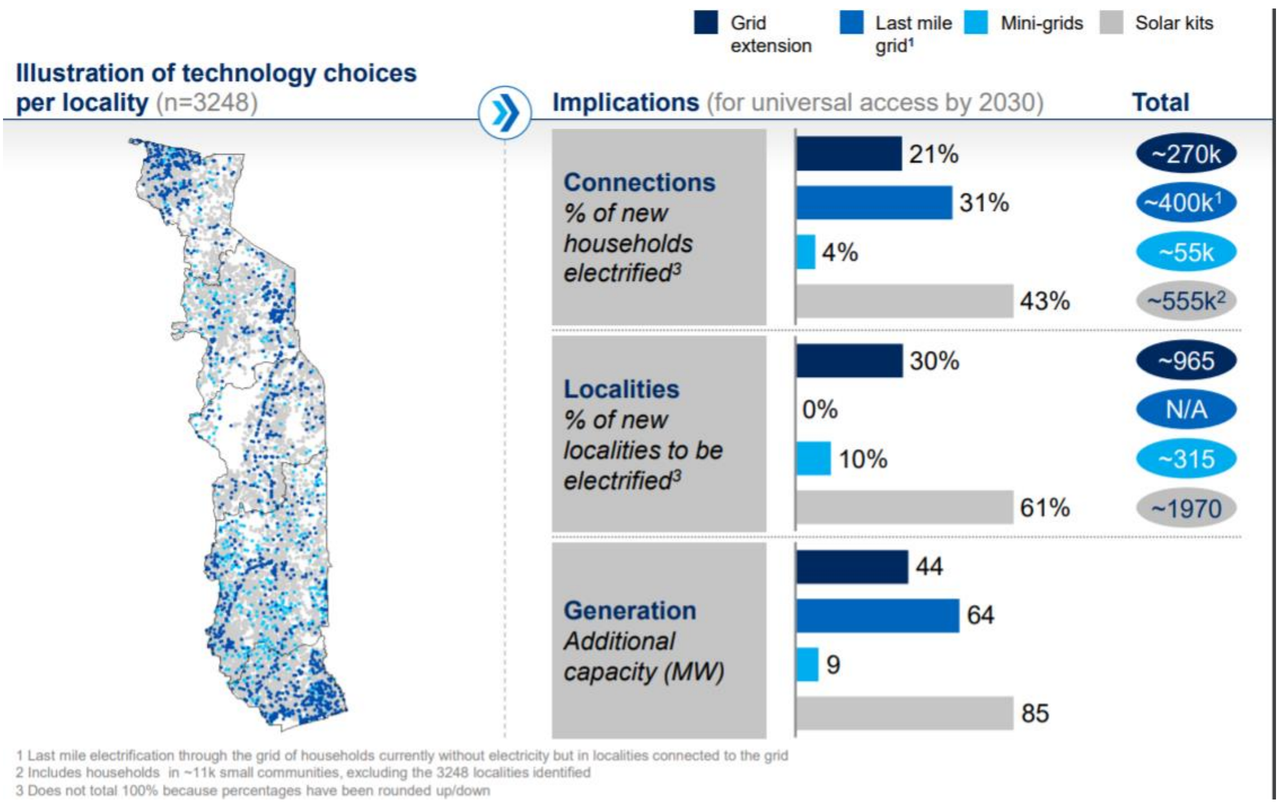
[190] Dimitris Mentis, Chiara Odetta Rogate, and Yann Tanve, "Electrification Planning Made Easier with New Open Source Tool," *World Bank Blogs* (blog), Sustainable Energy for All, July 19, 2017, *https://blogs.worldbank.org/energy/electrification-planning-made-easier-new-open-source-tool*.

[191] "Global Electrification Platform," Energy Sector Management Assistance Program (ESMAP) and World Bank Group.

[192] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[193] Energy Sector Management Assistance Program (ESMAP), *Mini Grids for Half a Billion People: Market Outlook and Handbook for Decision Makers*, ESMAP Technical Report 014/19 (working paper, Washington, DC: World Bank, June 2019), *http://hdl.handle.net/10986/31926*.

Figure 10: Results of LCOE-based planning in Togo



Source: Lighting Global.[194]

3.2.2. Energy Justice Through Meaningful Consultations

Decentralized energy is one solution for last-mile energy access, but such systems are not always designed to meet the needs of low-income residents,[195] particularly when consultation processes are overlooked. In Mozambique, the lack of consultation around a EUR 2.5 million mini-hydro project resulted in the system bypassing a local mill. Electrification of the mill was a priority for residents, particularly women who traveled long distances to use a diesel-powered mill in neighboring Malawi.[196] In Peru, where a massive solar off-grid solution program was deployed, similar challenges arose around participation, cultural sensitivity, and failures to meet energy needs.[197]

Meaningfully engaging with all segments of rural communities, including women and marginalized groups, is necessary to build trust, determine energy needs and priorities, understand capacity-building requirements, and assess the affordability of electricity for residents. In Peru, when projects actively engaged communities, there were lower rates of payment default, while projects that did not involve the participation of local communities tended to end in project failure. [198]

Training and public sensitization around the uptake of renewables in rural areas[199] are also key to enabling energy justice. In Peru, for example, as part of the country's Rural Electrification Scheme (REI Part II), rural schools are

[194] Lighting Global, *Togo Electrification Strategy*.

[195] Festus Boamah, "Desirable or Debatable? Putting Africa's Decentralised Solar Energy Futures in Context," *Journal of Energy Research & Social Science* 62, (April 2020), *https://doi.org/10.1016/j.erss.2019.101390*.

[196] Vanesa Castan Broto, Idalina Baptista, Joshua Kirshner, Shaun Smith and Susana Neves Alves, "Energy Justice and Sustainability Transitions in Mozambique," *Journal of Applied Energy 228,* (October 2018): 645–655, *https://doi.org/10.1016/j.apenergy.2018.06.057*.

[197] Sarah Feron and Raul R. Cordero, "Is Peru Prepared for Large-Scale Sustainable Rural Electrification?" *Sustainability* 10, no. 5, (May 2018): 1683, *https://doi.org/10.3390/su10051683*.

[198] Ibid.

[199] Festus Boamah, "Desirable or Debatable? Putting Africa's Decentralised Solar Energy Futures in Context."

prioritized for access to electricity. Having these newly powered schools as focal points, the Peruvian government uses videos and leaflets prepared by professionals to promote knowledge of renewable energy for both children and adults. The government then collaborates with private distribution companies with service in rural communities to use them as local educators for renewable energy education. With an outlined curriculum for renewable energy education, the government has identified a number of rural schools in different departments throughout the country so as to have the greatest educational impact in rural communities.[200]

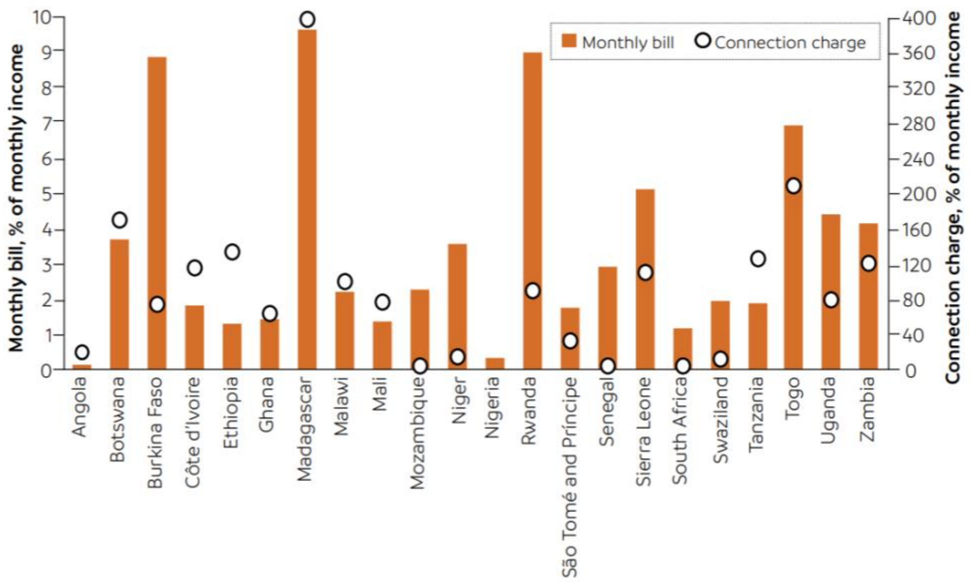
Educational outreach, in turn, lowers the pressure to extend the grid connection when this is not the least-cost solution (which, in turn, causes affordability problems); this situation happened in Morocco despite a well-crafted plan based on a least-cost solution (see Box 9 above).

3.2.3. Affordability of the Connection to Grids, Mini-Grids, and Solar Home Systems

Grid connection

Connection fees and tariffs are still unaffordable for many African households (see Figure 11). Connection fees are the costs of wiring, metering equipment, and professional services that can be passed on to the customer. To offset this connection fee, some households share electricity meters; however, the combination of the consumptions puts the poorer households in higher tariff brackets, which exacerbates the unaffordability.[201]

Figure 11: Monthly bill for 30kWh and connection charge as percentage of monthly household income



Source: Kojima et al. 2016.

Note: Household weights are used for the calculations. Nigeria charges households for the cost of materials needed. In South Africa, both the connection fee and the monthly bill may be waived for households according to different eligibility criteria depending on the municipality.

Source: World Bank.[202]

Tariff unaffordability is where the ability or willingness to pay for electricity is lower than the applicable rates. Where this occurs, customers may reduce their demand, use inferior substitutes or circumvent payment. As a result, utilities cannot recoup their investment while end-users cannot afford electricity. Each of these challenges should be addressed head-on to alleviate roadblocks to mass electrification. The affordability problem differs per country and

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[200] World Bank Sustainable Development Department, *Implementation Completion and Results Report: Republic of Peru Rural Electrification Project* (World Bank, 2013), *http://documents1.worldbank.org/curated/en/325061468297302609/pdf/ICR23580P090110C0disclosed010230140.pdf*.

[201] Kojima and Trimble, *Making Power Affordable for Africa and Viable for Its Utilities*.

[202] Ibid.

requires a bespoke solution. In Kenya, an affordability analysis revealed that many off-grid households and communities located near the grid remained unconnected because they could not afford the connection fee. To solve this problem, Kenya's government kicked off the Last-Mile Connectivity Project, whose goal was to connect a minimum of 284,200 residential and 30,000 commercial customers to the grid with no grid extension.[203] (see Box 10). Such affordability analysis should be deployed in every country to assess electrification gaps that can be closed through subsidies and minimal additional infrastructure deployment.

Box 10: Providing electricity access to under-grid population in Kenya

In 2013, in Kenya, despite the extension of the grid to 90% of public facilities (schools, hospitals, etc.), only 26% of households were connected.

In 2015, using 20,000 geotagged structures across 150 rural communities in Western Kenya, researchers found that even in areas of high population density and extensive grid coverage, electrification rates were on average 5% among rural households and 22% among rural businesses. More surprisingly, half of the unconnected households lived within 200 meters of a low voltage power line,[204] proving that there is sometimes a gulf between the availability and accessibility of electricity.

The main reason was the high cost of grid connections. For example, the median cost of a deployed transformer was estimated at USD 21,820, leading to household connection costs of USD 412 (2015 costs), at least 30% higher than residents' average willingness to pay.[205] Despite the government's push for 100% electrification to be achieved, it was yet to make economic sense for the provider and buyer.

To address this, Kenya's government instituted the Last-Mile Connectivity Program (LMCP) targeted at "under grid" rural and low-income areas. The LMCP pre-financed all the distribution and connection costs, including meters, to at least 314,200 potential customers, supporting economic growth and poverty reduction. It reduced the KES 35,000 cost of grid connection by 57% per household and provided subsidized loans when households were unable to afford the reduced fee.

The project was spread across four phases. The first phase connected households within 600 meters of an existing transformer. The second phase focused on the outskirts of cities. The third phase involved extending the grid by providing new transformers and extending the low-voltage network. The fourth and final phase involved installing additional transformers and increasing customer connections to transformers. The project cost was estimated at 99 MMUSD, with the African Development Bank as the key lender (91%) and the Government of Kenya funding the remaining 9%.[206]

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[203] African Development Bank, "Kenya - Last Mile Connectivity Project - Project Appraisal Report" (October 2014), *https://www.afdb.org/en/documents/kenya-last-mile-connectivity-project-project-appraisal-report*.

[204] Kenneth Lee, Eric Brewer, Carson Christiano, Francis Meyo, Edward Miguel, Matthew Podolsky, Javier Rosa, Catherine Wolfram, "Electrification for 'Under Grid' Households in Rural Kenya," *Journal of Development Engineering* 1 (June 2016): 26–35, *https://doi.org/10.1016/j.deveng.2015.12.001*.

[205] Kenneth Lee, Edward Miguel, and Catherine Wolfram, *Experimental Evidence on the Demand for and Costs of Rural Electrification* (Cambridge, MA: National Bureau of Economic Research, May 2016), 22292, *https://doi.org/10.3386/w22292*.

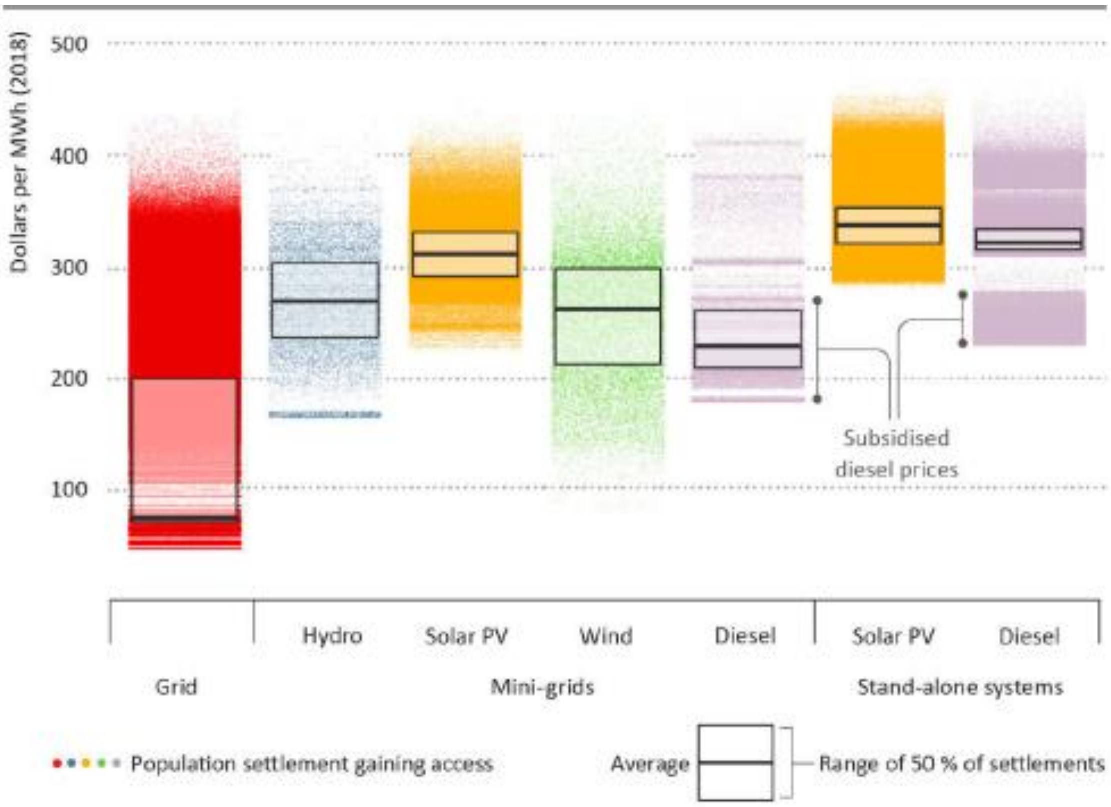
[206] "Last Mile Connectivity Program: Kenya," Inclusive Infrastructure, Global Infrastructure Hub, *https://inclusiveinfra.gihub.org/case-studies/last-mile-connectivity-program-kenya/*.

The LMCP was planned to connect 1.2 million people and to run from 2015 to 2020. During this time, Kenya's access to electricity rate grew from 41% (2015) to 65% (2016) to 64% (2017) to 75% (2018).[207]

Off-grid consumers

In Africa, the least-cost option is, on average, four times most costly between the most remote areas and the easily accessible ones (see Figure 12).[208] While decentralized solutions are the most adapted to remote settings, the high costs inevitably require a subsidy policy to support widespread availability. Government subsidies, either to the supplier or the customer, are a proven approach to financing SHS and mini-grids. Given the competing uses of funds such as healthcare, education, and security in many African countries, as well as the size of debts and deficits in these countries, public subsidies are a means of financing that should be leveraged as strategically as possible to fill gaps from other financing avenues.

Figure 12: LCOE to achieve universal access by 2030 according to the IEA



Source: International Energy Agency (IEA).[209]

A partition of the territory into roughly three types of areas—urban, peri-urban, and remote rural—could be helpful to design subsidy allocation. In urban areas, the electrification rate, average population density, and ability to pay are high; SHS might operate when the grid is unreliable, but subsidies should remain limited (and net metering, as piloted in India, could be a better solution).[210] In peri-urban areas, electrification rates are limited, but there is high-

[207] World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program.

[208] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[209] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[210] Hemant Mandal and Sivaram Krishnamoorthy, "Gujarat Solar Rooftop Program: Sharing Experience on Structuring an Innovative Solar PPP Project,"(Powerpoint presentation, International Finance Corporation, April 2014), *https://www.esmap.org/sites/esmap.org/files/DocumentLibrary/ESMAP_SAR_EAP_Renewable_Energy_Gandhinagar_Mandal.pdf.*

to-medium population density and ability to pay; subsidies will be at a moderate level and support connection to SHS until grids and mini-grids are extended. In remote rural areas, significant subsidies per household are to be expected to support connection to SHS (as Togo has done; see Box 12 below). Higher granularity would help target subsidies even better.

Urban areas might also support cross-subsidies to fund the electrification of rural areas (as Morocco has done; see Box 11). As of 2019, 59% of the Sub-Saharan African population is estimated to be rural, which means that the customer base needed to cross-subsidize rural households may not be sufficiently large; this is particularly true when tariffs are too low. Countries that do not suffer from underpricing of their tariffs—that is, countries able to charge better-off, larger consumers more to help finance grid extension to rural areas—may be best positioned to apply cross-subsidies. According to the World Bank,[211] as of 2016, only Niger, Togo, and Uganda fall into this category. However, with growing urbanization expected by 2050, cross-subsidizing (much like Morocco's approach in its electrification program) will increasingly become a viable solution that should be relied on in the roadmap to 2030 and 2050.

Box 11: Cross subsidies between urban and rural areas in Morocco

Morocco's rural electrification program (PERG) sought to address issues identified in the implementation of a similar program, the National Program for Rural Electrification (PNER), which had achieved fairly limited success. One of the factors of PERG's success, compared to PNER, was the financing approach that tackled the affordability problem.

PERG applied the least-cost approach and promoted mini-grids and SHS where the cost of grid extension was too high. Consequently, ring-fenced funds for rural electrification were set up with contributions from the utility and a levy on electricity sales to alleviate the end-user's financial burden for rural electrification.

About 100,000 homes were identified as candidates for SHS, and PERG allowed consumers self-select either paying MAD 2500 (EUR 220) per household upon connection or MAD 40 (EUR 3.60) per month over seven years. This amounts to 20% of the total cost of electrification and is sourced from household income or NGO support. In addition, the local municipality contributes 25% of the cost, which amounts to paying either MAD 2085 (EUR 185) at the start-up of electricity supply or MAD 500 (EUR 44) per year for each household over five years. Lastly, ONEE—the utility company—covers the remaining cost of electrification (up to 55% of the total cost) using solidarity tax (2.25% of grid electricity sales) and donor grants and financing.[212]

The solidarity tax was generated by charging on-grid customers in urban areas. In addition to this charge, grid electricity consumption also attracts a 14% VAT charge.[213]

Subsidies should also proceed from **an affordability analysis** that could be supported by development finance institutions (DFIs) and could apply to both the supplier and the consumer depending on the multiplier effect. The most vulnerable segments of the population should generally be supported. This is what Togo has done (see Box 12).

[211] Kojima and Trimble, *Making Power Affordable for Africa and Viable for Its Utilities*.

[212] Nygaard and Dafrallah, "Utility Led Rural Electrification in Morocco: Combining Grid Extension, Mini-Grids, and Solar Home Systems."

[213] PricewaterhouseCoopers (PwC), *Africa Energy and Utilities: Tax Guide (2018)* (PwC, 2018) *https://www.pwc.com/ng/en/assets/pdf/africa-energy-utilities-tax-guide.pdf*.

Box 12: Public subsidies for off-grid electrification projects in Togo

In 2018 Togo set up a country-wide electrification program (CIZO project) to increase the access rate from 27% in 2015 to 50% in 2025 and 100% by 2030.[214] As part of this program, already in 2018, the government awarded two firms—Bboxx and Soleva—tenders to supply 300,000 SHS by 2022 across the country.[215] The SHS products range from 51 Wh to 650 Wh and are paid by consumers through mobile payments.[216]

An affordability analysis assessed that if the daily price of Bboxx's SHS product were reduced to XOF 85 (USD 16 cents) from XOF 160 (USD 30 cents),[217] the potential market would grow to over 500,000 units sold, which would help electrify 56% of Togo's off-grid households in line with the national electrification strategy target.[218]

To improve affordability, Togo offered the licensees (Bboxx and Soleva) the opportunity to use the Togo Post Office, at a 20% discount, for transportation, storage, and product display. In addition, they benefitted from Value Added Tax (VAT) and duty waivers.[219]

Furthermore, to stimulate adoption, the government began in 2019 to offer a monthly subsidy of XOF 2000 to households that procured this system to partly cover its monthly fee of XOF 4800. The subsidies are also disbursed via mobile money accounts and will stretch for three years. The 11 regions where electrification rates are below 10% are prioritized for this subsidy.[220] By September 2018, Bboxx had installed over 4,000 units of its SHS.[221]

3.2.4. Affordability and Profitability: Regulatory and Commercial Model

In the context of forming a PPP-enabling environment, which enables affordability for consumers as well as profitability for suppliers, reducing the number of subsidies needed, the following principles are important:

- Building a strong institutional framework
- Leveraging mobile payments to finance energy as a service
- Encouraging the electrification of co-productive uses
- Facilitating data sharing
- Subsidizing private investors based on results (rather than upfront and unconditionally)

Building a strong institutional framework

Two models for decentralized energy have been observed. In the first, decentralization system deployment happens through the free market with incentives (for suppliers) and subsidies (for buyers). The alternative is for regulatory or utility companies to grant territorial sub-concessions to mini-grid or SHS providers through what is called an

[214] Ministere Des Mines et des Energies, *Togo - Projet d'Électrification Rurale CIZO – Résumé du Cadre de Gestion Environmentale et Sociale* (August 2019), *https://www.afdb.org/fr/documents/togo-projet-delectrification-rurale-cizo-resume-cges.*

[215] Lighting Global, *Off Grid Solar Market Research for Togo,* (PowerPoint presentation, Washington, DC: World Bank, December 2018), *https://www.lightingglobal.org/wp-content/uploads/2018/12/Togo-Off-Grid-Solar-Market-Assessment.pdf.*

[216] "Products Managed by Bboxx Pulse®," Bboxx, *https://www.bboxx.com/technology/#/products.*

[217] Jan 14 OXF/ USD Exchange rate.

[218] Lighting Global, *Off Grid Solar Market Research for Togo.*

[219] Lighting Global, *Togo Electrification Strategy.*

[220] "Togolese Government Approves Innovative Solar Subsidy," *ESI Africa*, March 1, 2019, *https://www.esi-africa.com/industry-sectors/future-energy/togolese-government-approves-innovative-solar-subsidy*.

[221] Lighting Global, *Off Grid Solar Market Research for Togo.*

integrated system.[222] The latter model is more conducive to fast-paced and efficient electrification that enables energy justice at the same time. It, however, necessitates an operationally and financially sound utility and strong strategic direction. Morocco is a good example of such a situation (see Box 13).

Box 13: The role of utility ONEE in the adoption of decentralized energy across Morocco[223]

From 1994, Morocco progressively liberalized its electricity policy, allowing the utility ONE (later renamed ONEE) to enter into power purchase agreements with private investors. Further partnerships and concessions resulted in the privatization of electricity generation and distribution, enabling ONEE to focus on transmission and setting the strategic direction of electricity programs.

In addition, ONEE set up a rural electrification directorate to drive rural electrification. Its flagship program PERG (as also mentioned in Box 11 above) achieved significant success because of a strategic model that over time evolved towards integrating community participation, cross-subsidies, and a well-laid-out partnership between ONEE and private firms.

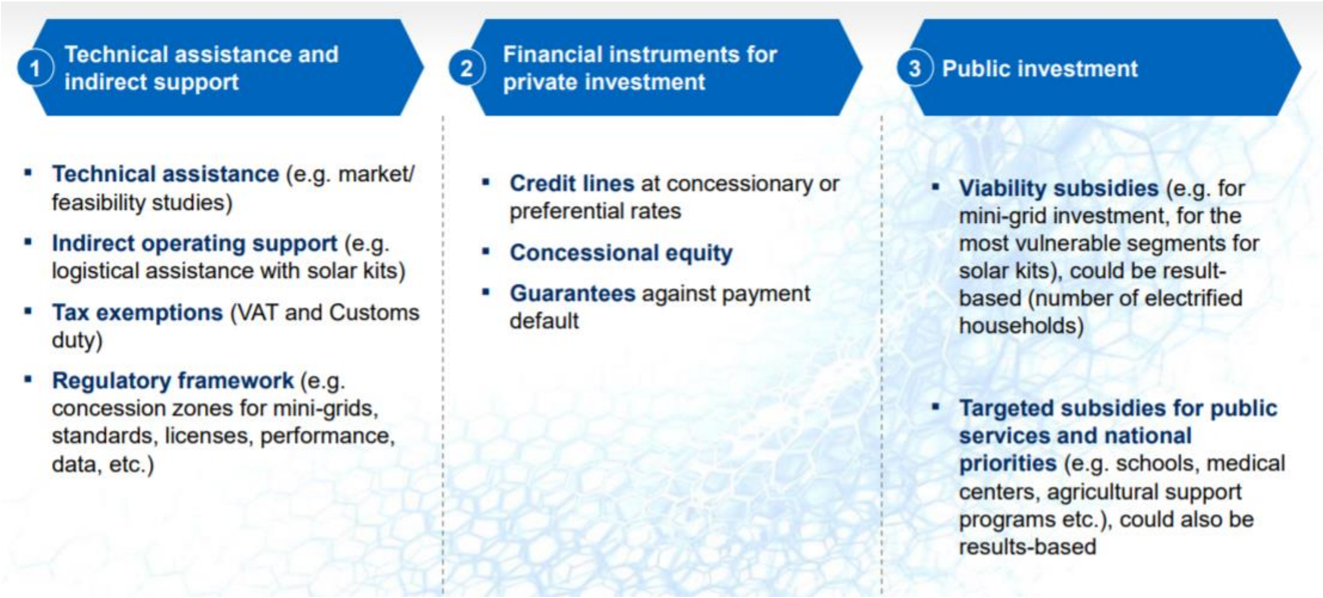
The partnership involved ONEE outsourcing off-grid electrification to private partners using a ten-year, fee-for-service model where the partner provides the unit, and the customer, the municipality, and ONEE collectively pay for it. The partners were responsible for identifying market expansion opportunities, preparing and signing electricity subscription contracts with the end-user on behalf of ONEE, procuring and installing all solar PV system components, providing free post-installation service, and collecting the connection fee and monthly fee. On its part, ONEE determined the end-user's or village's eligibility, certified the PV systems to be installed, and conducted quality control of their performance. ONEE also remained the owner of the installation and the client relationship.

A strong utility or rural electrification agency, in either case, supported by a strong Ministry of Energy, is the basis of creating an enabling environment for a PPP that is attractive to the private sector while taking into account the consumers' ability to pay. While the costs of construction and operation are borne by the private sector, there is a range of public sector tools that could support this investment. Those mobilized by Togo to enable electrification by 2030 are demonstrated in Figure 13.

[222] Grégoire Jacquot, Ignacio Pérez-Arriaga, Divyam Nagpal, and Robert J. Stoner, *Toward Actionable Electrification Frameworks: Reassessing the Role of Stand-alone Solar* (MIT Energy Initiative working paper, Cambridge, MA: MIT Energy Initiative, May 2020), *http://energy.mit.edu/wp-content/uploads/2020/05/MITEI-WP-2020-04.pdf*.

[223] Nygaard and Dafrallah, "Utility Led Rural Electrification in Morocco."

Figure 13: Range of public sector tools to support the development of the off-grid market



Source: Lighting Global..[224]

As SHS and mini-grids are different types of investment, they require distinct public support tools. In particular, the main risk to the business model of mini-grids is regulatory, related to tariff level and setting (often approved by the regulator) and the competition with the grid at a certain point in time. The main risk for SHS is customers' ability to pay. From the tools mentioned in Figure 13 above, creating concession zones that are temporarily exclusive for mini-grids, setting up a transition model for when the grid arrives (as Tanzania has done[225]), and clarifying and standardizing licensing procedures will help address the regulatory risk, while the guarantee against payment default will help address the revenue risk for SHS.

Leveraging mobile payments to finance energy as a service

The digitalization of communication and financial services (mobile phones, mobile money accounts, and associated telecommunication and payment infrastructure), as well as the increasing penetration of mobile phones in the continent (from 700 million in 2017 to 1 billion by 2023[226]) has been instrumental to the development of mini-grids and SHS markets in the last five years.[227]

For their SHS, customers are increasingly being offered affordable payment plans over several months or years, often with an initial deposit followed by periodic (e.g., daily) payments which cost less than what customers currently spend on alternatives such as kerosene (these are also called rent-to-own models). Moreover, mobile networks enable direct communication with customers, remote operation and maintenance of devices, and even the option to disable functionality for defaulting customers.[228] Thus, "in the past five years, Pay-as-you-go (PAYG) solar companies have raised over USD 360 million in capital and served about 700,000 customers in East and West Africa."[229]

[224] Lighting Global, *Togo Electrification Strategy.*

[225] In Tanzania, "mini-grids can become small power producers (SPPs) selling electricity to the grid; they can become small power distributors (SPDs) buying electricity from the grid; they can combine the two (SPP+SPD); or they can sell the mini-grid assets to the utility." (IEA)

[226] Yinka Adegoke, "The Mobile Phone is still Changing the Game in Africa," *Quartz Africa,* November 12, 2017, *https://qz.com/africa/1127274/one-billion-people-in-sub-saharan-africa-will-have-mobile-phones-by-2023/.*

[227] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[228] Ibid.

[229] Ayobami Solomon Oyewo, Javier Farfan, Christian Breyer, and Pasi Peltoniemi, "Repercussion of Large Scale Hydro Dam Deployment: The Case of Congo Grand Inga Hydro Project," *Energies 11*, no. 4 (April 2018), *https://doi.org/10.3390/en11040972*.

In Kenya, M-KOPA has been a pioneer.[230] In Togo, the CIZO project (mentioned in Box 12) aimed at providing electricity for 300,000 households in off-grid areas while also leveraging a national mobile payment platform enabling PAYG modes of payments.[231] Despite being one of the smallest economies by GDP in Sub-Saharan Africa, Togo's total mobile phone subscription of 6.2 million is 77% of the total population (some customers have multiple SIM cards).[232] In a country with a banking rate of 15%,[233] mobile money has increased access to financial services for the population, and thus, the accessibility of renewable energy products and services. One company, in particular, Bboxx, although not selling any equipment, uses smartphones to automatically turn on and off rented solar and battery systems based on whether or not payment was received.[234]

PAYG is now enabling the storage-as-a-service and energy-as-a-service models. The idea is that the off-grid customer buys an electrification package and can rent batteries, solar panels, and home appliances for a small fee—by some estimates, less than USD 10 per month. This offer allows for energy access at a fraction of the cost of ownership.[235]

The latest technology solutions offered by the private sector should be assessed before setting a subsidy package. For instance, here, ownership of SHS and home appliances is not required to raise development outcomes, so subsidizing ownership is not necessary.

In some countries, microfinance institutions (MFIs) have deep penetration into rural areas. For instance, in Togo, they are present in 43% of rural areas as of 2015.[236] This presence could be actively leveraged to support the off-grid solar sector with both consumer finance and distribution. Synergistic partnerships could be established between solar solution distributors and MFIs; MFIs would develop solar-specific financial products with affordable lending terms for the consumer through PAYG (as is already the case in Togo, for instance) while solar distributors would focus on their core business instead of engaging into financial solutions too. As the solar market matures in some countries, providing an enabling environment to disaggregate the value chain of solar could lead to important cost reductions and higher affordability.[237]

Encouraging the electrification of co-productive uses

Co-productive uses of electricity integrate consumption by industrial and domestic users and small and medium-sized enterprises (SME). Productive uses of electricity not only impact the industrial and commercial sector but also increase consumption, raise household income, and boost willingness to pay for electricity, so they contribute to solving the affordability question. As a result, private companies, such as providers of mini-grids and SHS, have started considering how to support the development of commercial activities alongside the electrification of communities in order to ensure the sustainability of their investment.[238]

For instance, irrigation pumps require systems of higher power (from 500 W to a few kW) than what is usually offered by PAYG solar companies (5–30 W range), thus enabling the creation of new consumption centers and leveraging irrigation pumps as anchor demand.[239]

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[230] "Breaking Records in Financing Off grid," *M-KOPA*, October 10, 2017, *https://m-kopa.com/2017/10/10/breaking-records-in-financing-off-grid*.

[231] Ministère des Mines et des Energies, *Togo – Projet d'Électrification Rurale CIZO – Résumé du Cadre de Gestion Environmentale et Sociale*.

[232] "Togo Number of Subscriber Mobile," CEIC Data, *https://www.ceicdata.com/en/indicator/togo/number-of-subscriber-mobile*.

[233] Arvind Ashta, Isabelle Demay, and Mawuli Couchoro, "The Role of Stakeholders in the Historical Evolution of Microfinance in Togo," *Economic History of Developing Regions* 31, no. 2–3 (January 2016): 303-344, *https://doi.org/10.1080/20780389.2015.1114413*.

[234] Michael Coren, "A New Business Model Built with Cheap Batteries may Finally Electrify Africa", *Quartz Africa*, September 5, 2018, *https://qz.com/africa/1378556/cheap-batteries-may-allow-africa-to-abandon-the-grid*.

[235] Amrit Chandan, "Answering Africa's Energy Access Questions Cleanly and Affordably," *Energy Storage News*, March 9, 2020, *https://www.energy-storage.news/blogs/answering-africas-energy-access-questions-cleanly-and-affordably*.

[236] Lighting Global, *Off Grid Solar Market Research for Togo.*

[237] Daniel Waldron, "Solar Energy: A New Frontier for Microfinance," *Consultative Group to Assist the Poor (CGAP)* (blog), April 17, 2017, *https://www.cgap.org/blog/solar-energy-new-frontier-microfinance*.

[238] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[239] Grégoire Jacquot et al., *Toward Actionable Electrification Frameworks.*

In Ghana, the DFI consortium behind Endev partnered with Ghana to incorporate productive uses of electricity at the community level. A Light Industrial Zone set up with grid electricity, where SMEs, cooperatives, and artisans were encouraged to relocate, increased their productivity. This project resulted in giving access to electricity to 375 SMEs and 1500 people. Moreover, electricity for mechanized farming was provided through grid extension, benefiting 213 farmers and 7 solar PV-powered irrigation pumps. Funds were channeled to where demand was, using subsidies. Farmers who were willing to pay 60–70% of the total investment were given subsidies for 30–40% of the cost of the solar PV irrigation system, including installation and maintenance.[240]

Moreover, renewable energy technologies that provide electricity access at the household level can also be used to provide access to clean drinking water for both consumption and agriculture. An interesting project in that matter is the Ikondo-Matembwe project in rural Tanzania. It serves eight villages and consists of two community-scale hydro-power mini-grids that power an anchor client, an agribusiness focused on producing animal feed, while providing electricity and water to the surrounding households. A cost-benefit analysis based on the results of this project showed that a 20-year renewable energy project serving several needs has more than twice as much economic impact on a local community than a project serving one purpose. In particular, this integrated approach has a multiplier effect linked to the increase in local purchasing power emerging from better education, improved agricultural productivity, and time saved from having water and energy access on site.[241]

DFIs and Ministers should jump on the bandwagon, which will imply further coordination between the ministries of water, agriculture, industry, and energy. Local agriculture cooperatives can also be efficient channels to satisfy productive uses.[242]

Facilitating data sharing

Across Africa, limited access to local financing and small market sizes are examples of challenges that have eroded the profitability margins of SHS. Data monetization could be an opportunity to reverse this trend towards revenue growth.[243] Moreover, the lack of information on consumers' behaviors, needs, and willingness to pay has discouraged mini-grid operators (with margins even lower than SHS providers) to penetrate remote rural areas, particularly given the difficulty in appropriately sizing, designing, and pricing the system.[244]

During their operations that started in the early 2010s in rural Africa, SHS providers have been able to acquire significant data on markets—such as electricity demand and population—and customers—such as their willingness to pay and creditworthiness. This data can be a key source of insights for mini-grid operators when making investment decisions. Monetizing this data is an opportunity for SHS providers to grow revenues and for mini-grid or grid operators to de-risk their projects and plan their market entry.[245]

Where the government is the owner of the client relationship or providing a concession to the SHS or mini-grid provider (for example, as in Morocco (see Box 13 above)), it is possible to leverage its influence to facilitate data sharing. In addition, DFI providing equity and loans to private investors can enable and facilitate this data sharing (see Box 14 below).

Data sharing as a service provided by the government also helps de-risk the market. For instance, Togo is securing DFIs' help to run a national study on consumers' readiness to pay and a pre-feasibility study to facilitate mini-grid investment. The World Bank's Energy Sector Management Assistance Program (ESMAP) has a database of over 26,000 installed and planned mini-grid projects around the world,[246] which could help support governments in putting together the data needed to support the investment.

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[240] "Solar Pumps for Irrigation- The Success of EnDev Approach in Ghana," Energypedia, *https://energypedia.info/wiki/Solar_Pumps_for_Irrigation-_The_Success_of_EnDev_Approach_in_Ghana*.

[241] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[242] Lighting Global, *Off Grid Solar Market Research for Togo.*

[243] Grégoire Jacquot et al., *Toward Actionable Electrification Frameworks.*

[244] Green Climate Fund (GCF), "Desert to Power G5 Sahel Facility."

[245] Grégoire Jacquot et al., *Toward Actionable Electrification Frameworks.*

[246] Energy Sector Management Assistance Program (ESMAP), *Mini Grids for Half a Billion People.*

Subsidizing private investors based on results (rather than upfront and unconditionally)

There are some markets in which a product or service provider has no or low incentive to participate, perhaps due to exchange rate fluctuation, market size, low permeation of financial services or mobile payments, or poor business or regulatory environments. It is particularly important to use results-based financing in these cases as it is an incentive-led approach that closes the viability gap in a way that rationalizes the use of subsidies while ensuring electrification results.

Box 14: Results-based financing in Zambia

Beyond the Grid Fund for Zambia (BGFZ) is a social impact procurement fund led by Power Africa and the Swedish government that closes the viability gap between energy providers and customers in Zambia. It was set up in 2017 to bring affordable, renewable, off-grid energy to 1 million people in Zambia by 2021.

BGFZ periodically invites off-grid energy companies to apply for results-based funding to provide clean, modern, and affordable energy in a specific market in Zambia. The application uses a "reverse auction" mechanism where BGFZ asks the investor to set an incentive per connection that they require to roll out their product to the market.

The bidding companies are evaluated based on value for money and the viability of their business plan. BGFZ nominates winning suppliers and sets market target, quality, warranty, and minimum service for them, continually measuring their performance through electronic tracking of product and awarding funding as they perform. BGFZ also works with the Zambian government and other stakeholders to get approval and support for the program and the products.

Suppliers, on their part, share data with BGFZ, providing them crucial market intelligence that serves to further de-risk the market for other investors. In addition to the direct benefits, jobs are created (agents, technicians, etc.), and complementary products (e.g., TVs and radios) are introduced into the market.

Since 2017, BGFZ has impacted 901,000 beneficiaries and facilitated the sale of 173,275 energy service subscriptions. Beyond the Grid Fund for Africa was set up in 2019 to replicate the success of BGFZ in Burkina Faso, Liberia, Mozambique, and Zambia.[247]

Critical to results-based financing should be ensuring that only quality-certified products are on the market. For instance, in Togo, only 13.8% of solar products on the market are certified. Here the World Bank's Lighting Global certification helps maintains industry-approved quality standards.[248] Licenses and subsidies should only be granted to certified products to help protect the consumer.

3.3. Phase-Out of Fossil Fuels: The Remaining Role for Oil and Gas

African policymakers must determine, on economic grounds, the extent to which fossil fuel production and export can be part of their energy and economy over the next three decades.[249] The destiny of Africa's remaining coal, oil, and natural gas resources represents a fundamental consideration for governments in determining the possible trajectories of zero-carbon energy development. This consideration is relevant in all African countries with significant endowments of these resources and related expectations or concrete plans to exploit and extract them for revenues and development, whether these countries are incumbent or new producers in the fossil fuel industry. Here we

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[247] "Beyond the Grid Fund for Africa," Renewable Energy and Energy Efficiency Partnership (REEEP), REEEP, 2018, *https://www.reeep.org/bgfz*; "From Zambia to Africa: Bringing Clean Energy Access to Five Million People Beyond the Grid," Beyond the Grid Fund for Zambia, Power Africa: Beyond the Grid Fund for Zambia, 2019, *https://www.bgfz.org*.

[248] Lighting Global, *Off Grid Solar Market Research for Togo.*

[249] Different scenarios relay different levels of ambition in the transition away from fossil fuels in the African power sector. While in the IEA model, coal, gas, and oil would still account for a total of 37% of the electricity supply in sub-Saharan Africa in 2040; under GEIDCO's model, this percentage would fall to 30% by 2040 and even lower, to 22%, by 2050. In turn, IRENA points to an even more limited role of fossil fuels (only 5% for fossil gas) by 2050, and LUT bets on full decarbonization—in power generation as well as in transportation, heat, and desalination—by 2050.

explain why we believe that Africa's energy development should focus on a gradual and, to the extent feasible, substantial phase-out of the domestic use of fossil fuels by 2050, and with the expectation of falling export revenues from fossil fuels in the years to 2050.

Africa accounts for a relatively small historical share of global greenhouse gas emissions: for example, only 5.8% of global historical emissions of CO_2, even when including emissions from land-use and land-use change, come from Sub-Saharan Africa.[250] Looking more narrowly at global cumulative energy-related CO_2 emissions since 1890, Africa's contribution has been limited to 2%.[251] Accordingly, based solely on the principle of countries' common but differentiated responsibilities to protect the climate system,[252] Africa would be well-positioned to claim an entitlement to exploit its fossil fuel resources to the limits of the remaining carbon budget, leaving the burden of mitigation to high-emitting countries. This is the approach adopted by some analysts, who argue that Africa should not shy away from ramping up exploration and exploitation of its fossil fuel resources to power—and generate revenue to fund—its economic development strategies.[253]

However, our justification for suggesting a deep decarbonization pathway for Africa's domestic energy system by 2050 lies mainly in economic considerations. Given Africa's ample supplies of zero-carbon energy, and the global conversion to electric vehicles and other forms of electrification, providing opportunities for Africa to follow the same trends and to invest in zero-carbon energy, materials, and products for African consumption and global export, Africa will best be served by building an integrated zero-carbon domestic energy and industrial system, while anticipating a gradual decline in export markets in hydrocarbons as the world economy shifts to net-zero emissions by 2050.

3.3.1. Impacts of the COVID-19 Crisis on the Fossil Fuel Industry

Reduced demand and prices were already an evident trend in fossil fuel development in the recent past, and in 2020 they became even more accentuated. The COVID-19 pandemic has caused an unprecedented global economy-wide crisis; in the petroleum industry, in particular, it led to even lower oil prices, between USD 20 and 40 for most of 2020.[254]

African planned oil and gas investments were particularly affected as prices remained below their break-even prices of USD 45 to 60 per barrel (see Figure 14).[255] As a result of the pandemic, other signs of the industry's decline were exacerbated in Africa's established and new producers alike: drilling rigs were left idle, relatively high-cost projects delayed or paused, licensing rounds postponed, and exploration plans cancelled.[256]

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[250] "Historical GHG Emissions," ClimateWatch, *https://www.climatewatchdata.org/ghg-emissions?breakBy=regions&chartType=line&end_year=2016&gases=co2&regions=WORLD%2CSSA&sectors=total-including-lucf&start_year=1990*.

[251] International Energy Agency (IEA), *Africa Energy Outlook 2019*, 194.

[252] United Nations Framework Convention on Climate Change, opened for signature May 9, 1992, entered into force March 21, 1994, Art. 3.1: "The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof."

[253] NJ Ayuk, "Africa Will Develop with Oil and Gas - Whether the West Likes It or Not," *World Economic Forum*, January 19, 2020, *https://www.weforum.org/agenda/2020/01/africa-oil-gas-development*; Lisa Friedman, "Africa Needs Fossil Fuels to End Energy Apartheid," *Scientific American,* E&E News, August 5, 2014, *https://www.scientificamerican.com/article/africa-needs-fossil-fuels-to-end-energy-apartheid*; Laurie Goering, "Pump Or Dump? With Oil In Decline, Africa Ponders Its Energy Future," *Reuters,* July 2, 2020, *https://www.reuters.com/article/africa-oil-climatechange/pump-or-dump-with-oil-in-decline-africa-ponders-its-energy-future-idINL8N2E9259*; Leigh Eston and Megan Darby, "Gas Curse: Mozambique's Multi-Billion Dollar Gamble on LNG," *Climate Home News*, July 10, 2020, *https://www.climatechangenews.com/2020/07/10/gas-curse-mozambiques-multi-billion-dollar-gamble-lng*.

[254] "Oil Price Charts," Oilprice.com, *https://oilprice.com/oil-price-charts*.

[255] Siva Prasad, "It Was Time for Africa: Now Covid-19 and Cheap Oil are Set to Hit New Projects and Slash State Budgets," *Rystad Energy Press Release*, March 26, 2020, *https://www.rystadenergy.com/clients/articles/press-releases/it-was-time-for-africa-now-covid-19-and-cheap-oil-are-set-to-hit-new-projects-and-slash-state-budgets*.

[256] Siva Prasad, "Covid-19 may Forever Spoil Angola's Plans to Rebuild Its Declining Oil Production," *Rystad Energy Press Release*, July 7, 2020, *https://www.rystadenergy.com/clients/articles/press-releases/covid-19-may-forever-spoil-angolas-plans-to-rebuild-its-declining-oil-production*; Laurie Goering, "Pump Or Dump?"; Christophe Le Bec, "Coronavirus: Pandemic Puts Strain 30 Major African Oil and Gas

Figure 14: Top 2020–2022 crude oil and gas FIDs in Africa facing the risk of getting delayed

Top 2020–2022 crude oil and gas FIDs in Africa facing the risk of getting delayed
By breakeven prices and resource size

RYSTAD ENERGY

Project	Country	Operator	Breakeven oil price USD per barrel	Resources (Liquids / Gas) Million barrels of oil equivalent
Tilenga	Uganda	Total/Tullow Oil	40.35	825
Bonga Southwest – Aparo	Nigeria	Shell	58.75	630
Etan – Zabazaba	Nigeria	Eni	41.95	510
Pecan	Ghana	Aker Energy	49.00	300
South Lokichar Phase 1	Kenya	Tullow Oil	60.65	215
Kingfisher South	Uganda	CNOOC	48.00	195
Agogo FFD	Angola	Eni	44.80	180
PAJ (Block 31)	Angola	BP	47.80	150
Preowei (Egina FPSO)	Nigeria	Total	43.30	145

Project	Country	Operator	Breakeven gas price USD per thousand cubic feet	Resources (Liquids / Gas) Million barrels of oil equivalent
Area 4 LNG Train 1 & 2	Mozambique	ExxonMobil	7.05	2325
GTA LNG Hub	Mauritania	BP	7.30	1420
Yakaar (domestic)	Senegal	BP	5.32	220
HA	Nigeria	Shell	6.00	210

Source: Rystad Energy research and analysis

Source: Rystad Energy.[257]

3.3.2. Bleak Recovery Outlook for the Global and African Fossil Fuel Industry

Even after the global economy restarts and under optimistic scenarios, oil prices are expected to recover to pre-COVID-19 prices in the next five to seven years to no more than USD 60 per barrel range: in Exxon's estimates, Brent oil prices would vary between USD 50 and 55 per barrel between 2020 and 2025, hitting USD 60 in 2026 and 2027; for BP, prices would be around USD 55 until 2025; for Shell, long-term crude prices would be at USD 60.[258] In a pessimistic scenario, prices do not return to past levels.[259] While there is inherent uncertainty in price estimates, the global transition to zero-carbon energy sources tends to cause a structural decline in long-term oil prices.[260] For example, according to some studies, a swift transition to zero-carbon energy in line with a 2°C trajectory would lead

Projects," *The Africa Report,* May 8, 2020, *https://www.theafricareport.com/27566/coronavirus-pandemic-puts-strain-30-major-african-oil-and-gas-projects*.

257 Siva Prasad, "It Was Time for Africa."

258 Gillian Rich, "Exxon Bearish On Oil In Private While Dividend Protected At All Costs," *Investor's Business Daily,* November 25, 2020, *https://www.investors.com/news/oil-prices-bleaker-than-exxon-admits-protects-dividend-job-spending-cuts/.*

259 Filipe Barbosa, Giorgio Bresciani, Pat Graham, Scott Nyquist, and Kassia Yanosek "Oil and Gas after COVID-19: The Day of Reckoning or a New Age of Opportunity?" *McKinsey Insights,* May 15, 2020, *https://www.mckinsey.com/industries/oil-and-gas/our-insights/oil-and-gas-after-covid-19-the-day-of-reckoning-or-a-new-age-of-opportunity*.

260 David Manley, David Mihalyi, and Anna Fleming, *A Race to the Bottom and Back to the Top: Taxing Oil and Gas During and After the Pandemic* (Natural Resource Governance Institute, October 27, 2020), *https://resourcegovernance.org/sites/default/files/documents/a_race_to_the_bottom_and_back_to_the_top_taxing_oil_and_gas_during_and_after_the_pandemic.pdf*.

to long-term oil prices between USD 40 and 50;[261] even lower prices could be expected for compliance with a 1.5°C trajectory. According to the IEA's 2021 *Net Zero by 2050* report, the outlook for oil and gas is as follows:[262]

- The oil price (in real terms) will be around USD 35/bbl by 2030 and USD 24/bbl by 2050.
- Gas import prices (in real terms) in 2050 would range from USD 3.50 per Million Btu in Europe to USD 4.60 in China.
- Oil demand would drop from 90 million bopd in 2020 to 24 million bopd in 2050.
- Gas demand would drop from 3,900 billion cubic meters (Bcm) in 2020 to 1750 Bcm in 2050.

Despite the falling costs of oil production, the average break-even prices for most oil sources remain higher than current prices.[263] Therefore, the low prospects for price recovery make for a bleak outlook for a rebound of the fossil fuel industry, particularly in African oil-producing countries, where the cost of production is not globally competitive at the new price levels. For example, in 2016, the estimated production cost in Algeria (USD 20.40 per barrel) was more than twice the cost of production in Kuwait (USD 8.50), and the production cost in Angola (USD 35.40) and Nigeria (USD 31.60) were three times the cost in Saudi Arabia (USD 9.90) (see Figure 15).[264]

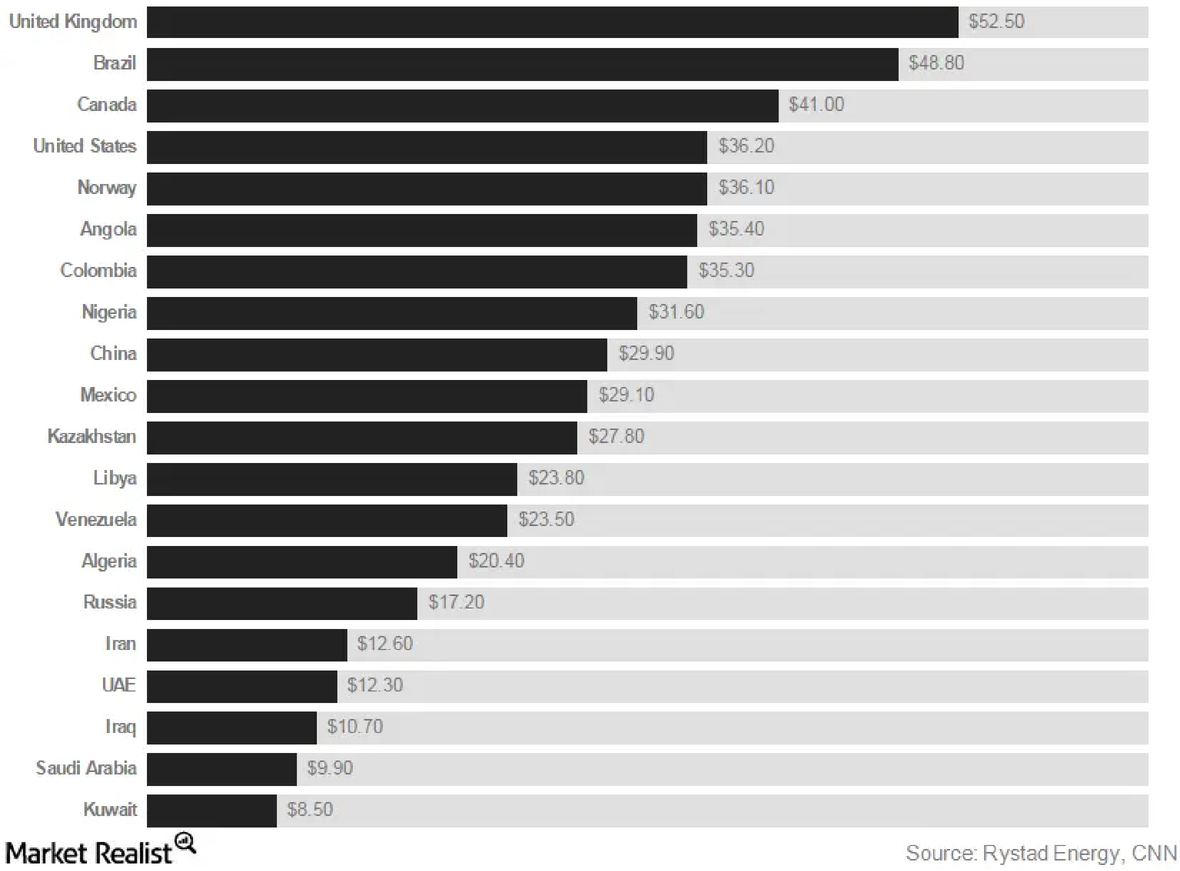
[261] Silas Olan'g, Evelyne Tsague, and Zeina Dowidar, *African Oil and Gas Producers Will Face Taxing Challenges Post-Pandemic* (Natural Resource Governance Institute, October 27, 2020), *https://resourcegovernance.org/blog/african-oil-and-gas-producers-will-face-taxing-challenges-post-pandemic*; Carbon Tracker Initiative, *Breaking the Habit: Why None of the Large Oil Companies Are "Paris-aligned," and What They Need to Do to Get There* (Carbon Tracker Initiative, 2019), *http://carbontracker.org/reports/breaking-the-habit*.

[262] International Energy Agency (IEA), *Net Zero by 2050*, 51.

[263] Espen Erlingsen, "Oil Production Costs Reach New Lows, Making Deepwater One Of The Cheapest Sources of Novel Supply," Rystad Energy (press release, October 21, 2020), *https://www.rystadenergy.com/clients/articles/press-releases/oil-production-costs-reach-new-lows-making-deepwater-one-of-the-cheapest-sources-of-novel-supply*.

[264] Gordon Kristopher, *Crude Oil's Total Cost of Production Impacts Major Oil Producers* (Market Realist, January 13, 2016), *https://marketrealist.com/2016/01/crude-oils-total-cost-production-impacts-major-oil-producers*.

Figure 15: Total cost to produce one barrel of crude oil



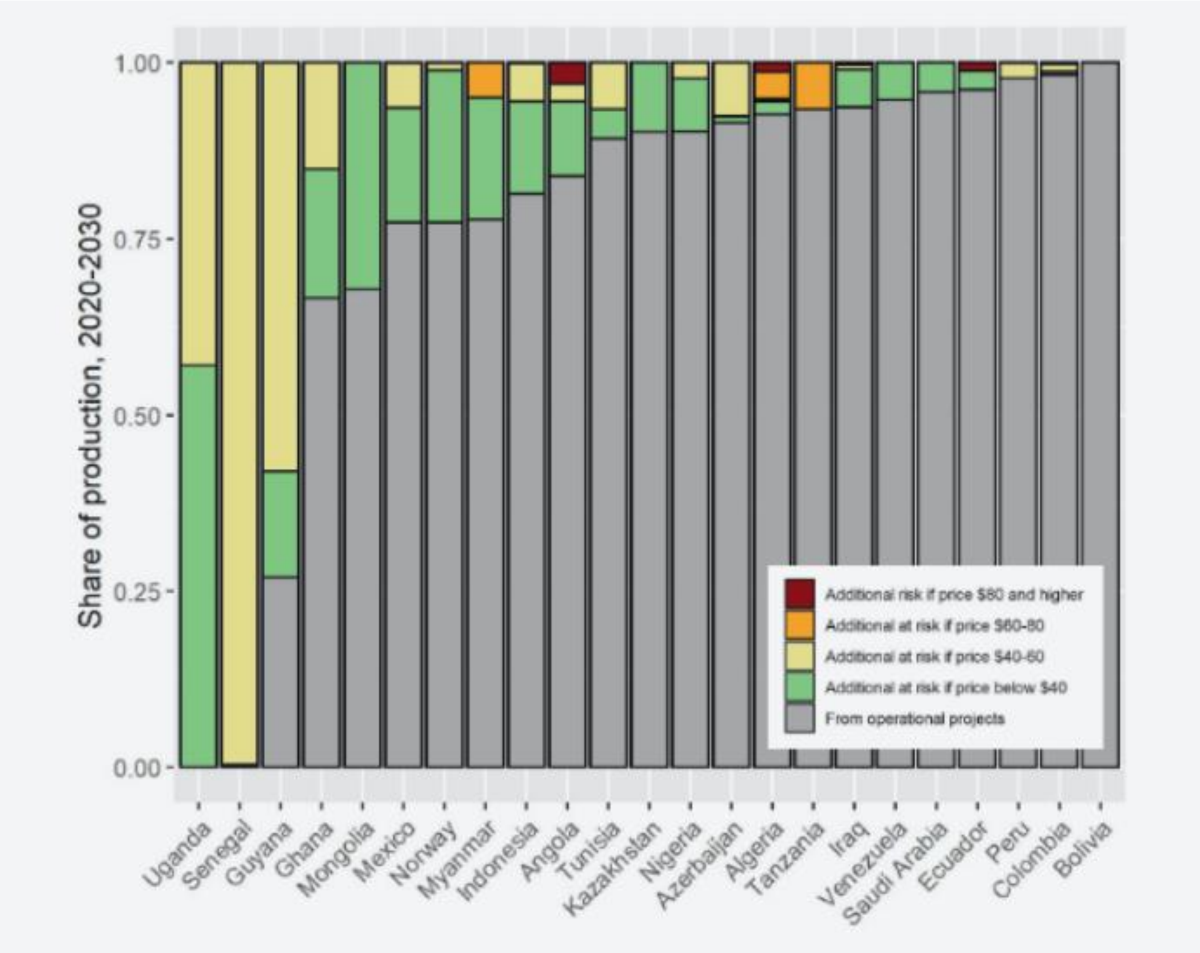
Source: Market Realist.[265]

Lower long-term oil prices and the diminishing role that fossil fuels will play in the global economy tend to frustrate the expectations of other new oil producers in sub-Saharan Africa that rely on projects with high production costs, as companies may ultimately give up developing them. For example, oil prices below USD 40 would put more than half of Uganda's potential oil production at risk, and prices between USD 40 and 60 would put over one-quarter of its new projects at risk. Senegal's scenario is even worse: its entire projected production would be at risk with prices between USD 40 and 60 (see Figure 16).[266] The case of the Turkana project offers a preview of what could happen in Uganda, Senegal, and other high-cost producers (see Box 15).

[265] Ibid.

[266] Olan'g, Tsague, and Dowidar, *African Oil and Gas Producers Will Face Taxing Challenges Post-Pandemic*.

Figure 16: Share of total oil and gas production from operating and prospective projects



Source: NRGI.[267]

Box 15: Turkana project

The Turkana project is located in Kenya's South Lokichar basin and covers onshore Blocks 10BA, 10BB, and 13T, Kenya's first oil fields. The project's Final Investment Decision (FID) was expected in 2019, but the FID is still pending, and the commercial partners—Tulow, Total, and Africa Oil—have had trouble staying committed to the project despite already investing nearly USD 2 billion in exploration.[268] The uncertainties of the market relative to the cost of the project are tipping the balance towards the exit of the commercial partners. An analysis done by Open Oil and InVhestia in 2018, under a much more optimistic scenario (USD65/ barrel), showed that the consortium would need to commit to substantially higher production than they were publicly announcing and the 20% participation of the National Oil Company would not yield extra profits until the 2030s.[269] In a 2020 analysis, Open Oil and inVhestia explained that with prices below USD 53 per barrel, the National Oil Company of Kenya would never reach breakeven,

[267] Ibid.

[268] Ron Bousso, Bate Felix, and Shadia Nasralla, "Total and Tullow Launch Joint Sale of Stakes in Kenyan Oil Project: Sources," *Reuters*, January 23, 2020, *https://www.reuters.com/article/us-m-a-oil-kenya/total-and-tullow-launch-joint-sale-of-stakes-in-kenyan-oil-project-sources-idINKBN1ZM1FZ*.

[269] Johnny West and Stephen Gugu, "Turkana oil field, Kenya: Narrative Report," (InVhestia Africa and Open Oil, Decemeber 2018), *http://openoil.net/wp/wp-content/uploads/2016/12/ooinv_ke_turkana_narrative_181212.pdf*.

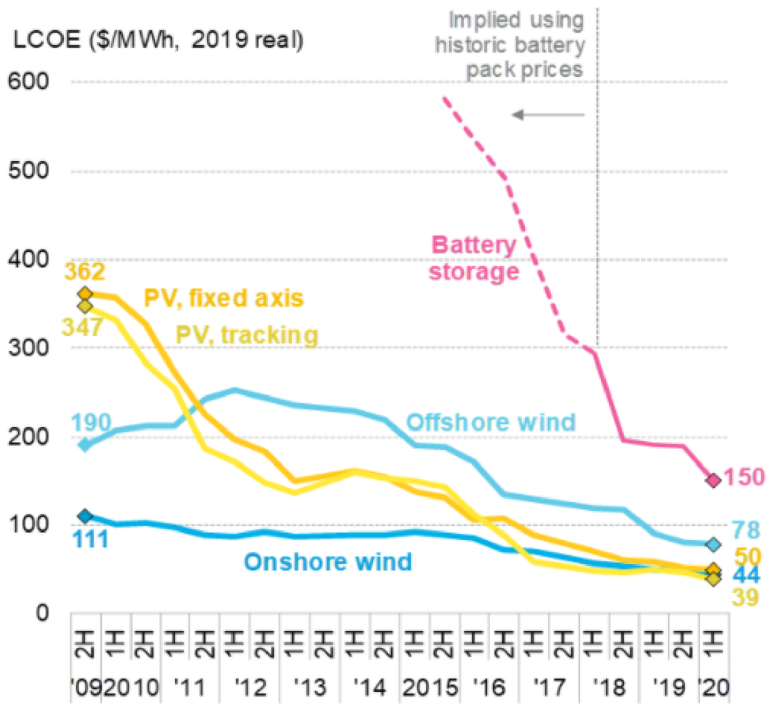
and with prices below USD 72, it would never reach a positive net present value with a 10% discount rate; additionally, under all price scenarios, the rates of returns for the contractors are low or inexistent.[270]

3.3.3. Renewables: Lower Costs and Negative Externalities than Fossil Fuels

Fossil fuel producers tend to experience declining export potential for their hydrocarbons, considering the global trend to transition away from fossil fuels toward zero-carbon energy sources that are increasingly competitive from an economic standpoint and technically viable, accompanied by increasing desirability of deploying renewable power generation for their domestic use.

Bloomberg NEF forecasts that renewable energy sources could meet half of the world's energy demand by 2050.[271] In late 2019, electricity costs from new solar PV plants were 83% lower than ten years earlier,[272] and renewable energies are now competitive with fossil fuels on a non-subsidized basis. Coal is being phased out in many parts of the world.[273] The levelized cost of electricity (LCOE) of renewable energy sources has been decreasing globally over the past decade (Figure 17) and is expected to continue to decrease in Africa as the continent advances toward large-scale development of renewables.[274]

Figure 17: Global LCOE benchmarks for solar PV, wind, and batteries



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[270] Ibid.

[271] Ramanan Krishnamoorti, "What Does The Oil Price Crisis Mean For The Energy Transition?," *Forbes*, March 13, 2020, *https://www.forbes.com/sites/uhenergy/2020/03/13/what-does-the-oil-price-crisis-mean-for-the-energy-transition*.

[272] BloombergNEF, "Falling Clean Energy Costs Can Provide Opportunity to Boost Climate Action in COVID-19 Recovery Packages," B*loombergNEF* (blog), June 10, 2020, *https://about.bnef.com/blog/falling-clean-energy-costs-can-provide-opportunity-to-boost-climate-action-in-covid-19-recovery-packages.*

[273] Gaurav Ganti, "Coal Phase-Out," (briefing, Berlin, Lomé, and New York: Climate Analytics), *https://climateanalytics.org/briefings/coal-phase-out*.

[274] See, e.g., LCOE of various power sources in Africa over time (USD cents/kWh). Global Energy Interconnection Development and Co-operation Organization (GEIDCO), *Africa Energy Interconnection Planning Research Report*.

Note: The global benchmark is a country weighted average using the latest annual capacity additions. The storage LCOE is reflective of utility-scale projects with four-hour duration, including charging costs.

Source: BloombergNEF.[275]

Analyzing electricity costs and LCOEs provides only a partial assessment of the societal impacts of the energy system; taking into account the significantly high negative externalities caused by fossil fuel sources of energy strengthens the argument for Africa to invest in renewables-based electrification and move away from fossil fuels. The external costs of coal, oil, and gas include environmental damage from resource extraction, air pollution from combustion and industrial processes, and impacts of extreme weather events resulting from climate change.[276] An IRENA study concludes that when internalizing these external costs estimated to amount to USD 3–10.5 trillion per year globally, the increased use of renewables by 2030 could generate global annual savings of up to USD 4.2 trillion, an amount 15 times higher than the cost to deploy those renewables.[277] According to one estimate, the combination of health costs and work absences as a result of fossil fuel-related air pollution generates costs of USD 8 billion per day worldwide, the equivalent to 3.3% of global GDP.[278] By adding calculated mean externalities to LCOEs, another study finds that wind, geothermal, and solar thermal would be among the most socially cost-effective electricity sources, with coal energy being the most uneconomical.[279]

3.3.4. Fiscal Challenges for Incumbent and Entrant Fossil Fuel Producers

The energy transition will pose fiscal challenges to several African economies that are highly dependent on oil and gas earnings. Africa accounts for 9 of the top 40 countries in oil and gas revenues as a share of GDP ('petrostates'). Figure 18 shows that the fiscal dependence of these nine countries on oil and gas revenues ranges from 12% to 81% of average government revenues between 2015 and 2018.

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[275] BloombergNEF, "Scale-up of Solar and Wind Puts Existing Coal, Gas at Risk," *Bloomberg NEF* (blog), April 28, 2020, *https://about.bnef.com/blog/scale-up-of-solar-and-wind-puts-existing-coal-gas-at-risk*.

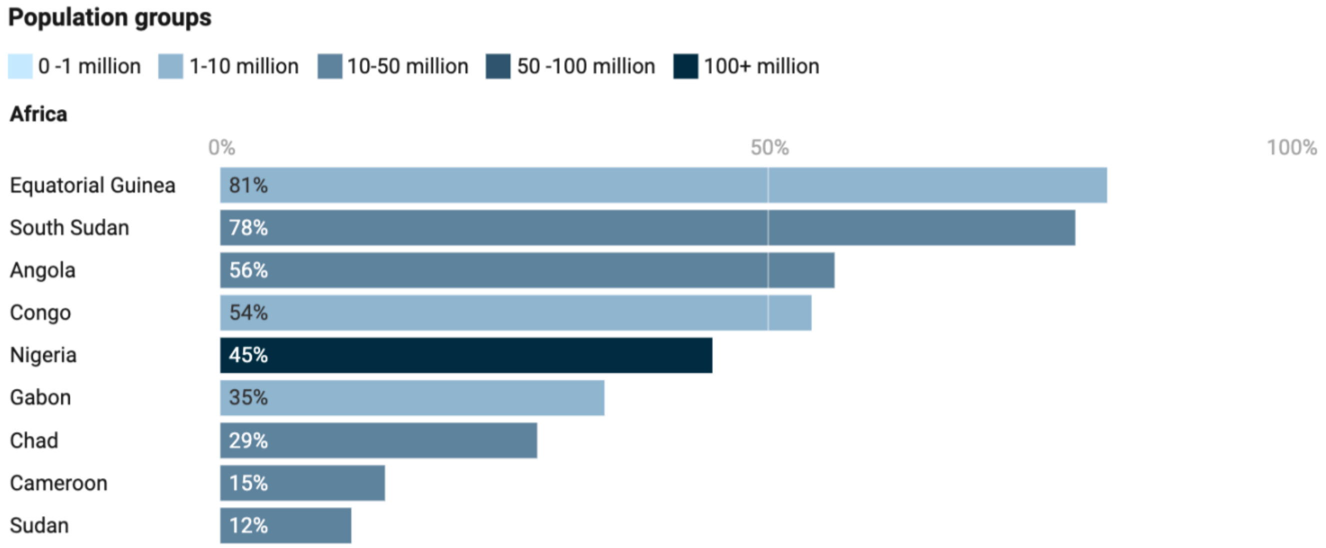
[276] IRENA, *The True Cost of Fossil Fuels: Saving on the Externalities of Air Pollution and Climate Change* (IRENA, 2016), 1, *https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_REmap_externality_brief_2016.pdf?la=en&hash=803CA3E34600905E17E99586640BFC9FECD08AB7*.

[277] Ibid., 10.

[278] Aidan Farrow, Kathryn A. Miller, and Lauri Myllyvirta, *Toxic Air: The Price of Fossil Fuels* (Greenpeace, February 2020), *https://storage.googleapis.com/planet4-southeastasia-stateless/2020/02/21b480fa-toxic-air-report-110220.pdf*.

[279] Benjamin K. Sovacool, Jinsoo Kim, and Minyoung Yang, "The Hidden Costs of Energy and Mobility: A Global Meta-Analysis and Research Synthesis of Electricity and Transport Externalities," *Energy Research & Social Science* 72 (February 2021), *https://doi.org/10.1016/j.erss.2020.101885*.

Figure 18: African petrostates' fiscal dependence on oil and gas revenue



Source: Carbon Tracker.[280]

Ironically, the heavy dependence of these economies on oil and gas has not been conducive to overall economic development, a phenomenon widely summarized as the "resource curse." The high dependence on fossil fuels in Africa's main fossil fuel–producing countries, resulting from poor governance of the sector and the economy more broadly, has led to a lack of economic diversification and a very small fiscal capacity in taxation other than fossil fuels.[281]

Even established African oil producers currently face formidable challenges, including increasing global competition, reductions in long-term demand, inadequate regulation, lack of local expertise, political and social instability, and risks of economic distress in countries with resource-based loans.[282] In many African countries, the fiscal breakeven price—the oil price needed for the country to achieve fiscal balance—is significantly higher than current and expected oil price levels. For example, in Nigeria, the fiscal breakeven price is USD 144 per barrel;[283] in Algeria, USD 109.3, and in Libya, USD 70.3.[284]

The zero-carbon energy transition will exacerbate the global decline in demand for oil and gas, resulting in a significant fiscal impact on the governments of hydrocarbon-dependent countries. A study by Carbon Tracker forecasts government revenue in the world's top 40 petrostates under three scenarios:[285]

1. Industry Expectations: business-as-usual production, assuming long-term oil prices at USD 60;
2. Low-Carbon (Base-Case Prices): reduced demand under a low-carbon scenario while continuing to assume oil prices at USD 60; and
3. Low-Carbon: reduced demand under a low-carbon scenario, with a flat price assumption of USD 40, roughly corresponding to the marginal breakeven price in Carbon Tracker's analysis, and accounting for the expectation that lower demand will lead to lower pricing.

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[280] "Mike Coffin, Axel Dalman, and Andrew Grant, *Beyond Petrostates: The Burning Need to Cut Oil Dependence In The Energy Transition* (Carbon Tracker Initiative, February 2021), *https://carbontracker.org/reports/petrostates-energy-transition-report*.

[281] International Energy Agency (IEA), *Africa Energy Outlook 2019*, 157; Laurie Goering, "Pump Or Dump?"

[282] International Energy Agency (IEA), *Africa Energy Outlook 2019*, 157.

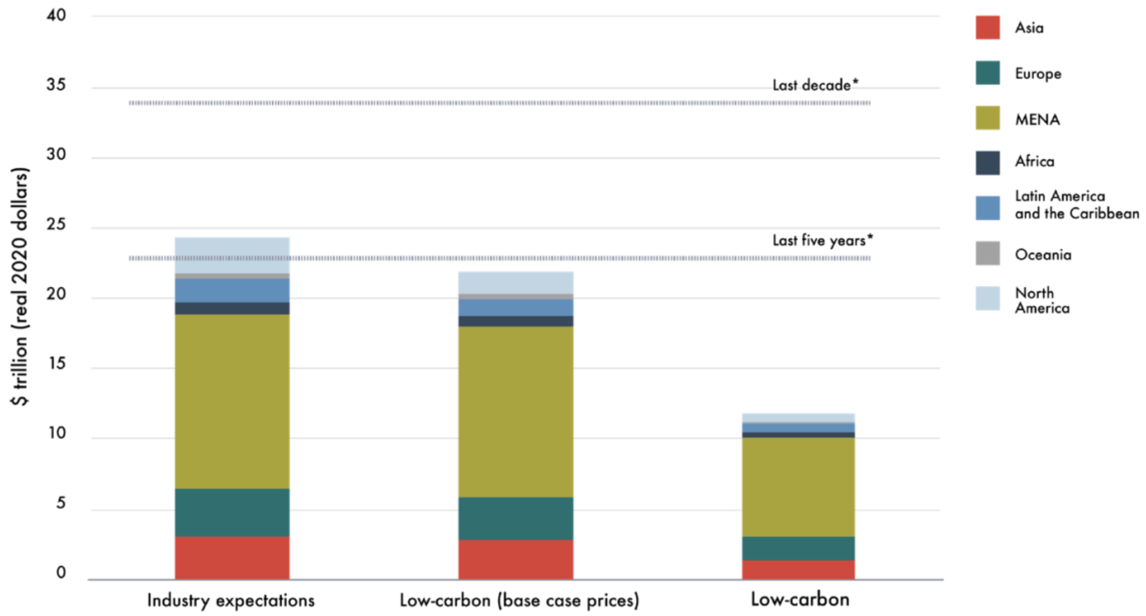
[283] Alex Kimani, "Deep Oil Cuts Put Africa At Serious Risk," *Oilprice.com,* March 1, 2021, *https://oilprice.com/Energy/Crude-Oil/Deep-Oil-Cuts-Put-Africa-At-Serious-Risk.html*.

[284] "Cost of Oil Production by Country," Knoema, December 17, 2020, *https://knoema.com/infographics/vyronoe/cost-of-oil-production-by-country*.

[285] Coffin, Dalman, and Grant, *Beyond Petrostates*, 25.

Figure 19 shows that total government revenues between 2021 and 2040 would be 51% lower in the Low-Carbon than in the Industry Expectations scenario, amounting to a USD 13 trillion gap.

Figure 19: Future (2021–2040) government revenue under different demand/price scenarios compared to last five years and last decade



*Notes: * 2010–2019 and 2015–2019; extrapolated to 20-year values for comparability.*

Source: Carbon Tracker.[286]

Revenues from fossil fuels in top-ten African producers to 2040 will remain below the levels achieved in the mid-2000s to the mid-2010s in both IEA's Stated Policies and Africa Case scenarios (see Figure 20). In this context, the IEA points out that "changing energy dynamics make it risky to assume that ample [fossil fuel] resources will translate into reliable future revenues" for African countries.[287]

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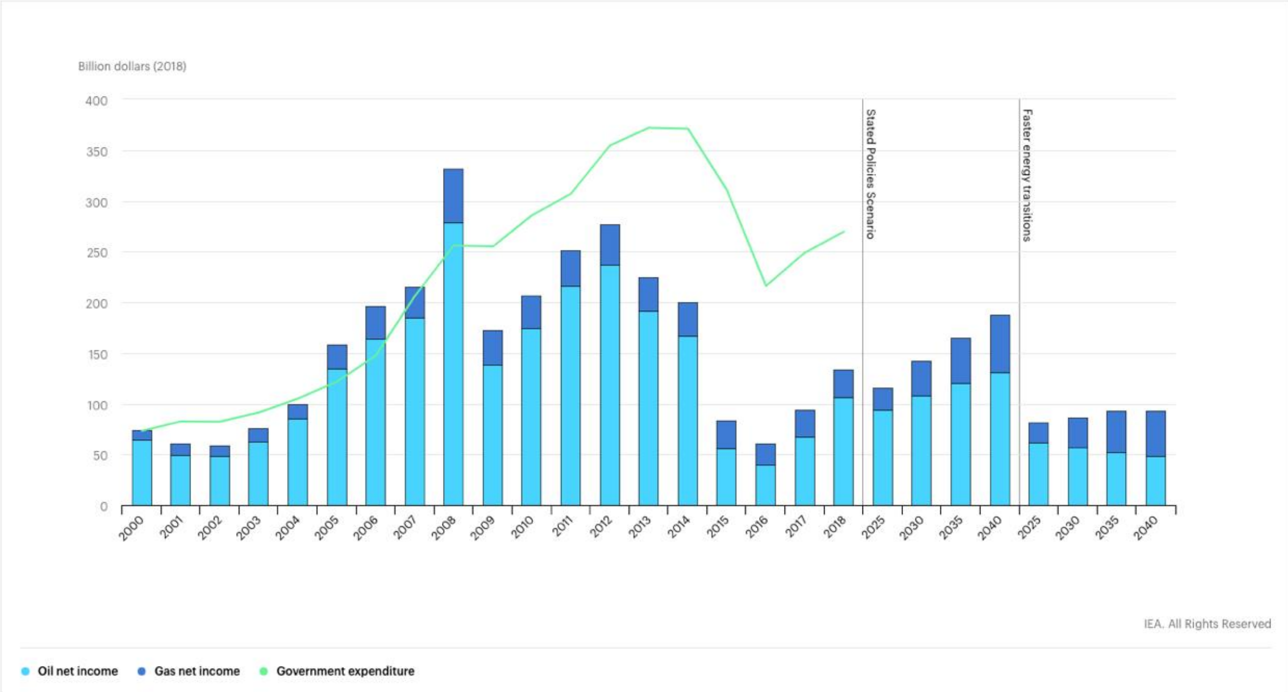
[286] "Ibid. 26.

[287] International Energy Agency (IEA), *Africa Energy Outlook 2019*, 157.

Figure 20: Net income from oil and gas production in top-ten producers in Africa, 2000–2040



Source: International Energy Agency (IEA).[288]

The fiscal challenges faced by incumbent producers also apply, and are even greater, for prospective or new producers. An analysis of 12 sub-Saharan countries that made their first major oil and gas discoveries between 2001 and 2014 evidenced that, in all cases, these discoveries failed to deliver the expected development benefits. In 4 countries (Guinea Bissau, Liberia, São Tomé and Príncipe, and Sierra Leone), discoveries were deemed commercially unviable, which is an inherent risk in petroleum exploration; in the other 8 (Ghana, Kenya, Mauritania, Mozambique, Niger, Senegal, Tanzania, and Uganda), timelines from discovery to production were, on average, 73% longer than the initial forecast. In the 3 countries that reached the production stage, government revenues were much lower than forecasts (90% less in Mauritania, 60% less in Niger, and 50% less in Ghana). In several of the 12 countries, revenue expectations have led to increasing national debt.[289]

While, in theory, fossil fuel investment can bring not only revenues but also other co-benefits through domestic linkages—by bringing technology and know-how that can spill over to other sectors and anchoring the broader development of the economy—these linkages and their positive socio-economic impacts have not always materialized in resource-rich countries.[290]

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[288] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[289] David Mihalyi and Thomas Scurfield, "Post-Coronavirus: More Sorrow for Africa's New Oil and Gas Producers," *The Africa Report,* May 28, 2020, *https://www.theafricareport.com/28902/post-coronavirus-more-sorrow-for-africas-new-oil-and-gas-producers/.*

[290] Columbia Center on Sustainable Investment, *Linkages to the Resource Sector: The Role of Companies, Government and International Development Cooperation* (GIZ, 2016), *https://ccsi.columbia.edu/sites/default/files/content/docs/our%20focus/Linkages-to-the-resource-sector-GIZ-CCSI-2016.pdf.pdf*.

3.3.5. Recommendations for Africa to Phase Out Fossil Fuels

As the world ramps up efforts to achieve global climate change mitigation objectives, regardless of the weight and role African countries should or will have in that achievement, fossil fuel reserves will be considered stranded resources, becoming uneconomical to be explored. In addition, existing investments in fossil fuels and related infrastructure will become stranded assets, losing their economic value earlier than anticipated.[291] The stranding of fossil fuel resources and assets and the resulting need to phase them out will cause substantial negative impacts to both incumbent and new fossil fuel producers in Africa.

Africa should plan for a rapid fossil fuel phase-out for various reasons: to seize the increasing direct cost advantage of renewables, to minimize the economic costs imposed on Africans of the negative externalities associated with fossil fuels, to anticipate the drop in international prices and demand for fossil fuels, and to prepare for the reduced availability of international finance for fossil fuel investments.[292] Below are recommendations for African countries to manage their fossil fuel phase-out.

Adopting Legal and Policy Frameworks Conducive to the Phase-Out of Fossil Fuels

Current legal and policy frameworks in Africa aggravate existing fossil fuel–dependence on incumbent producers and encourage new producers to continue to hold overly optimistic expectations based on coal, oil, and gas. For instance, Nigeria's 2020 capital budget relied on plans to produce 2.1 million barrels of oil per day throughout the year at a price of USD 57 per barrel.[293] Coal and gas generation dominates the energy masterplans of countries in Eastern and Southern Africa. In 2040, the two regions expect 47% of total power to come from fossil fuels, even in their high renewable scenarios.[294]

African countries should adopt legal and policy frameworks with explicit energy transition strategies to provide market signals that Africa is determined to move away from fossil fuels in the long term. Beyond removing the existing inconsistent frameworks, governments can look for inspiration in established, internationally competitive fossil fuel producers outside Africa that are moving toward zero-carbon energy. For instance, despite being the least expensive and most competitive source of oil globally,[295] Saudi Arabia tripled its renewable energy target. The United Arab Emirates, another competitive oil producer, launched its "Energy Plan 2050," aiming to cut carbon dioxide emissions by 70%, improve energy efficiency by 40%,[296] and reach a 50% stake in clean energy by 2050.[297]

Adopting Reformed Industrial and Economic Diversification Policy and Creating More Jobs in Zero-Carbon Electricity Generation and Storage

As African countries move away from fossil fuels, they should also swiftly reform their industrial policies to green existing industries, enjoy the cost advantage of renewables, and secure a relevant role in markets that are forming or expanding significantly thanks to the energy transition and in which Africa has competitive advantages.[298] These

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[291] Kyra Bos and Joyeeta Gupta, "Stranded assets and stranded resources: Implications for climate change mitigation and global sustainable development," *Energy Research & Social Science* 56 (October 2019): 101215, *https://doi.org/10.1016/j.erss.2019.05.025*.

[292] E3G, "Public finance for fossil fuels – the beginning of the end?" *E3G* (blog), December 21, 2020, *https://www.e3g.org/news/public-finance-for-fossil-fuels-the-beginning-of-the-end*.

[293] Siva Prasad, "It Was Time for Africa."

[294] Seán Collins and Yunshu Li, "Africa's Energy Pathways Presentation," (presentation, Columbia University Workshop, July 2020).

[295] Espen Erlingsen, "Oil Production Costs Reach New Lows."

[296] Patrick Heller, "Fiscal Futures: Are National Oil Companies Champions or Obstacles for Energy Transition?" *International Budget Partnership* (blog), May 22, 2019, *https://www.internationalbudget.org/2019/05/fiscal-futures-are-national-oil-companies-champions-or-obstacles-for-energy-transition.*

[297] "UAE Energy Strategy 2050," United Arab Emirates Government, *https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/federal-governments-strategies-and-plans/uae-energy-strategy-2050*; Pilita Clark, "Kingdom Built On Oil Foresees Fossil Fuel Phase-out This Century," *Financial Times,* May, 21, 2015, *https://www.ft.com/content/89260b8a-ffd4-11e4-bc30-00144feabdc0*.

[298] United Nations Economic Commission for Africa (UNECA), *Economic Report on Africa 2016: Greening Africa's Industrialization* (Addis Ababa: Economic Commission for Africa, 2016), *https://repository.uneca.org/handle/10855/23017*.

markets include, for example, the production of green hydrogen[299] and the production and recycling of batteries (see Section 3.1.2).[300]

With a reformed industrial policy geared toward zero-carbon energy, industry, and jobs, Africa can ease its reliance on the collapsing fossil fuel industry, replace jobs lost, ensure long-term government revenues, and allow the continent's continued sustainable development in line with Agenda 2063.[301] The potential benefits of renewables in job creation are roughly three times higher than fossil fuel-based energy.[302] As of 2018, solar PV jobs in Africa represented 4% of 3.6 million jobs globally in the solar industry,[303] whereas Africa enjoys only 1% of the global solar PV installed capacity.[304] Togo has jumped on the bandwagon of the solar boom, creating five solar academies to train 3,000 technicians on solar kit maintenance and installation techniques (see Box 12). South Africa, which has adopted an energy transition strategy (see Section 3.1.2), stands to benefit significantly: as compared to a business-as-usual scenario based on the government's current projections and energy plans, if South Africa reaches net-zero by 2050, it will gain 3.3% in GDP, 18% in welfare impact,[305] and 1.2% in total employment (direct, indirect, and induced).[306]

Redirecting Oil and Gas Revenues Toward Diversification and the Zero-Carbon Energy Transition

Africa's fossil fuel–producing countries—whether established or new and regardless of how dependent they are on hydrocarbons—should immediately start to invest their fossil fuel revenues in industrial diversification and other policies to support the zero-carbon energy transition, ensuring that the exploitation of remaining African fossil fuel resources provides meaningful development opportunities rather than nourishing the fossil fuel sector. The sooner structural economic issues are addressed, the faster countries will reap the benefits of the transition. African countries may consider using their oil and gas revenues to improve institutional capacity to enact and enforce policy and monitor progress in the following key areas:[307]

- Minimization of the carbon footprint of remaining competitive fossil fuels (for example, by imposing stringent carbon emission standards, outlawing routine venting and flaring, and regulating non-routine flaring)
- Transparent and balanced fiscal frameworks for remaining competitive fossil fuel investments to support public investment in diversification;

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299 Global green hydrogen export market assessed to be worth US$300 billion yearly by 2050. Yahya Anouti, Shihab Elborai, Raed Kombargi, and Ramzi Hage, *The Dawn of Green Hydrogen: Maintaining the GCC's Edge in a Decarbonized World,* PwC Strategy& Report (PwC, 2020), *https://www.strategyand.pwc.com/m1/en/reports/2020/the-dawn-of-green-hydrogen/the-dawn-of-green-hydrogen.pdf*.

300 The global market value by 2025 of the battery making industry is assessed to be USD 1.18 trillion as compared to USD 11 billion for mining. Kwasi Ampofo, "Africa's COVID-19 Response within the Extractives Sector: Future of Mining" (PowerPoint presentation, Bloomberg NEF, December 2020).

301 African Union Commission, *Agenda 2063: The Africa We Want*.

302 Heidi Garrett-Peltier, "Green versus brown: Comparing The Employment Impacts of Energy Efficiency, Renewable Energy, and Fossil Fuels Using An Input-Output Model," *Journal of Economic Modeling* 61, (February 2017), *https://www.sciencedirect.com/science/article/abs/pii/S026499931630709X.*

303 International Renewable Energy Agency (IRENA), *Renewable Energy and Jobs* (Masdar City: IRENA, May 2018), *https://www.irena.org/publications/2018/May/Renewable-Energy-and-Jobs-Annual-Review-2018*.

304 Global Solar Council, "Global Solar Council supports new PV markets in Africa: collaboration for solar growth and universal access to electricity," *PV Magazine,* November 4, 2020, *https://www.pv-magazine.com/press-releases/global-solar-council-supports-new-pv-markets-in-africa-collaboration-for-solar-growth-and-universal-access-to-electricity/*.

305 As measured by the economic indicators (total employment, consumption and investment (i.e., current expenditure plus the future benefits of improved capital stock)), the social indicators (total (public and private) expenditure in education, and (reduction of) health impacts from air pollution), the environmental indicators ((reduction of) GHG emissions and the depletion of natural resources through consumption of materials (measured in direct material consumption of minerals and biomass for food and feed, excluding fossil fuel energy resources)). International Renewable Energy Agency (IRENA), *Global Energy Transition* (Abu Dhabi: IRENA, 2018), *https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Apr/IRENA_Report_GET_2018.pdf.*

306 International Renewable Energy Agency (IRENA), *Global Energy Transition*.

307 See: International Energy Agency (IEA), *Africa Energy Outlook 2019*, Ch. 4.3.2; Greg Muttitt and Sivan Kartha, "Equity, Climate Justice and Fossil Fuel Extraction: Principles for a Managed Phase Out," in "Curbing Fossil Fuel Supply to Achieve Climate Goals," special issue, *Climate Policy* 20, no. 8 (May 2020): 1024-1042, *https://doi.org/10.1080/14693062.2020.1763900*.

- Shared use of the infrastructure built or used by remaining competitive fossil fuel investments to leverage more co-benefits from the industry;
- Economic diversification, employment, education, and reskilling to guarantee a just transition for affected workers and communities;
- Support to small and medium enterprises (SMEs) to build domestic supply chains; and
- Sound management of resource revenues to finance the sustainable development agenda.

Avoiding and Minimizing Carbon Lock-in

African countries must proceed with caution to avoid and minimize locking in capital in coal, oil, and gas, as well as locking out zero-carbon alternatives. It has been suggested that Africa could respond to the resource and asset stranding risk "either by switching up a gear on renewable power in a bid to meet development and climate change goals or by pumping fossil fuels faster while they still can."[308] A more nuanced view is that African countries "need to be sensible in deciding which sectors to develop, focus on phasing-in low- to no-carbon technologies (leapfrogging carbon-intensive development) and avoid creating new stranded assets as a fossil fuel development model will be too risky, but they need to move fast as any delay in action will only increase the amount of stranded assets."[309]

In a zero-carbon pathway to 2050, no new investment is necessary for developing or expanding fossil fuel production, and market supply will be concentrated in a small number of low-cost oil and gas producers. At the same time, renewable electricity generation, transmission and distribution grids, charging points for EVs, battery production, and green hydrogen will require more investment.[310] Africa is a promising host for this investment: while it accounts for less than 10% of the global share of oil production, it is endowed with 39% of global technical solar and wind potential. Most North African countries and the Republic of South Africa have solar and wind technical potential 100 times greater than their current energy demand; this figure rises to above 1,000 times greater in most of sub-Saharan Africa.[311]

Accordingly, all African countries should focus on making zero-carbon energy investments, ramping up their solar, wind, hydropower, and other renewable generation as well as storage capabilities and electricity infrastructure, and recognizing that pursuing costly oil exploration and exploitation would likely prove to be an uneconomical course of action, leading eventually to stranded assets. Established fossil fuel producers, while continuing to exploit existing resources from operational investments only to the extent they might be competitive, should refrain from additional costly exploration and infrastructure expansions, particularly in coal and oil.

Limiting Investments in Fossil Gas and Related Infrastructure, Consistent with a Phase-Out by 2050

Whether and to what extent fossil gas should play a role in the transition from other fossil fuels to renewables is a contested topic in the literature. Some studies envision that a mix of technological solutions—including storage, grid development, demand management, and flexible renewables—would allow for a fully renewable-based grid, eliminating the need for fossil gas and avoiding asset stranding in fossil gas as a short-term "bridge" or transition fuel.[312] Others, though acknowledging the risk that fossil gas could lock out the development of renewables and would eventually need to be phased out as well, highlight how gas can help cut emissions from more carbon-intensive

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[308] Laurie Goering, "Pump Or Dump?"

[309] Bos and Gupta, "Stranded Asets and Stranded Resources."

[310] International Energy Agency (IEA), *Net Zero by 2050*, 21, 23.

[311] Carbon Tracker Initiative, *The Sky's the Limit: Solar and Wind Energy Potential Is 100 Times as Much as Global Energy Demand* (Carbon Tracker Initiative, April 2021), *https://carbontracker.org/reports/the-skys-the-limit-solar-wind*.

[312] Carbon Action Tracker, *FOOT OFF THE GAS: Increased Reliance on Natural Gas in the Power Sector Risks an Emissions Lock-in* (Carbon Action Tracker, June 2017), *https://climateactiontracker.org/documents/55/CAT_2017-06-16_DecarbNaturalGas_CATAnalysis.pdf*.

fuels (particularly coal)[313] and support renewables by "balancing intermittency, providing reliable energy, [and] offering affordable investments and consumer prices."[314]

For the IEA, even if it would be desirable for Africa to leapfrog to renewables, which should be developed as rapidly as possible, there would be opportunities for fossil gas to complement the expansion of sola PV and replace diesel and heavy fuel oil in sub-Saharan Africa, given the region's need to fuel industrial growth.[315]

Recent major gas discoveries in Egypt, Mauritania, Mozambique, Senegal, South Africa, and Tanzania could positively influence the outlook for some gas development. Higher supply capacity from foreign liquefied natural gas (LNG) producers abroad at low prices and technological innovations in LNG could also lead to a demand boost for African gas importers.[316] However, significant challenges persist for fossil gas in sub-Saharan Africa, including its small market size, infrastructure limitations, and affordability concerns.[317]

Possibly today's new technologies in compressed natural gas (CNG), mini- and small-scale LNG, and small-scale regasification plants could help address these challenges without locking in capital as the small size of infrastructure, in theory, should necessitate lower demand to reach breakeven, a shorter period of time to amortize and less capital to develop. These new technologies could also help commercialize associated petroleum gas, that could be flared otherwise, without incentivizing the extraction of excessive non associated gas fields to amortize the infrastructure.[318] As such, small-scale LNG is increasingly discussed as an opportunity to reach users in remote supply areas relying on expensive diesel through "virtual pipelines" (as used for transportation fuels).[319] As of today, however, even in the United States, "many projects fail to get off the ground due to the technical, financial, and logistical issues that [mini-LNG] developers often encounter."[320] In particular, despite the progress, depending on the technology, the small-scale infrastructure might still suffer from a lack of economies of scale.[321]

By the time the small-scale gas infrastructure, which is often discussed as a solution for Africa's context,[322] becomes reliably economical for the continent, the falling costs of renewable energy and batteries will likely make renewables the most reliable and affordable technology of choice. This is already the case in Europe, China, and Japan, where the benchmark LCOE for battery storage (4-hour duration) has dropped to USD 150/MWh, half of what it was in 2018.[323]

In light of these challenges and uncertainties, African countries choosing to afford a role for fossil gas in their energy transitions should limit their investments in fossil gas and associated infrastructure to those that minimize their LCOE and factor in negative externalities. The assessment of the economics of gas infrastructure should include a

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313 Akos Losz and Jonathan Elkind, "The Role of Natural Gas in the Energy Transition," (New York: Columbia SIPA Center on Global Energy Policy, September 2019), *https://www.energypolicy.columbia.edu/research/commentary/role-natural-gas-energy-transition.*

314 C. Gürsan and V. de Gooyert, "The Systemic Impact of a Transition Fuel: Does Natural Gas Help or Hinder the Energy Transition?" *Renewable and Sustainable Energy Reviews* 138 (March 2021): 110552, *https://doi.org/10.1016/j.rser.2020.110552*.

315 International Energy Agency (IEA), *Africa Energy Outlook 2019*, 170–171.

316 Ibid., 159–160.

317 Ibid., 170.

318 This is particularly true in the old oil fields, such as in Nigeria, where the associated gas is abundant and relatively less dependent on oil production.

319 Jinrui Zhang, Hans Meerman, René Benders, and André Faaij, "Comprehensive review of current natural gas liquefaction processes on technical and economic performance," *Applied Thermal Engineering* 166 (February 2020): 114736, *https://doi.org/10.1016/j.applthermaleng.2019.114736*.

320 Travis Bowman, "Driving the Viability of Micro-LNG Projects," Gas Processing & LNG, Gulf Publishing Holdings LLC, 2021, *http://gasprocessingnews.com/features/201910/driving-the-viability-of-micro-lng-projects.aspx*.

321 Ibid.

322 See for instance: Energy Futures Initiative, *Investing in Natural Gas for Africans: Doing Good and Doing Well* (Africa50, 2018), *https://www.africa50.com/fileadmin/uploads/africa50/Photos/Knowledge_Center/Investing_in_Natural_Gas_for_Africans_-_Doing_Good_and_Doing_Well.pdf*.

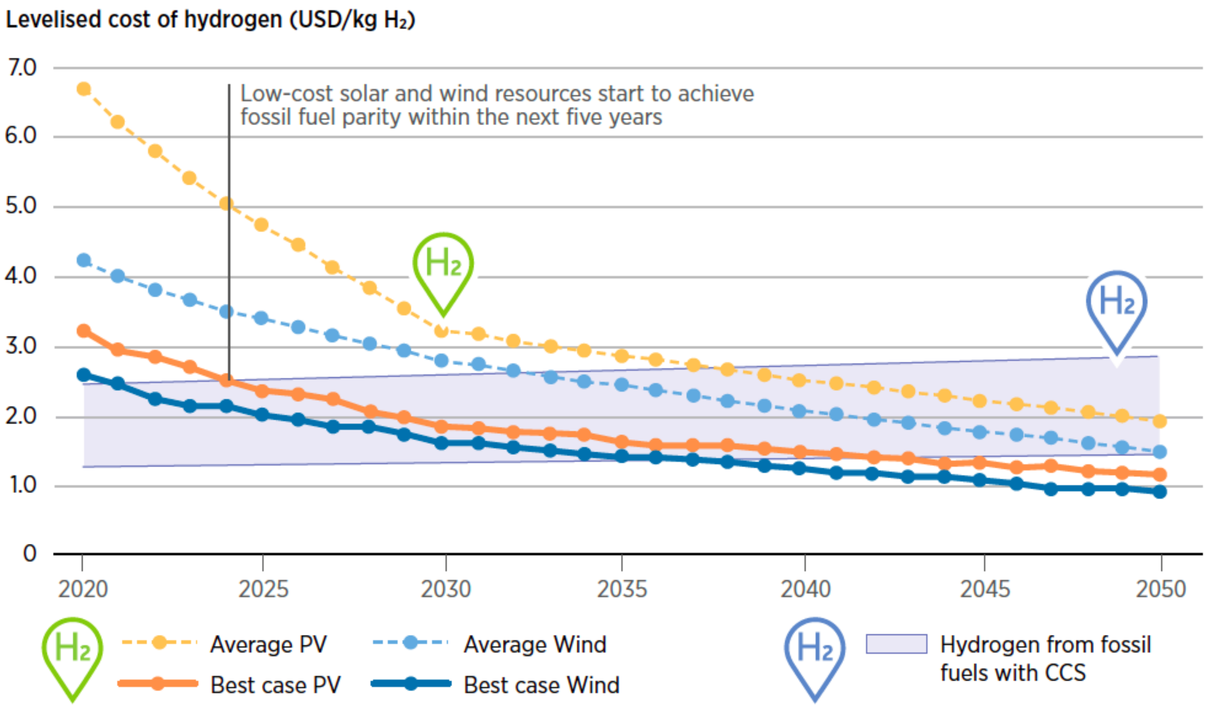
323 BloombergNEF, "Scale-up of Solar and Wind Puts Existing Coal, Gas at Risk," *Bloomberg NEF (*blog), April 28, 2020, *https://about.bnef.com/blog/scale-up-of-solar-and-wind-puts-existing-coal-gas-at-risk*.

comparison with the present and future economics of renewable energies associated with storage technologies and consider a timeline consistent with a phase-out by 2050.

Considering the Potential Role of Green Hydrogen Leveraging Existing Gas Infrastructure

Increasingly using fossil gas infrastructure for hydrogen and in future retrofitting it for use with green hydrogen only may further reduce stranded asset risks.[324] When not accounting for grey hydrogen's negative externalities, green hydrogen (produced from renewable energy) is still more expensive than grey hydrogen (produced from fossil fuels). However, the production costs of green hydrogen are falling due to diminishing costs of electrolyzers and renewable energy. Green hydrogen may become competitive with blue hydrogen (produced from fossil fuels while using carbon capture and storage) in the coming decades (see Figure 21).

Figure 21: Green hydrogen production costs versus grey hydrogen production costs



Note: Electrolyser costs: 770 USD/kW (2020), 540 USD/kW (2030), 435 USD/kW (2040) and 370 USD/kW (2050). CO_2 prices: USD 50 per tonne (2030), USD 100 per tonne (2040) and USD 200 per tonne (2050).

Source: IRENA[325]

Starting to blend hydrogen with fossil gas in pipeline networks at even a 5% penetration level would spur demand for green hydrogen and reduce its costs. Transporting hydrogen in existing and refurbished gas pipelines is still being studied, and those pipelines would need to be upgraded when hydrogen concentrations exceed 20% of the total gas.[326]

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[324] Davine Janssen, "Hydrogen Transport Costs Will Vary on a Case-by-case Basis, Industry Says," *EURACTIV*, October 14, 2020, *https://www.euractiv.com/section/energy/news/hydrogen-transport-costs-will-vary-on-a-case-by-case-basis-industry-says*.

[325] International Renewable Energy Agency (IRENA), *Global Renewables Outlook*, 181.

[326] International Energy Agency (IEA), *The Future of Hydrogen*.

However, IRENA notes that adjusting equipment standards to use more hydrogen may take time and that the potential for hydrogen should not serve as an excuse to build more pipelines for fossil gas.[327] As discussed in Section 3.1.2, Africa could also look at green hydrogen production, once competitive, for domestic use and export.[328]

Gas- and coal-based hydrogen is currently produced and used at an industrial scale in Africa to make ammonia-based fertilizers and refine oil (out of gas in Algeria, Egypt, and Nigeria and out of coal in South Africa). With the deployment of solar power and the technology evolution of hydrogen-making by water electrolysis, Africa could be well-positioned to make green hydrogen concurrent with the development of heavy industry such as steel in Africa.[329] Moreover, research is advancing to make hydrogen out of food waste, and a study in Nigeria has shown the potential to displace 6.05 million liters of diesel fuel through this method.[330]

Phasing Out Fossil Fuels Subsidies

While making energy more affordable could help achieve greater access to electricity and other social goals, fossil fuel subsidies (FFSs) are generally poorly designed and have negative economic, social, and environmental impacts. By distorting the energy market in a way that artificially lowers coal, oil, and gas prices, they discourage the deployment of renewables, impose significant costs on governments and taxpayers, disproportionately benefit the wealthiest consumers, and create incentives for energy waste and increased CO_2 emissions. The G20, the IEA, the International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development (OECD), and other organizations have, accordingly, been promoting FFS reform.[331]

The IEA's list of the top 25 countries by value of FFSs in 2019 includes four African countries—Algeria, Egypt, Libya, and Nigeria—with a combined amount of USD 35.3 billion in subsidies. Notably, in 2019 FFSs accounted for 16.7% of Libya's GDP, 7.6% of Algeria's, and 5.2% of Egypt's.[332] According to IMF data for 2017, FFSs were in place in 25 other African countries, amount to a total of USD 17.75 billion (see Table 5).

[327] International Renewable Energy Agency (IRENA), *Global Renewables Outlook*, 191.

[328] International Energy Agency (IEA), *The Future of Hydrogen*; Aurora Energy Research, "Hydrogen Could Be a €120 Billion+ Industry in Europe by 2050."

[329] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[330] T.R. Ayodelea, M.A. Alaob, A.S.O. Ogunjuyigbeb, and J.L.Munda, Electricity generation prospective of hydrogen derived from biogas using food waste in south-western Nigeria," *Biomass and Bioenergy* 127 (August 2019): 105291, *https://doi.org/10.1016/j.biombioe.2019.105291*.

[331] "Climate Change: Fossil Fuel Subsidies," International Monetary Fund (IMF), 2021, *https://www.imf.org/en/Topics/climate-change/energy-subsidies*; "Energy Subsidies: Tracking the Impact of Fossil-Fuel Subsidies," International Energy Agency (IEA), 2021, *https://www.iea.org/topics/energy-subsidies*; Organisation for Economic Cooperation and Development (OECD), "Governments Should Use Covid-19 Recovery Efforts as an Opportunity to Phase Out Support for Fossil Fuels, Say OECD and IEA," May 6, 2020, *https://www.oecd.org/environment/governments-should-use-covid-19-recovery-efforts-as-an-opportunity-to-phase-out-support-for-fossil-fuels-say-oecd-and-iea.htm*; Tim Gould, Zakia Adam, and Molly Walton, "Low Fuel Prices Provide a Historic Opportunity to Phase Out Fossil Fuel Consumption Subsidies," *IEA*, June 2, 2020, *https://www.iea.org/articles/low-fuel-prices-provide-a-historic-opportunity-to-phase-out-fossil-fuel-consumption-subsidies*.

[332] International Energy Agency (IEA), "Value of fossil-fuel subsidies by fuel in the top 25 countries, 2019," Last updated June 21, 2021, *https://www.iea.org/data-and-statistics/charts/value-of-fossil-fuel-subsidies-by-fuel-in-the-top-25-countries-2019*.

Table 5: Fossil fuel subsidies in Africa, 2017/2019

Region / % of FFSs in Africa	Country (Pre-tax values)	Fossil Fuel Subsidies	Year of Analysis	Value (billion USD)	% of GDP
Northern Africa	Algeria	Yes	2019	13.30	7.6
	Egypt	Yes	2019	15.90	5.2
	Libyan Arab Jamahiriya	Yes	2019	4.40	16.7
66.30%	Morocco	Yes	2017	0.40	0.4
	Tunisia	Yes	2017	1.17	2.9
Eastern Africa	Burundi	No	2020	-	-
	Comoros	Yes	2017	-	0.1
	Djibouti	No	2020	-	-
	Eritrea	No	2020	-	-
	Ethiopia	Yes	2017	0.01	0.3
	Kenya	No	2020	-	-
	Madagascar	No	2020	-	-
	Malawi	Yes	2017	0.15	2.4
	Mauritius	No	2020		
	Mozambique	Yes	2017	1.11	8.8
	Rwanda	Yes	2017	0.03	0.4
14.34%	Somalia	No	2020	-	-
	Sudan	Yes	2017	0.23	0.5
	South Sudan	No	2020	-	-
	Uganda	Yes	2013	0.38	1.5
	United Republic of Tanzania	Yes	2017b	1.06	2.0
	Zambia	Yes	2017	2.15	8.4
	Zimbabwe	Yes	2017b	2.49	14.1
Central Africa	Angola	Yes	2017	0.48	0.4
	Cameroon	Yes	2017	0.86	2.5
	Central African Republic	No	2017b	-	-
	Chad	No	2017b	-	-
	Congo	Yes	2017b	0.70	8.0
4.98%	Democratic Republic of the Congo	Yes	2020	0.60	1.5
	Equatorial Guinea	No	2017b	-	-
	Gabon	Yes	2017	-	0.0
	Sao Tome and Principe	No	2017b	-	-
Southern Africa	Botswana	Yes	2017	0.10	0.5
	Lesotho	No	2020	-	-
	Namibia	Yes	2017	0.10	0.7

Region / % of FFSs in Africa	Country (Pre-tax values)	Fossil Fuel Subsidies	Year of Analysis	Value (billion USD)	% of GDP
6.97%	South Africa	**Yes**	**2017a**	3.50	1.7
	Eswatini	**No**	**2020**	-	-
Western Africa	Benin	**No**	**2017b**	-	-
	Burkina Faso	**Yes**	**2017**	0.18	1.5
	Cape Verde	**Yes**	**2017b**	0.06	3.4
	Côte d'Ivoire	**Yes**	**2017b**	1.17	2.9
	Gambia	**No**	**2017b**	-	-
	Ghana	**No**	**2017**	-	-
	Guinea	**No**	**2017b**	-	-
	Guinea-Bissau	**No**	**2017**	-	-
7.41%	Liberia	**No**	**2020**	-	-
	Mali	**Yes**	**2017**	0.18	1.2
	Mauritania	**Yes**	**2017**	0.05	1.1
	Niger	**No**	**2017b**	-	-
	Nigeria	**Yes**	**2019**	1.70	0.4
	Senegal	**Yes**	**2017**	0.59	2.8
	Sierra Leone	**No**	**2017b**	-	-
	Togo	**No**	**2017b**	-	-

Source: Prepared by the authors based on IMF.[333]

FFS reform is advancing, including in Africa. Taking advantage of low oil prices in 2014 and 2015, Morocco phased out consumption subsidies (with the exception of bottled butane), with petrol and diesel prices now linked to the international market.[334] Other countries are following suit. For example, Egypt committed to reduce fuel subsidies by 40% and electricity subsidies by 75% in the 2019–2020 financial year.[335] Even so, the figures above—and troubling examples of policy reversals or postponements[336]—indicate that more work is needed to remove FFSs across Africa.

The 29 African countries with FFS in place, with a total value amounting to USD 53.5 billion, should initiate or expedite FFS phase-outs, drawing inspiration from Morocco, for example, and taking the "golden opportunity" of the low fuel prices resulting from the COVID-19 crisis to eliminate FFS. Lower prices make fossil fuel subsidy removal easier for importers because of the smaller adjustment of end-user prices and impact on inflation. This is also the case for fossil fuel-producing countries, for whom lower prices mean significant revenue losses and pressures on public finances and the broader economy. Importantly, subsidy removal should be accompanied by broader energy policy measures

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[333] 2019 Data: "Climate Change: Fossil Fuel Subsidies," IMF, *https://www.imf.org/en/Topics/climate-change/energy-subsidies*; 2017 Data: UNEP, OECD, and IISD, *Measuring Fossil Fuel Subsidies in the Context of the Sustainable Development Goals* (Nairobi: UN Environment, 2019), *https://wedocs.unep.org/bitstream/handle/20.500.11822/28111/FossilFuel.pdf*; and 2017b Data: "Green Fiscal Policy Network," Green Fiscal Policy Network, UN Environment Programme, IMF, and GIZ, 2020, *https://greenfiscalpolicy.org*.

[334] "Data and Statistics," IEA, *https://webstore.iea.org/download/summary/2736?fileName=IDR_Morocco_ES_UK.pdf*; IEA, "International Energy Agency Publishes New Review of Morocco's Energy Policies," May 7, 2019, *https://www.iea.org/news/international-energy-agency-publishes-new-review-of-moroccos-energy-policies*; World Bank Group, *Morocco Energy Policy MRV: Emission Reductions from Energy Subsidies Reform and Renewable Energy Policy* (June 2018), *http://documents1.worldbank.org/curated/en/964331541085444404/pdf/Morocco-Energy-Policy-MRV.pdf.*

[335] Gould, Adam, and Walton, "Low Fuel Prices Provide a Historic Opportunity To Phase Out Fossil Fuel Consumption Subsidies."

[336] Ibid.

targeted at protecting vulnerable consumers and promoting renewables.[337] As the OECD suggests, "money spent supporting coal, oil, and gas could instead be invested in sustainable energy infrastructure, research and job training."[338]

Repurposing National Oil Companies for the Zero-Carbon Energy Transition

African countries that have national oil companies (NOCs) should redirect the core activities of their NOCs toward the zero-carbon transition. This process might start with winding down the commercial role of NOCs and turning them into strict regulatory entities. This kind of reform is critical when the revenues held by the NOC, and therefore dedicated to fossil fuels, are much higher of the revenues invested in other development priorities. For instance, in 2015, the sales revenues of the Nigerian National Petroleum Corporation (NNPC), Nigeria's NOC, "were more than 5 times the country's health expenditure, nearly 7 times its foreign aid receipts, and more than 15 times the value of the country's sovereign wealth fund.[339] Box 16 presents critical reform efforts recommended for NNPC that can be useful to other African NOCs as they reconsider their role and repurpose themselves for the energy transition.

Box 16: Critical reform efforts for NNPC to become a player in the zero-carbon transition

"Critical reforms should focus on:

- Hiring expertise to develop an energy transition plan for Nigeria and run an institutional analysis of the role of each key public or private institution in the energy transition, including NNPC.
- Reforming NNPC to ensure it can play this role by:
  - making NNPC independent from political interference at all operational and management levels, reducing opportunities for corruption,
  - enshrining transparency and internal as well as external oversight in NNPC's governance framework,
  - legally clarifying its funding mechanism and revenue retention model,
  - institutionalizing principles of climate change governance,
  - *if profound reform is not feasible for lack of political champions inside the government or within NNPC, a better avenue would be to privatize NNPC or, at least, privatize some of its subsidiaries*.
- Setting up a separate division of NNPC or, in the case of NNPC privatization, an independent entity with clear objectives related to the energy transition that are measured by transparent and auditable metrics. This division or entity would be in charge of developing a timeline to eliminate routine flaring and minimize non-routine venting and flaring for existing fields; developing criteria to award new fields in accordance with a stranded asset risk analysis; and establishing carbon emission standards.
- Identifying funding sources for this new division or entity in advance and in ways that incentivize desired results."

Source: CCSI.[340]

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[337] Ibid.; Organisation for Economic Cooperation and Development (OECD), "Governments Should Use Covid-19 Recovery Efforts as an Opportunity to Phase Out Support for Fossil Fuels, Say OECD and IEA."

[338] Ibid.

[339] Perrine Toledano, Martin Dietrich Brauch, Tehtena Mebratu-Tsegaye, and Francisco Javier Pardinas Favela, *Equipping the Nigerian National Petroleum Corporation for the Low-Carbon Transition: How Are Other National Oil Companies Adapting?* (New York: CCSI, 2020), *http://ccsi.columbia.edu/files/2020/09/CCSI-NNPC-Nigerian-National-Petroleum-Corporation-Low-Carbon-Transition-rev.pdf*.

[340] Ibid.

Cutting Public Financing for Fossil Fuel Investment

As countries recognize the need to transition away from fossil fuels and toward renewables, they must also redirect the lending policies of national and multilateral development banks (MDBs) and development finance institutions (DFIs) accordingly, so that public finance for development does not counter energy and climate policy goals. This redirecting is yet to happen, neither globally nor in Africa, and recent numbers indicate concerning trends.

A July 2018 report focused on public finance for energy infrastructure in Africa between 2014 and 2016 found that, on average, fossil fuel investments received an average of USD 11.7 billion of public finance per year, including from China, the World Bank Group, several European countries, and the European Investment Bank (EIB). According to the report, this figure represents 58.9% of public finance for energy infrastructure in Africa.[341]

Some development finance institutions are slowly taking steps to change this landscape. In December 2017, the World Bank Group announced that it would no longer finance upstream oil and gas investments after 2019.[342] The EIB launched a new climate strategy and energy lending policy in November 2019, committing to end "new financing for unabated, fossil fuel energy projects, including gas, from the end of 2021 onwards."[343] And, at a November 2020 summit, 450 of the world's public development banks pledged to "consider the range of fossil fuel investments in our portfolios, avoid stranded assets, and work towards applying more stringent investment criteria, such as explicit policies to exit from coal financing,"[344] even though shying away from a more forceful commitment to "develop explicit policies to exit from or reduce fossil fuels investments" (including oil and gas) included in an earlier draft.[345]

The AfDB had already announced in September 2019 that it would no longer finance coal projects (which in practice it had anyway not done since 2015), thus catching up with other MDBs with similar policies, such as the World Bank Group, the European Bank for Reconstruction and Development, and the EIB. Though committed to help African countries transition away from oil and gas, the AfDB should also conduct economic analysis with a view to progressively eliminate finance for midstream and downstream fossil fuel projects,[346] which both international and African stakeholders have called on the bank to exclude from its portfolio.[347]

Research shows that the role of development finance institutions in securing concessional finance and de-risking investments increases the likelihood of success of energy projects, particularly in countries that are starting to deploy new technologies.[348] These institutions should, therefore, move away from facilitating fossil fuel investment and leverage their strength, instead, to facilitate investments in renewables.

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[341] Allison Lee and Alex Doukas, *Assessing International Public Finance for Energy in Africa: Where Do Development and Climate Priorities Stand?* (Washington DC: Oil Change International, 2018), *http://priceofoil.org/content/uploads/2018/07/africa_finance_report_final_web.pdf*.

[342] World Bank Group, "World Bank Group Announcements at One Planet Summit," Press release (December 12, 2017), *https://www.worldbank.org/en/news/press-release/2017/12/12/world-bank-group-announcements-at-one-planet-summit*.

[343] European Investment Bank, "EU Bank Launches Ambitious New Climate Strategy and Energy Lending Policy," Press release (November 14, 2019), *https://www.eib.org/en/press/all/2019-313-eu-bank-launches-ambitious-new-climate-strategy-and-energy-lending-policy*.

[344] Finance in Common, *The first global summit of all Public Development Banks: Join Declaration of All Public Development Banks in the World* (FiC, November 2020), *https://financeincommon.org/sites/default/files/2020-11/FiCS%20-%20Joint%20declaration%20of%20all%20Public%20Development%20Banks.pdf*.

[345] Kate Abnett, Simon Jessop, and Matthew Green, "Development Banks Make Landmark Climate Pledge, But No Fossil Fuel Phase Out," *Reuters*, November 11, 2020, *https://www.reuters.com/article/us-climate-change-finance-development-idUSKBN27R30D*.

[346] Sara Jerving, "African Development Bank commits to coal-free financing," *Devex* (blog), September 26, 2019, *https://www.devex.com/news/african-development-bank-commits-to-coal-free-financing-95698*.

[347] Alex Doukas, "Response to African Development Bank's commitment to stop financing coal," Oil Change International, (press release, September 25, 2019), *http://priceofoil.org/2019/09/25/response-to-african-development-banks-commitment-to-stop-financing-coal*; Boris Ngounou, "Africa: NGOs Call for a Total End to AfDB Support for Fossil Fuels," *Afrik21*, November 2, 2020, *https://www.afrik21.africa/en/africa-ngos-call-for-a-total-end-to-afdb-support-for-fossil-fuels*; United Nations, "Secretary-General Urges Finance Ministers to Ensure Development Banks Policies, Portfolios Align with Goals of Paris Agreement on Climate Change," Press release (October 12, 2020), *https://www.un.org/press/en/2020/sgsm20330.doc.htm*.

[348] Galina Alova, Philipp A. Trotter, and Alex Money. "A Machine-Learning Approach to Predicting Africa's Electricity Mix Based on Planned Power Plants and Their Chances of Success." *Nature Energy* 6, no. 2 (2021): 158–166, *https://www.nature.com/articles/s41560-020-00755-9*.

The AU, the AfDB, and African states should seize the global momentum to commit to reducing and ultimately eliminating public financing for investments not only in coal but also in oil and gas exploration, exploitation, and related infrastructure. The reduction could be more gradual when it comes to gas-to-power projects when the economic and electricity analysis show their value to increase electricity access. At the same time, they should ensure to redirect these public resources to investments in renewable energy generation and energy efficiency, building on the continent's renewable energy riches and preparing it for the zero-carbon future. As potential beneficiaries of high-return energy investments, African countries and institutions should also express to non-African national and multilateral providers of development finance that the continent seeks to attract investments not in coal, oil, and gas but in zero-carbon energy.

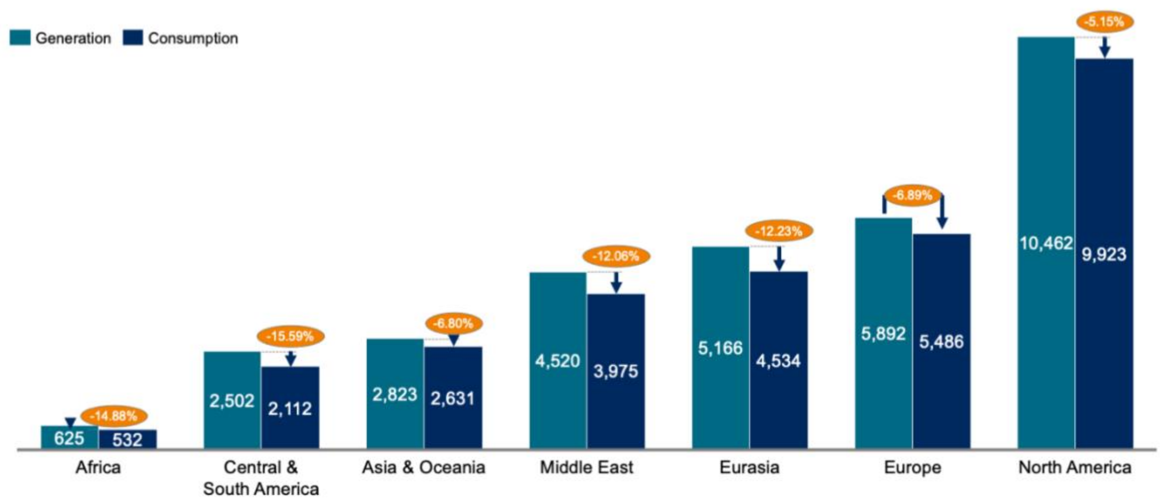
3.4. A Timeline for Energy Development from 2021 to 2050

3.4.1. Starting Point in 2021

Electricity

Africa continues to lag other continents on electricity consumption and generation (Figure 22).

Figure 22: Electricity generation and consumption per capita, 2018, kWh



Source: Prepared by the authors based on the World Bank's Global Electrification Database (GED).

While renewable energy sources are plentiful, they only made up 20% of the installed electricity generation capacity,[349] and renewables-based electricity accounts for only 3.2% of Africa's energy consumption (Figure 23).

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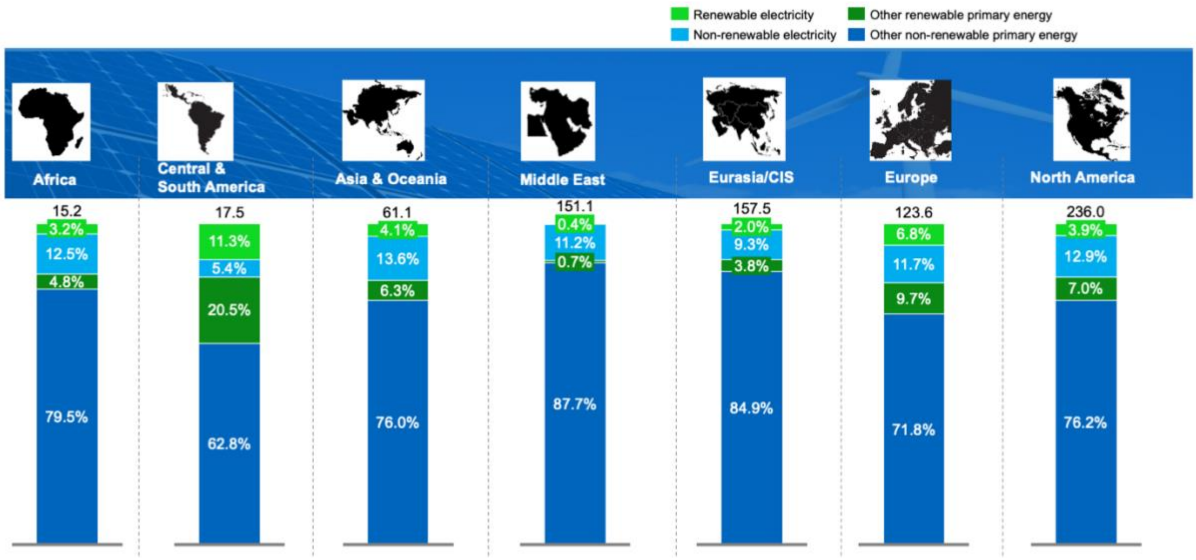
[349] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

Figure 23: Share of energy consumption by source in major regions globally



Source: Prepared by the authors based on BP Statistical Review of World Energy 2020.

Africa's transmission and distribution system needs tremendous strengthening to avoid the incidence of power outages and reduce network losses (18% today) to an acceptable level.[350]

In addition, power trade across the region remains low and is mostly conducted through bilateral contracts. The Southern African Power Pool (SAPP) is the only fully functioning and advanced power pool. Some countries sit outside of the regional grids, and often transmission interconnections are congested and need upgrades.[351]

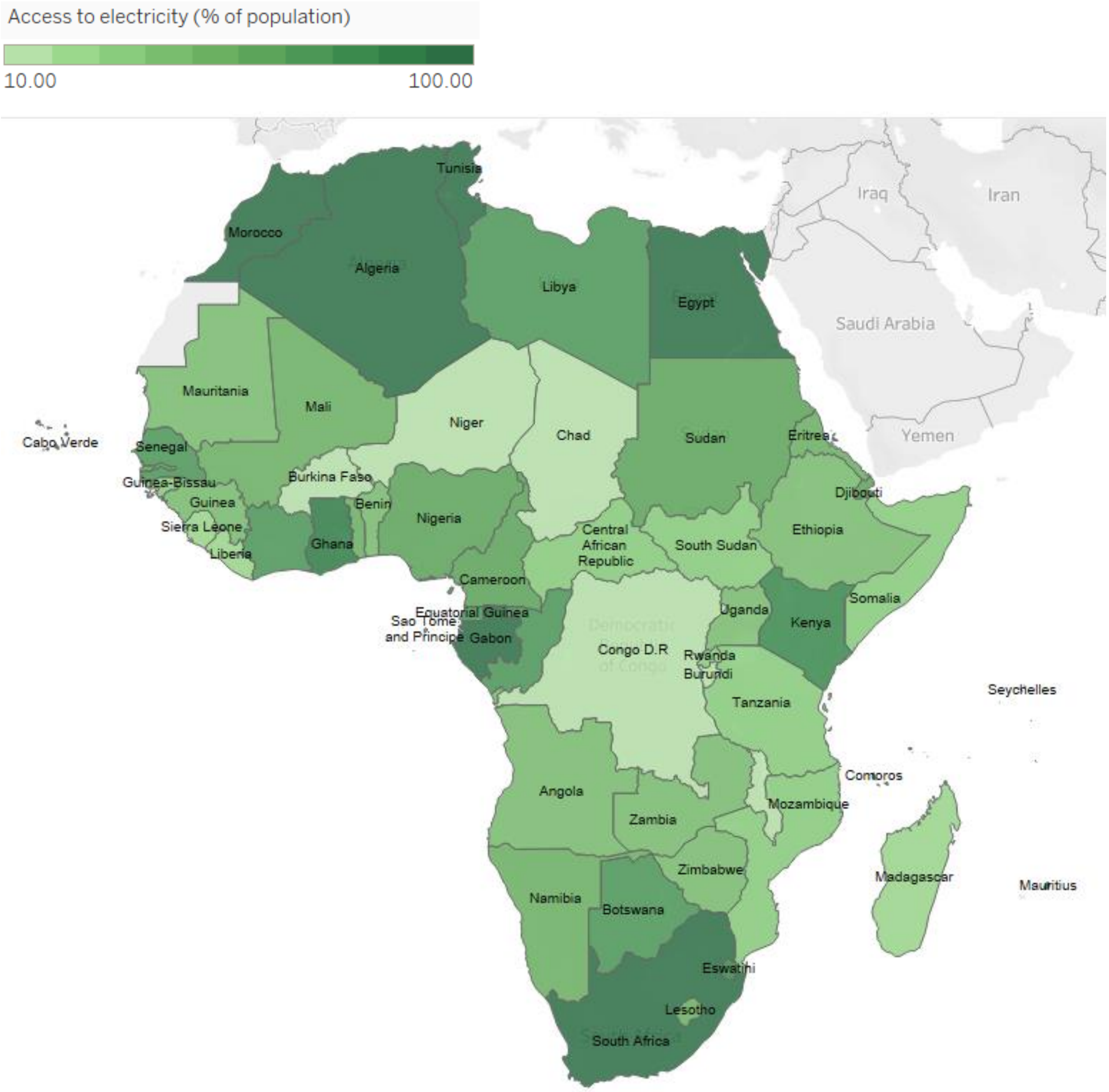
Access to electricity varies by region (see Figure 24), and the disparity is more pronounced in rural areas: NA at 99%, RSA at 71%, and other SSA countries at 16%.[352] The IEA estimates that 600 million people do not have access to electricity in Sub-Saharan Africa (excluding the Republic of South Africa), out of a total population of 1.1 billion.

[350] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[351] Ibid.

[352] Ibid.

Figure 24: Access to electricity (% population)



Source: Prepared by the authors based on World Bank, Sustainable Energy for All (SE4ALL) database.

In addition, the cost to obtain a permanent electrical connection is three times higher than the global average and 52 times higher than in high-income OECD countries (Figure 25).[353] Between 2006 and 2018, around 80% of businesses in Sub-Saharan Africa, excluding South Africa, suffered from frequent electricity disruptions, averaging six hours in length and causing losses of around 8% of annual sales, on average.[354] Similarly worrisome is the proportion of people with access to clean cooking in sub-Saharan Africa: only 17%.[355]

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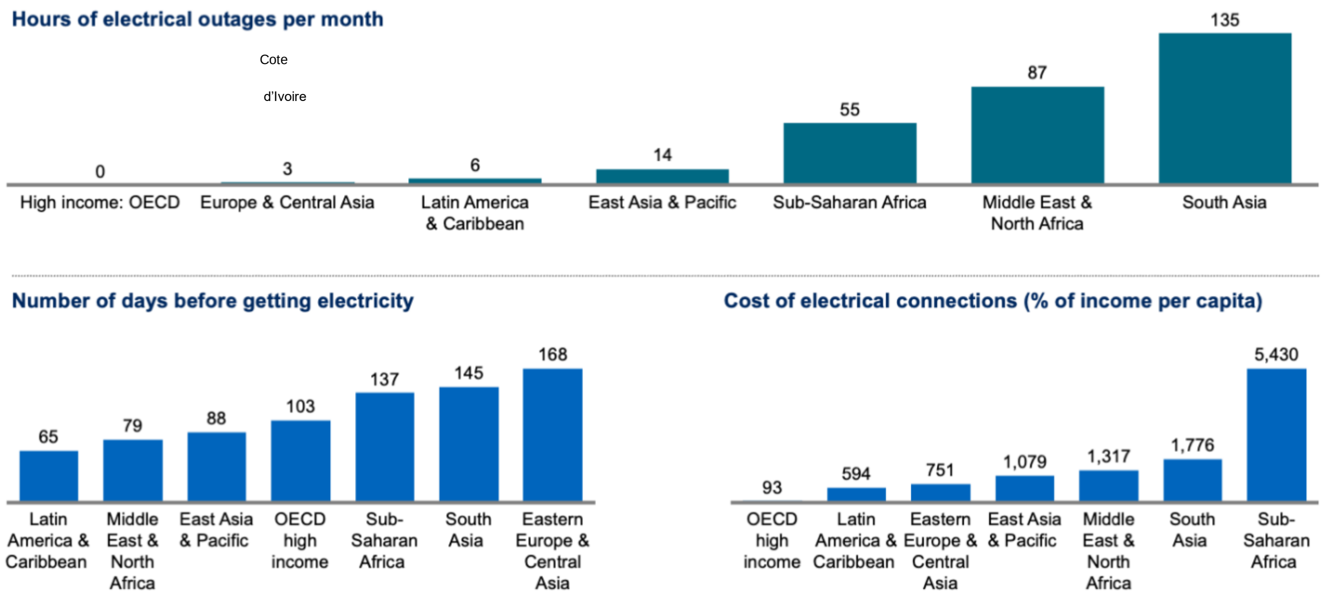
[353] World Bank Group, *"Doing Business 2020: Fact Sheet – Sub-Saharan Africa,"* (World Bank, 2020), *https://www.doingbusiness.org/content/dam/doingBusiness/pdf/db2020/DB20-FS-SSA.pdf*.

[354] World Bank Group, "Underutilized Potential: The Business Costs of Unreliable Infrastructure in Developing Countries," (World Bank Group Policy Research working paper, Washington, DC: World Bank, June 2019), *http://documents.worldbank.org/curated/en/336371560797230631/Underutilized-Potential-The-Business-Costs-of-Unreliable-Infrastructure-in-Developing-Countries*.

[355] As of 2018: "SDG7: Data and Projections: Access to clean cooking," International Energy Agency (IEA), October 2020, *https://www.iea.org/reports/sdg7-data-and-projections/access-to-clean-cooking.*

Figure 25: Electricity availability, accessibility, and affordability compared across global regions



Source: Prepared by the authors based on the World Bank Doing Business database.

Digitization

In the last decade (2010–2019), Africa's household and individual internet access rates have tripled. While fixed broadband subscriptions have only grown by 3 million (0.3% points per capita) in this period, mobile broadband has become increasingly adopted across the continent, growing 18-fold and becoming the primary means by which Africans access the internet, with 89% of the population covered by a 3G network in 2019.[356]

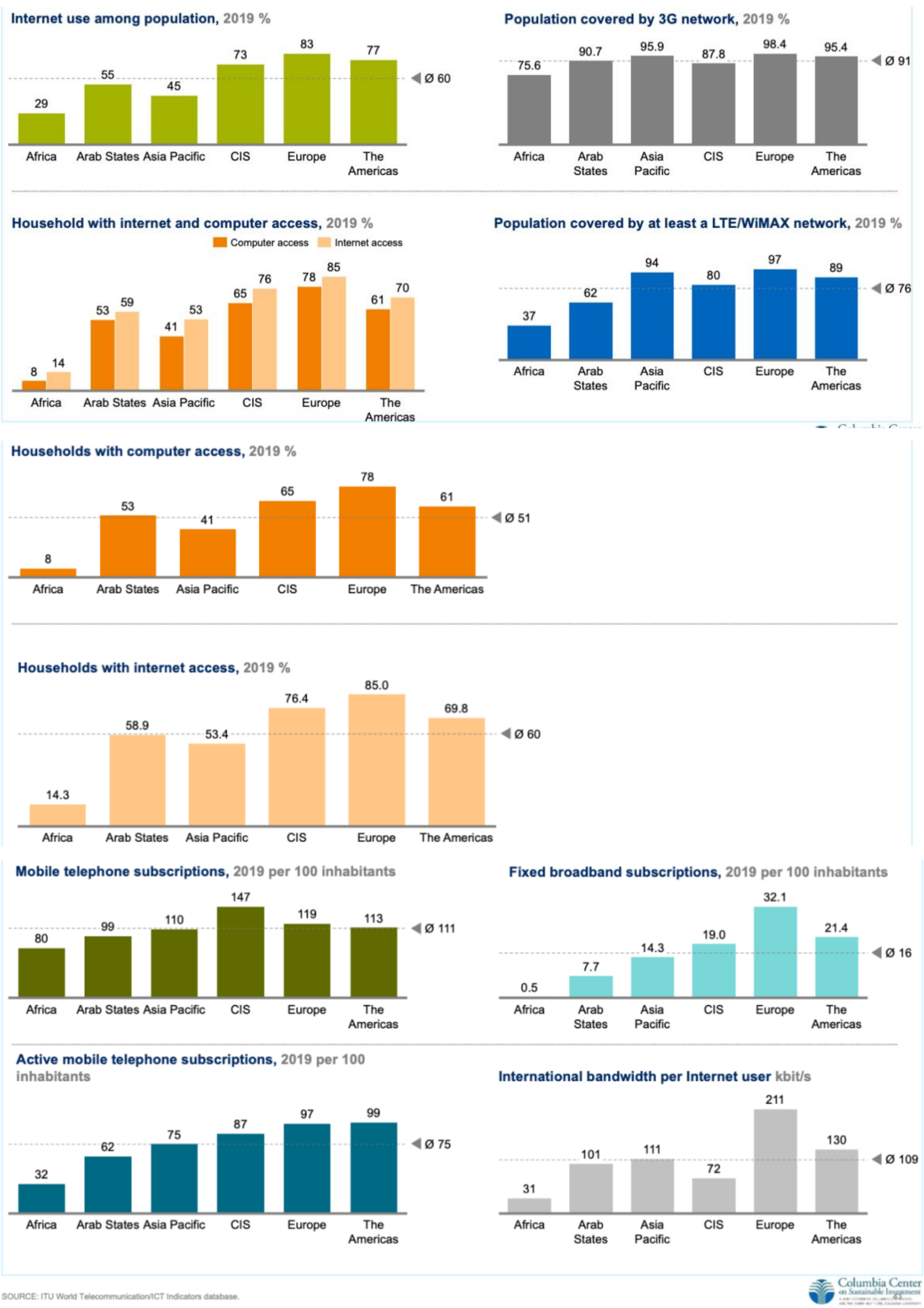
However, this growth has not been uniform across the continent. For example, while 98% of the North African population is covered by 3G, this figure is only 67% in Sub-Saharan Africa.[357] While 90% of Kenyans have internet access, only 5% of Burundians do. In addition, speed and affordability are still a problem. The average mobile broadband speed of 2.7 Mbps is still half the global average, and fixed broadband connections cost 37% of the average national income in Africa, compared to 15% globally.[358] See Figure 26 for the range of digital connectivity indices.

[356] World Bank Group, *Connecting Africa Through Broadband: A strategy for Doubling Connectivity by 2021 and Reaching Universal Access by 2030* (Broadband Commission for Sustainable Development, ITU, and UNESCO, October 2019), *https://www.worldbank.org/en/topic/digitaldevelopment/publication/connecting-africa-to-broadband-a-roadmap-for-inclusive-growth*.

[357] Ibid.

[358] Brahima S. Coulibaly (ed.), *Foresight Africa: Top Priorities for the Continent 2020–2030* (Brookings Africa Growth Initiative,2020), *https://www.brookings.edu/wp-content/uploads/2020/01/ForesightAfrica2020_20200110.pdf*.

Figure 26: Key indices of digital connectivity in Africa and other global regions



Source: Prepared by the authors based on the ITU World Telecommunication/ICT Indicators database.

Note: CIS is the Commonwealth of Independent States region.

3.4.2. Milestones to be Achieved by 2030, 2040, and 2050

Table 6 illustrates milestones that Africa could pursue every decade to achieve the continent's energy transformation. Targets are illustrative and only provide the direction of travel. They are inspired by the most ambitious but realistic plans developed by experts. While targets should be developed based on a range of studies that should be already conducted in 2021, setting a long-term strategy and short-to-medium-term targets will guide implementation and garner political buy-in across the continent. The AU has done it in several strategic documents and should do it for the energy transition. See Section 5 for further details.

Table 6: Milestones of Africa's zero-carbon energy development 2021–2050

	Sector	Indicator	2021- 2023	2030	2040	2050
Industrial Policy	Skill development to reach to seize the opportunities of the energy transition	Skill development target (e.g. number of local workers trained for zero-carbon sectors)	Skill diagnostic study to establish the skills to be developed in each country	50%	75%	100%
	Update AMV to seize the energy transition opportutnities	Completion of the reform	100%			
	Solar panels and wind turbine production, battery production and recycling, green hydrogen production	Industrial target achievement (e.g. % of value added to be reached) to be set at AU level with member states, continent-wide and at country level	Develop/ Finalize the market study and endorse at AU level	25%	60%	100%
Energy tranformation	Renewables in the energy mix	% of renewables in the energy mix	Update of law and policy framework for renewables	60%	75%	100%
	Phase-out of fossil fuels	Completion of the strategy analyzing stranded asset risks and how to optimize competitive oil and gas for country's needs	100%			
	Remove fossil fuel subsidies	% of the value of subsidies removed continent wide	15%	100%		
	Electrification	Electricity as % of final energy consumption (transport, industry, residential uses)	Plan and institutions for massive electrifiction of end use	25%	35%	50%
	Siting policies	Review, reform, and update to avoid and mitigate social and environmental externalities	100%			
Central Grid	Digitization infrastructure	Investment program	Assess digital infrastructure gap and development national plans to implement the AU's Digitization Transformation Strategy (2020-2030)	Finish installation of and connections to fiber optics + full coverage by 4G	Achieve 50% coverage by 5G (or improved technology)	Achieve 100% coverage by 5G (or improved technology)
	Generation	Installed capacity expansion (% of completion)	Plan for priority utility scale projects and assessment of needed installed capacity for each decade	50% of installed capacity	75% of capacity	100% of capacity
	Transmission	% of grid covered by improvement	Plan for strengthening of the grid (inc. digitization and compatibility with REO	50% of grid	80% of grid	100% of grid
		% of system losses	Plan to reduce losses	15%	12%	10%
	Distribution	Grid densification and extension (% of completion)	LCOE plan for all urban and peri-urban areas and affordability analysis to target under the grid communities	50% planned extension	75% planned extension	100% planned extension
		Collection rate	Plan to improve collection rates	80% of customers	100% of customers	
		Smart meter installation	Plan for smart meter deployment	40% of customers	85% of customers	100% of customers
	Regional integration	Fully functioning power pools (% of completion)	Plan and analysis	100%		
		DC links between power pools (% of completion)	Plan and analysis	25%	50%	100%
		International DC links (% of completion)	Plan and analysis	25%	50%	100%
Decentralized grid	Off-grid solutions	Educational outreach penetration in rural areas	100% of communities			
		Affordability analysis	100% of countries			
		% of rural areas reached by off -grid solutions at level 1 (min 12 Wh)	LCOE-based plan for all rural areas	100%		
		% of rural areas reached by off -grid at level 2 (min 200 Wh)	LCOE-based plan for all rural areas	50%	100%	
		% of rural areas reached by off-grid at level 3 or more (min 1000 Wh)	LCOE-based plan for all rural areas	25%	50%	100%
Transportation	Electric private vehicles	% of light-duty vehicles	Develop stringent fuel efficiency standards on imports	30%	50%	100%
	Electric or hydrogen-based public transport (passenger and cargo)	% of public bus fleet as electric or fueled by green hydrogen	Develop stringent fuel efficiency standards on imports	50%	100%	
		Functioning electric train lines on main strategic axes of the continent (% of completion of plans)	Develop the plan	25%	45%	65%
		% of cargo trucks as fueled by green hydrogen or biofuels	Develop the plan	25%	60%	100%
	Charging stations	Deployment as compared to need in %	Prepare policy and regulatory framework for EV penetration	25%	60%	100%

Source: Prepared by the authors.

4. Financing Strategy

As explained in Section 1, we roughly estimate that zero-carbon mass electrification of Africa by 2050, with most advances by 2030, will require an investment of roughly USD 136 billion per year. As compared to other studies, we target a somewhat higher level of electricity consumption, in rural areas in particular, and we assume that almost all new generation investment of the continent will be in renewable energies, with the unit cost of renewable energies dropping by one-third in 2030 and again in 2050.

The challenge is not unsurmountable: India and China have, respectively, invested 2.6% and 1.9% of their GDP since 2000.[359] By comparison, we assess that this investment will cost Africa around 2% of the continent's yearly GDP, on average, over 2020–2050.

Infrastructure financing by both China and India has a lot of lessons to teach African countries. China has relied on low-cost sovereign borrowing to finance large-scale projects,[360] while India has developed innovative financing approaches to mobilize private financing. Both approaches will be discussed below.

Planning for clean energy infrastructure deployment to ensure continent-wide electricity access should include solutions for financing adapted to the type of investment, both through massive MDB and DFI low-cost concessional financing (Section 4.1) and building local investment management capabilities with African governments (Section 4.2).

4.1. MDB and DFI Financing

In 2019, MDBs' contribution to climate finance[361] stood at USD 61.6 billion,[362] up 43.1% from 2018, and close to their target to reach USD 65 billion by 2025.[363] Low- and middle-income countries received 67% of those funds, and 76% (46.6 billion) of those funds went to climate change mitigation. Additionally, USD 102.7 billion were mobilized in co-financing (by other public[364] and private actors mobilized by the MDBs through blended finance) close to the 2025 target of USD 110 billion. Of this amount, USD 83.2 billion was allocated to mitigation. Low- and middle-income countries benefited from 36% (USD 30 billion) of mitigation co-financing.[365]

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[359] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[360] See for instance the Chinese "Tianjin model" that has underpinned the massive deployment of infrastructure in China in the last 20 years. Yongzhong Wang, *The Sustainable Infrastructure Finance of China Development Bank: Composition, Experience and Policy Implications* (Boston University Global Economic Governance Initiative working paper, Boston, MA: Boston University, July 2016), *https://www.bu.edu/pardeeschool/files/2016/07/Wang.New_.Final_.pdf*.

[361] Data gathered by the joint report on climate finance from financing contribution made by African Development Bank, the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), the European Investment Bank (EIB), the Inter-American Development Bank Group (IDB Group), the World Bank Group (WBG), the Islamic Development Bank (IsDB), and the Asian Infrastructure Investment Bank (AIIB). African Development Bank (AfDB), Asian Development Bank (ADB), Asian Infrastructure Investment Bank (AIIB), European Bank for Reconstruction and Development (EBRD), European Investment Bank (EIB), Inter-American Development Bank Group (IDBG), Islamic Development Bank (IsDB), and World Bank Group (WBG), *2019 Joint Report on Multilateral Development Banks' Climate Finance* (August 2020), *https://www.isdb.org/sites/default/files/media/documents/2020-08/1257-joint-report-on-mdbs-climate-finance-2019-final%5B1%5D.pdf*.

[362] Representing on average 35% of the MDB's finance. Joe Thwaites, "The Good, the Bad and the Urgent: MDB Climate Finance in 2019," *World Resources Institute* (blog), August 18, 2020, *https://www.wri.org/blog/2020/08/mdbs-climate-finance-insights-2019*.

[363] Alex Clark, June Choi, Bella Tonkonogy, Valerie Micale, and Cooper Wetherbee, *Implementing Alignment with the Paris Agreement: Recommendations for the Members of the International Development Finance Club* (Climate Policy Initiative (CPI) and Institute for Climate Economics (I4CE), 2019), *https://unfccc.int/sites/default/files/resource/Aligning%20with%20the%20Paris%20Agreement%20-%20Part%202%20-%20CPI-I4CE.pdf*; African Development Bank (AfDB) et al., *2019 Joint Report on Multilateral Development Banks' Climate Finance*.

[364] Through, for instance, the Climate Investment Funds (CIF), the Global Environment Facility (GEF) Trust Fund, the Global Energy Efficiency and Renewable Energy Fund (GEEREF), the European Union's funds for Climate Action, and the Green Climate Fund (GCF).

[365] African Development Bank (AfDB) et al., *2019 Joint Report on Multilateral Development Banks' Climate Finance*.

4.1.1. Insufficient Climate Finance Mobilization

While the MDBs are on track to reach their collective target, and many of their individual targets,[366] they fall very far short of what is needed. As noted in Section 2, to build a robust zero-carbon electricity system to achieve mass electrification, Africa needs roughly USD 136 billion per year, and Sub-Saharan Africa, other than Southern Africa, needs USD 105 billion per year. This compares to a current MDB mobilization of USD 3.8 billion per year for Sub-Saharan Africa in climate mitigation, of which only USD 2.3 billion per year went to building the zero-carbon energy system.[367] In addition, of the global amount of co-finance that went into climate mitigation in low- to middle-income countries (USD 30 billion[368]), we may assume that only around USD 2.5 billion went to zero-carbon energy systems in Sub-Saharan Africa.[369]

From other estimates, we obtain that, in 2018, the private sector roughly invested USD 5 billion in energy in Africa and, in 2019, renewable energy investments from all sources were less than USD 4 billion.[370]

In short, there is a need to increase climate finance (MDBs and co-finance) mobilization for energy systems in Africa by 10-20 times per year to achieve zero-carbon mass electrification by 2030.

Africa's historical contribution to greenhouse gas emissions has been minuscule, and as such, Africa is incurring net damages from climate change that are hugely disproportionate to Africa's contribution. Africa has the right to receive significant international official financing for mitigating and adapting to climate change.[371]

4.1.2. Insufficient Concessional Funding

Moreover, 73% of climate finance mitigation is committed through investment loans, and only 6% through grants and 3% through guarantees (see Figure 27).

[366] Thwaites, "The Good, the Bad and the Urgent."

[367] The remaining 1.5 billion was allocated to other decarbonization issues such as agriculture, forestry, waste and waste water, non-energy GHG reduction, and transport.

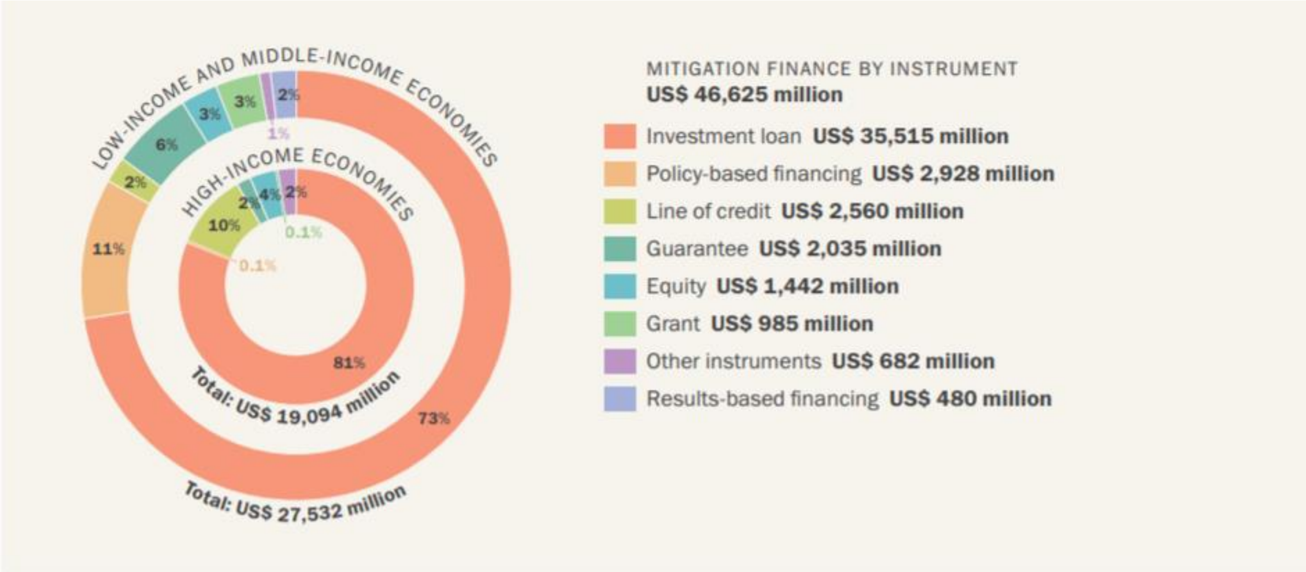
[368] Out of the total of USD 102.7 billion that was mobilized in co-financing.

[369] Applying to 30 billion, 14% which is the share of MDB finance that went into climate mitigation in sub-Saharan Africa and then 60% which is the share of MDB finance went into low carbon energy systems.

[370] UNECA, "Team Energy Africa Brochure" (2020), *https://www.uneca.org/sites/default/files/Africa-Business-Forum/4/Team-Energy_Africa_Brochure.pdf*.

[371] In 2019, MDBs invested USD3.5 billion in climate adaptation in sub-Saharan Africa. While this report doesn't benchmark how it compares to the need, climate finance for adaptation in Africa is of utmost importance.

Figure 27: MDB mitigation finance by type of instruments, 2019



Source: Climate Finance report.[372]

In addition, there has been a strong trend toward non-concessional funding to grow the pool of finance available for developing countries. According to the OECD, as of 2016, only one-third of loans are concessional, with 65% of concessional loans going into infrastructure and production sectors.[373] However, this does not include concessional financing from non-OECD countries that are contributing to solar development in Africa (see Box 17).

Box 17: Concessional funding from Abu Dhabi, India, China and South Africa

United Arab Emirates – Abu Dhabi

The IRENA/ADFD Project Facility, mobilizing funds from the Abu Dhabi Fund for Development (ADFD), has provided concessional loans for 11 renewable energy projects with clear development impact potential in 10 African countries.[374] Loans can cover up to 50% of project costs, have an interest rate of 1% to 2%, 20-year tenor, and 5-year grace periods.[375]

India

India's Prime Minister Narendra Modi and France's President Francois Hollande launched the International Solar Alliance (ISA) initiative during the Paris Climate Conference to promote solar energy development globally. Currently, the ISA has 121 countries involved, 34 of which are in Africa.[376]

These nations have agreed to the framework agreement, whose objectives include mobilizing investment of more than USD 1 trillion by 2030 from key institutions and reducing the cost of financing by providing innovative financial

[372] African Development Bank (AfDB) et al., *2019 Joint Report on Multilateral Development Banks' Climate Finance*.

[373] Organisation for Economic Co-operation and Development (OECD), *Multilateral Development Finance: Towards a New Pact on Multilateralism to Achieve the 2030 Agenda Together* (Paris: OECD Publishing, 2018), *https://doi.org/10.1787/9789264308831-en*.

[374] International Renewable Energy Agency (IRENA), *Scaling up Renewable Energy Deployment in Africa*.

[375] "Funding Database: Find funding sources that meet your needs," GET.invest, 2021, *https://www.get-invest.eu/_funds/international-renewable-energy-agency-irena-and-the-abu-dhabi-fund-fordevelopment-adfd*.

[376] "Countries Who Have Signed and Ratified the ISA Framework Agreement," International Solar Alliance (ISA), June 17, 2021, *https://isolaralliance.org/membership/countries*.

mechanisms. India's ambition is also to create a cross-border power grid plan—One Sun One World One Grid.[377] Among the active list of current projects are the scaling of solar applications for agricultural use, mini-grids, e-mobility and storage, and rooftop solar, as well as solar parks and affordable financing at scale.[378]

The Export-Import Bank of India (EXIM Bank) has already committed concessional financing for solar projects worth USD 1.4 billion, while AFD, the bilateral agency of France's commitment for solar projects, is worth EUR 700 million. The ISA secretariat has requested Australia, the Netherlands, and the United Kingdom to follow suit in providing concessional funding.[379]

Brazil, China, and South Africa

According to a study, as of today, three DFIs provide 61% of the renewable DFI financing in the Southern African Development Community (SADC) region—the China Export-Import Bank, the Brazilian National Development Bank (BNDES), and the Development Bank of Southern Africa.[380] At least China EXIM Bank and DBSA are involved in concessional finance.

4.1.3. Insufficient Blended Finance

Last, in 2019, MDBs mobilized less than USD 1 from the private sector for every USD 1 of MDB climate finance, except for the AfDB, which managed to catalyze more (see Figure 28).[381] Between 2013 and the first half of 2018, "outside South Africa, each dollar of public funding (from DFIs and state budgets) attracted USD 0.6 of private capital either directly (via equity and direct loan) or indirectly (via guarantee)—the figure is USD 0.4 for renewables. This compares unfavorably with USD 0.9 for Southeast Asia and more than USD 4 for South Africa."[382]

[377] International Solar Alliance (ISA), "Tender Reference No. 322/2/2020-NSM Corrigendum No. 1 dated 28th September 2020—Sub: Developing a Long-Term Vision, Implementation Plan, Road Map And Institutional Framework For Implementing 'One Sun One World One Grid', dated 27.05.2020" (Haryana, India: 2020), *https://mnre.gov.in/img/documents/uploads/file_f-1601537228434.pdf*.

[378] "Africa Mission," International Solar Alliance, June 17, 2021, *https://isolaralliance.org/work/activites*.

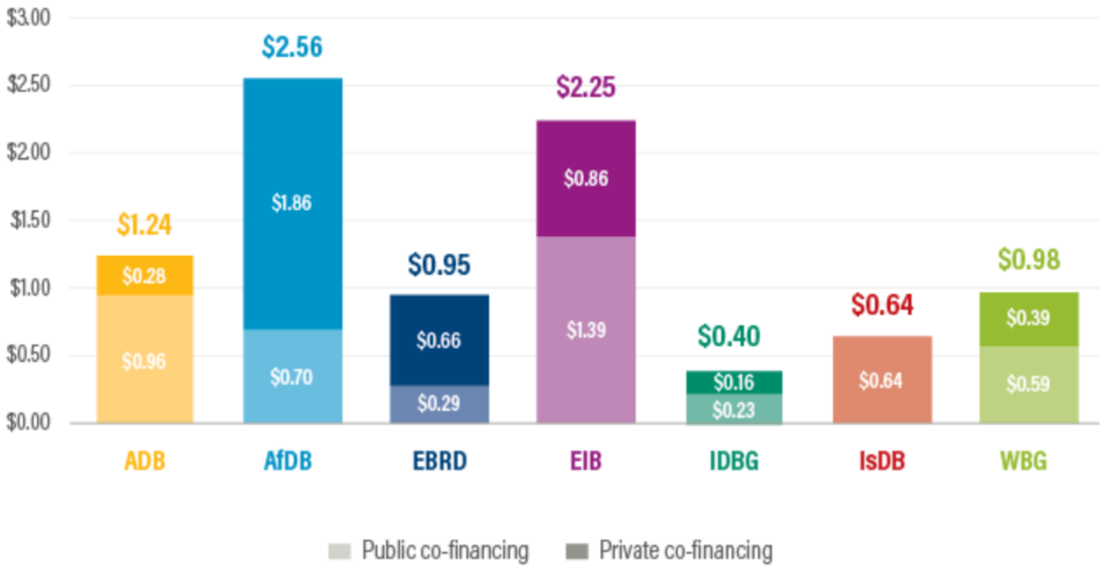
[379] "Innovative Finance Instruments," International Solar Alliance, June 17, 2021, *https://isolaralliance.org/work/affordable-finance-scale*.

[380] Cabré M. Muñoz, K. Ndhlukula, T. Musasike, D. Bradlow, K. Pillay, K.P. Gallagher, Y. Chen, J. Loots, & X. Ma, *Expanding Renewable Energy for Access and Development: The Role of Development Finance Institutions in Southern Africa* (Boston University Global Development Policy Center, 2020), *http://www.bu.edu/gdp/files/2020/11/GDP_SADC_Report_EN_Nov_16.pdf*.

[381] Thwaites, "The Good, the Bad and the Urgent."

[382] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

Figure 28: Co-finance mobilized by each dollar of MDB climate finance to low and middle-income countries in 2019



Source: World Resources Institute.[383]

In short, not only do concessional finance (loans and grants) make up a very low share of climate finance (roughly 30%), but MDBs' blended finance schemes have a low multiplier impact on private sector participation.

As a result, Africa's zero-carbon energy system build-up doesn't benefit from enough financing, and when it does, this is most often high cost, high risk, high default for African governments.

4.1.4. Urgent Need to Increase Official Finance

It is, therefore, urgent to tremendously increase the official financing for renewable energy projects in Africa. Fortunately, the low-interest-rate environment can facilitate a major increase of available financing for renewable energy power projects in Africa. As we have demonstrated, even a high degree of debt financing would lead to a manageable financial burden. The use of long-term guarantees should be intensified for the whole gamut of the types of needed guarantees (see Section 4.1.5 for the Lake Turkana case study for the successful use of multiple guarantees), and MDBs/DFIs should lower the hurdle rate.[384] Concessional finance in today's environment should be facilitated by the low interest rate paid on OECD countries' government bonds.[385] For instance, in the past decade, European countries have paid, on average, 1% interest on their bonds.[386] Low-cost money from donors' countries is, therefore, available and should be passed on to developing countries.

This is the most important message for the post-Covid-19 global recovery. Rich countries have been able to finance enormous budget deficits (in the United States, around 15% of GDP in 2020 and 2021) at very low interest rates. This has not been possible for developing countries, especially low-income countries. The global priority for international

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[383] Thwaites, "The Good, the Bad and the Urgent."

[384] Samantha Attridge and Lars Engen, *Blended Finance in the Poorest Countries: The Need for a Better Approach* (London: Overseas Development Institute (ODI), April 2019), *https://odi.org/en/publications/blended-finance-in-the-poorest-countries-the-need-for-a-better-approach*.

[385] "In Japan, a large amount of household savings is trapped in extremely low interest rates—well below 1 percent for 10-year government debt. In the United States, the yield on the 10-year Treasury bond is close to 2 percent. In China, the nominal interest rate on 10-year government bonds is 3 percent, with the real interest rate close to zero." African Development Bank (AfDB), "Chapter 4: Financing Africa's infrastructures: New Strategies, Mechanisms, and Instruments," in *African Economic Outlook 2018* (Abidjan: AfDB, January 2018), *https://www.afdb.org/en/documents/document/african-economic-outlook-aoe-2018-99877*.

[386] "Interest rates," OECD iLibrary, *https://doi.org/10.1787/86b91cb3-en*; Organisation for Economic Co-operation and Development (OECD), *Sovereign Borrowing Outlook for OECD Countries* (OECD, 2019), *https://www.oecd.org/finance/Sovereign-Borrowing-Outlook-in-OECD-Countries-2019.pdf.*

development should be to extend the creditworthiness of the high-income countries to the developing countries, mainly, we believe, by strengthening the balance sheets of the multilateral development banks so they can substantially increase their flow of financing for green and digital recovery. Africa's partners, including the United States, European Union, China, Japan, Korea, and others, should substantially increase their paid-in capital to the African Development Bank so that the ADB can spearhead a massive increase of financing for renewable energy and digitalization. Other means— debt relief, debt-for-SDG swaps, bilateral development aid, impact investing, foreign direct investment, public-private partnerships, blended project financing, and other kinds of risk-sharing (Figure 29)—should be deployed alongside the sharply higher flows from the ADB. (See section 3.1.6 below).

Figure 29: Spectrum of guarantee mechanisms to support infrastructure deployment

Mechanism	Direct public financing or guarantee?	Debt or equity?	Risk level	Mitigates which risks?
Political risk insurance	Guarantee	Mix	Medium	Currency inconvertibility, expropriation, regulatory, political violence
Credit enhancements	Guarantee	Debt	Medium	Commercial/default risks
Full credit wrap	Guarantee	Debt	High	Credit (covers entire debt load of project)
Sovereign guarantees	Guarantee	Mix	High	Contractual, failure to pay (provided by host government)
Partial risk guarantees	Guarantee	Debt	High	Political, sovereign, contractual (provided by DFIs regarding host governments)
Direct debt financing	Direct financing	Debt	Medium	Perceived credit and political risks by commercial banks
Forex liquidity facility	Direct financing	Debt	Low	Liquidity
Portfolio guarantees/first loss	Direct financing	Equity	High	Credit, political

Source: Adapted from the Institutional Investment in Infrastructure in Emerging Markets and Developing Economies, March 2014.

Source: Milken Institute.[387]

4.1.5. African Initiatives to Be Monitored, Amplified, and Replicated

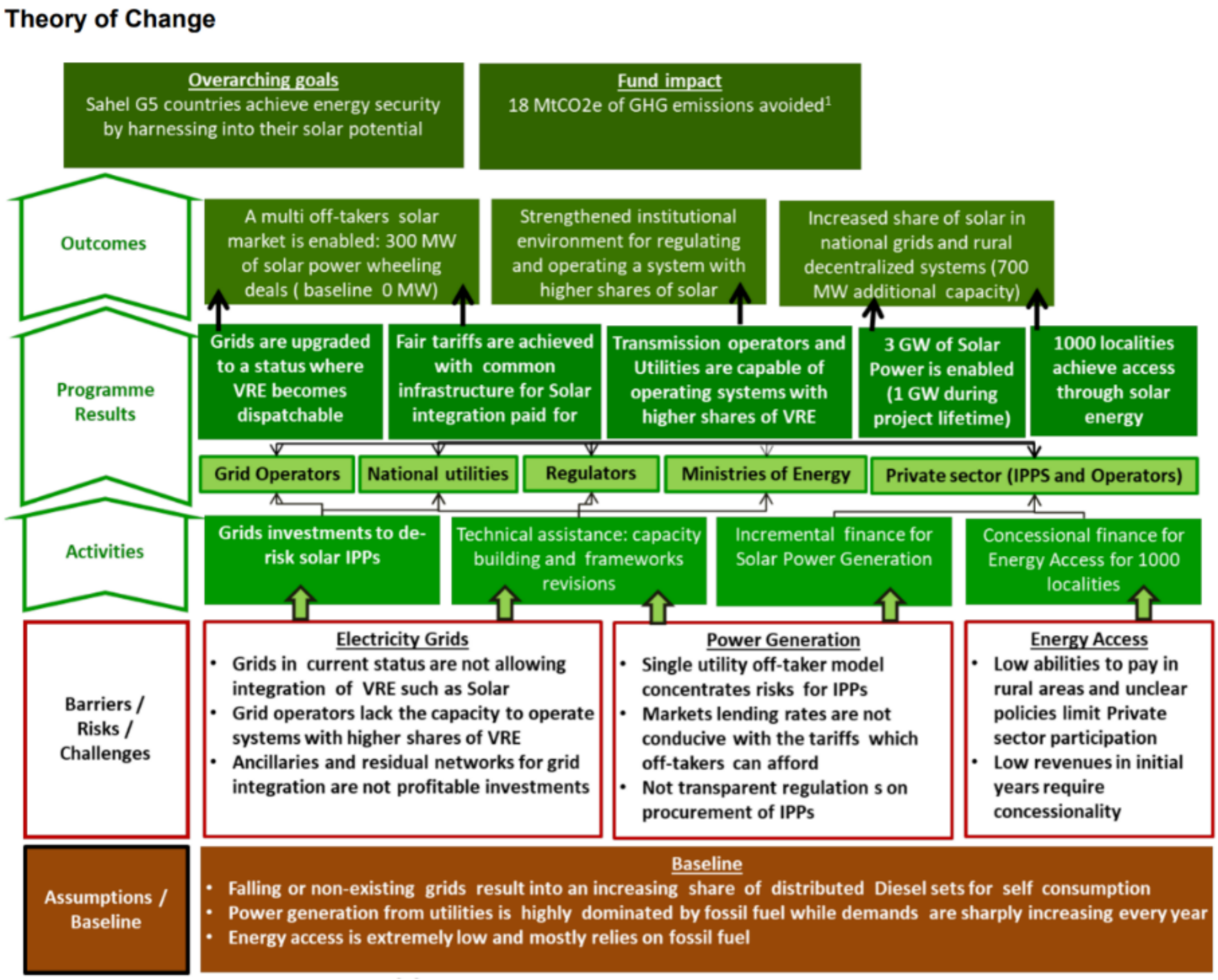
Desert to Power Initiative

The design of the Desert to Power Initiative, while in very early stages, achieves many of the above objectives.

The Desert to Power initiative is an investment agreement between the Green Climate Fund (GCF), the AfDB, and the nations of Burkina Faso, Chad, Mali, Mauritania, and Niger. The project aims to install 10 GW of solar power within these countries to both provide electricity and mitigate 18 MtCO_2eq emissions. The project consists of four components: grids investments to de-risk solar IPPs, additional finance for private sector-sponsored solar power generation, energy access for 1000 localities, and technical assistance. Figure 30 identifies the theory of change model for the project.

[387] Caitlin MacLean and Katie Olderman, *Innovative Financing Models for Energy Infrastructure in Africa* (Milken Institute, May 2015), *https://milkeninstitute.org/sites/default/files/reports-pdf/Milken-Institute-Lab-Energy-Infrastructure-Africa.pdf.*

Figure 30: Theory of change for the Desert to Power initiative



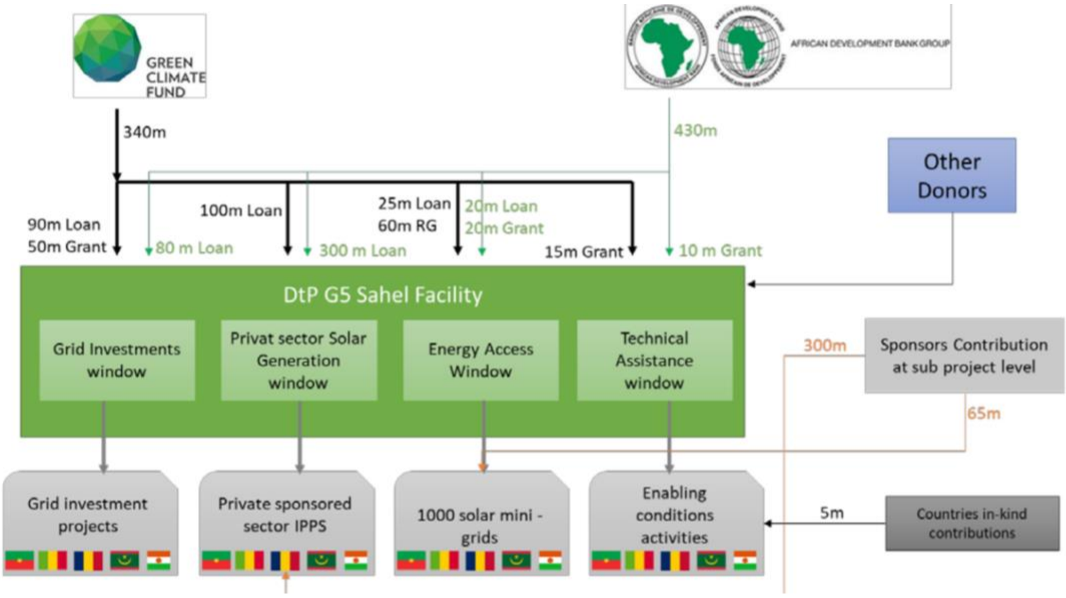
Source: Green Climate Fund.[388]

As a result of these components, the creation of this facility hopes to create a backbone grid for the region that can support up to 3 GW of integrated generation capacity, a regional solar market with the cross-border transmission of clean energy for up to 3 GW, market opportunities for solar energy that rely less on the balance sheet of single off-takers, IPPs for 700 MW of generation, baseload and stable grids that use utility-scale storage for solar energy, access to energy for 1000 localities, and local capacity building.

The current risks of the project are the potential operational risks due to safety and armed conflict in the region, as well as deployment risks associated with the countries' limited institutional capacity to support such a large endeavor. Nevertheless, the project will be financed in a joint loan fund agreement between the AfDB and the Green Climate Fund. The breakdown of funding for each subgroup of the project is explained below (Figure 31).

[388] Green Climate Fund (GCF), "Desert to Power G5 Sahel Facility."""

Figure 31: Breakdown of funding and types of financial instrument for the Desert to Power initiative



Component/ Output	Indicative cost (USD M)	GCF financing		AfDB co-financing		Other Mobilized / Leveraged financing	
		Amount (USD M)	Financial Instrument	Amount (USD M)	Financial Instrument	Amount (USD M)	Financial Instrument
Component 1: Grids investments to de-risk solar IPPs	330	90 50	Senior Loan Grant	80	Senior Loan	110	Equity/Loans
Component 2: Additional finance for Private sector sponsored solar power generation	700	100	Senior Loan	300	Senior Loan	300	Equity/debt
Component 3: Energy access through 1000 solar mini grids	190	25 60	Senior Loan Reimbursable Grant	20 20	Senior Loan Grant	65	Grant/Equity
Component 4: Technical assistance	30	15	Grant	10	Grant	5	In-Kind
Indicative total cost (USD)	**1,250**	**340**		**430**		**480**	

Source: Green Climate Fund.[389]

In the Desert to Power Initiative, different financial instruments are being used according to risks:

- Highly concessional loans will finance public infrastructure such as transmission grids.
- Grants will finance ancillary infrastructure, such as storage, which will stay in public ownership and is not investible.
- Loans will provide long-term finance at viable interest rates to the private sector on IPPs.
- Reimbursable grants will be offered to de-risk large-scale green mini-grids operations facing revenue uncertainties during the first years of operation. With the proceeds, a Mini-Grid Guarantee Facility will be set up, and guarantees will be triggered in the event of insufficient revenues in the first year.
- Subsidies will be given to attract small-scale mini-grid investors.
- Grant instruments will cover technical assistance and capacity-building activities.
- Each dollar of GCF funding will leverage an additional USD 2.7 from co-financiers (AfDB and other public and private partners).

The objective is to accelerate the penetration by IPPs in solar by covering the cost of grid integration for solar power plants without waiting for public utilities to find the means to do so.

[389] Adapted from: Green Climate Fund (GCF), "Desert to Power G5 Sahel Facility." ""

Africa50 Infrastructure Fund

The Africa50 fund has 23 African countries, AfDB, the Central Bank of West African States, and the Bank Al-Maghrib, and was capitalized initially by AfDB by an amount of USD 830 million. The objective is to attract funding from the private sector, governments, and DFIs to provide "early-stage risk capital, as well as expertise and support engaging investors and stakeholders, from project development to financial close." It seeks high developmental impact and aims to deliver differentiated returns across its portfolio.

The Africa50 fund was inspired by India's approach to attracting private sector financing. In 2000, the Indian government set the India Infrastructure Project Development Fund to support the development of bankable PPPs to bear the pre-financial close risk in the development of large projects in the infrastructure sector.[390] In 2004, the Viability Gap Financing scheme was established to support infrastructure projects justified for the public interest but not financially viable. It has been providing subsidies when user charges cannot be increased to commercial levels.[391] There is also the India Infrastructure Finance Company Limited,[392] a wholly state-owned company set up in 2006 to fund viable infrastructure projects in consortium by providing long term senior or subordinated debt through direct lending to infrastructure project companies or refinancing to banks.

Lake Turkana in Kenya and the Use of Guarantees

Lake Turkana is a USD 680 million, 310 MW wind farm—the largest renewable energy project in Africa. After eight years of planning and five years to build, the project was finally opened in 2019.[393] The risks involved in the financing of the wind farm ranged from "the absence of sufficient local capital resources, a viability gap between expected and required electricity revenues, off-taker risks linked to political uncertainty in the Kenyan government, and a lack of transmission infrastructure."[394]

For this reason, the project included an off-taker guarantee (AfDB and Kenyan government) on a 20-year PPA signed with utility KPLC and a loan guarantee (Danish Export Credit Agency, EKF) on AfDB and EIB loans. The AfDB also used its B-loan structure to enable bank participants to enjoy its Preferred Credit Status to mitigate transfer and convertibility risk. The Government of Kenya also assumed liability for political risk, but it was replaced by a sovereign guarantee from the AfDB's African Development Fund that provides political-risk guarantees.[395] Its capital structure involved senior debt, subordinated debt, concessional equity (EU–Africa Infrastructure Trust Fund), and commercial equity.[396]

While the project is an interesting example of a complex blended finance structure, it is particularly illustrative of the role of guarantees, with part of them coming from the government itself.[397]

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390 "India Project Development Fund (IPDF)," World Bank Group's Public Private Partnership Legal Resource Center, updated August 25, 2020, *https://ppp.worldbank.org/public-private-partnership/library/india-project-development-fund-ipdf*.

391 "What is the Viability Gap Funding (VGF) Scheme?" Civilsdaily: UPSC IAS Preparation, November 12, 2020, *https://www.civilsdaily.com/news/what-is-the-viability-gap-funding-vgf-scheme*.

392 "India Infrastructure Finance Company Ltd (IIFCL)," Government of India Department of Financial Services, *https://financialservices.gov.in/banking-divisions/Financial-Institutions-and-others/India-Infrastructure-Finance-Company-Ltd-(IIFCL)*.

393 Petrova, "Google Backs Out from Lake Turkana Wind Farm Stake Buy."

394 Climate Policy Initiative (CPI), *Blended Finance in Clean Energy: Experiences and Opportunities* (CPI, 2018), *http://climatepolicyinitiative.org/wp-content/uploads/2018/01/BlendedFinanceReport_Annexes.pdf*.

395 Judith Tyson, *Private Infrastructure Financing in Developing Countries: Five Challenges, Five Solutions* (Overseas Development Institute (ODI) working paper, ODI, 2018), *https://odi.org/en/publications/private-infrastructure-finance-in-developing-countries-five-challenges-five-solutions*.

396 Climate Policy Initiative (CPI), *Blended Finance in Clean Energy: Experiences and Opportunities*.

397 Sovereign guarantees can expose government to high risk of worsening debt sustainability. This should be resorted to with high care. Jason Zhengrong Lu, Jenny Jing Chao, and James Robert Sheppard, *Government Guarantees for Mobilizing Private Investment in Infrastructure* (Washington, DC: International Bank for Reconstruction and Development / The World Bank, 2019) *https://ppiaf.org/documents/5798/download*.

Benban Solar Park

The Benban solar park, the first one on the African continent that is above 1 GW, is a 37-km², 1.8 GW park located in the desert in the South of Egypt, built at an approximate cost of USD 4 billion.[398] A critical response to the Government of Egypt's goal of 20% renewable energy by 2022, Benban park is broken into 41 plots of various sizes, which collectively accommodate 32 power plants.[399] Once the plots were divided, a consortium of 30 international developers expressed interest in the project, including Spain's Acciona, UAE's Alcazar Energy, Italy's Enerray, China's Chint Solar, and Norway's Scatec Solar.[400] This project was not designed in official phases like the famous Bhadla Park in India[401] but rather had sections built whenever developers came forward. It has been operational since 2019.

To guarantee buy-in, the government promised a competitive price through feed-in tariffs in a guaranteed 25-year PPA[402] with the Egyptian Electricity Transmission Company (EETC) and backstopped by a sovereign guarantee. Benban solar park developers collectively funded the transmission infrastructure to the project site via a cost-sharing agreement with EETC and the New and Renewable Energy Agency of Egypt.[403]

The AfDB's Africa50 financing arm signed a Joint Development Agreement with Scatec Solar and Norway's private equity Norfund to finance six of the power plants (390 MW). In turn, it has helped secure senior debt from a number of development banks such as the EBRD, the Netherlands Development Finance Company, the Green Climate Fund, the Islamic Development Bank, and the Islamic Corporation for the Development of the Private Sector.[404]

The IFC also led a consortium of development and commercial banks—including the AfDB, the Asian Infrastructure Investment Bank, the Arab Bank of Bahrain, CDC of the United Kingdom, Europe Arab Bank, Green for Growth Fund, FinnFund, ICBC, and OeEB of Austria—for a total of USD 653 million in debt issuance for six project developers, thus financing 13 of the park's 32 solar plants (752 MW). World Bank's Multilateral Investment and Guarantee Agency (MIGA) provided USD 210 million–worth of political risk insurance.[405] The participation of the IFC enabled the respect of social and environmental performance standards.[406]

Provided that they are planned following sustainability standards and anchored on industrial demands when residential demand is not sufficient, solar parks could facilitate private sector investment in large-scale solar by providing economies of scale, access to land, and access to transmission infrastructure. This has been the approach taken by India for much of its solar capacity.[407]

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[398] African Development Bank Group (AfDB), "Infrastructure Fund Africa50 helps Egypt's Solar Power Sector Take-off," *AfDB News and Events,* June 18, 2020, *https://www.afdb.org/en/news-and-events/infrastructure-fund-africa50-helps-egypts-solar-power-sector-take-36247*.

[399] Amy Nordrum, "Egypt's Massive 1.8-Gigawatt Benban Solar Park Nears Completion", *IEEE Spectrum,* September 17, 2019, *https://spectrum.ieee.org/energywise/energy/renewables/egypts-massive-18gw-benban-solar-park-nears-completion*.

[400] Aidan Lewis, "Giant Solar Park in the Desert Jump-starts Egypt's Renewables Push", *Reuters*, December 17, 2019, *https://www.reuters.com/article/us-egypt-solar/giant-solar-park-in-the-desert-jump-starts-egypts-renewables-push-idUSKBN1YL1WS*.

[401] Priya Sanjay, "With 2,245 MW of Commissioned Solar Projects, World's Largest Solar Park is Now at Bhadla", *Mercom Clean Energy News and Insights,* March 19, 2020, *https://mercomindia.com/world-largest-solar-park-bhadla*.

[402] Nordrum, "Egypt's Massive 1.8-Gigawatt Benban Solar Park Nears Completion."

[403] African Development Bank Group (AfDB), "Infrastructure Fund Africa50 helps Egypt's Solar Power Sector Take-off."

[404] Africa50, "Africa50 and its Partners Announce the Completion of the 390 MW Benban Solar Power Project in Egypt," Press release (October 24, 2019), *https://www.africa50.com/news-insights/news/africa50-and-its-partners-announce-the-completion-of-the-390-mw-benban-solar-power-project-in-egypt-306*.

[405] "IFC-Led Consortium Invests $653 Million to Support the World's Largest Solar Park in Egypt," International Finance Corporation, October 29, 2017, *https://pressroom.ifc.org/all/pages/PressDetail.aspx?ID=17490*.

[406] Caitríona Palmer, "In Egypt's Desert, Working to Ensure Solar Power is Sustainable," International Finance Corporation (IFC), March 2019, *https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/egypt-benban-solar*.

[407] Fairley, "The Pros and Cons of the World's Biggest Solar Park."

4.1.6. Role of Country Donors in Enabling MDBs and DFIs to Increase Concessional Finance

Country donors to MDBs and DFIs should enable these institutions to significantly increase their lending and equity investments for energy-system scale-up, especially through new capital increases for the African Development Bank earmarked for the rapid scale-up of energy sector investments. Other possible steps include the following:

- Reviewing the rates of return donors require from MDBs and DFIs to secure more funding in pure grant form.[408]
- Reassessing DFI profitability targets:[409] the United Kingdom's Foreign, Commonwealth, and Development Office (FCDO) has lowered CDC Group's required rate of return to 3.5% for its "Growth Portfolio" (investment out of balance sheet) and "at least break even" over both the Growth and Catalyst portfolios (which is the impact fund). From December 2012 to 2017, CDC's average financial returns across the portfolio were 10.6%.[410]
- Contemplating the creation of special-purpose vehicles (SPVs) focused on providing high-risk capital (for early-stage finance and high-risk project tranches) (see Figure 32), which is what the AfDB has done.[411] After some of the initial risks have subsided, the government can sell the loan in the market to investors and use the revenues to repay the MDB. If the loan is convertible, then the government could reap any upside in the projects[412] (care should be applied to pass on the social and environmental obligations to the investor).
- Creating financing structure to enable the participation of country donors' institutional investors such as pension funds, life insurance funds, and sovereign funds in PPPs through project-puttable bonds, whereby the MDB could provide a put option after the construction early-stage period and receive a guaranteed premium. After the early-stage period, the investor would have the right to exercise the put option to sell the bond to the MDB if the project did not meet predefined minimum conditions, "such as successful construction completion, minimum coverage ratios, and minimum credit rating conditions."[413]
- Exploring the creation of earmarked off-balance-sheet facilities for the MDBs to overcome institutional capital-adequacy constraints.[414]
- Transparently analyzing whether the capital adequacy ratio is too conservative and the extent to which it could be lowered without compromising the AAA rating given by the credit rating agencies.[415] A 2018 study sees potential for the AfDB to increase lending by USD 14.1 billion (almost double its 2017 lending portfolio), provided that a portion of the callable capital is included in the capital adequacy model.[416]
- Contemplating relaxing the triple AAA rating. According to some calculations, a small relaxation in the credit rating could raise USD 1.9 billion in the SADC region. Another estimate gives that, for eight major MDBs, allowing the credit rating to fall to AA+ opens up an additional USD 320 billion to their lending capacity.[417]

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408 Adapted from Attridge and Engen, *Blended Finance in the Poorest Countries.*

409 Ibid.

410 Independent Commission for Aid Impact (ICAI), "Report: CDC's Investments in Low-Income and Fragile States" (ICAI, March 26, 2019), *https://icai.independent.gov.uk/html-report/cdc*.

411 MacLean and Olderman, *Innovative Financing Models for Energy Infrastructure in Africa.*

412 African Development Bank (AfDB), *African Economic Outlook 2018*.

413 African Development Bank (AfDB), *African Economic Outlook 2018.*

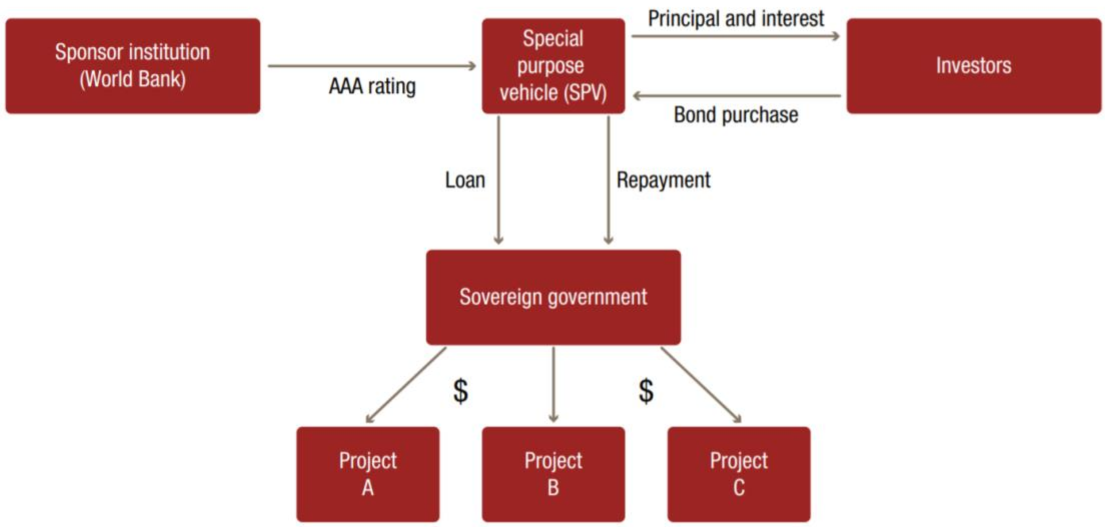
414 Adapted from Attridge and Engen, *Blended Finance in the Poorest Countries*.

415 Ibid.

416 Chris Humphrey, *The Role of Credit Rating Agencies in Shaping Multilateral Finance; Recent Developments and Policy Options*, Policy paper commissioned by the Intergovernmental Group of 24 (Swiss Federal Institute of Technology, 2018), *https://www.g24.org/wp-content/uploads/2018/04/The-Role-of-Credit-Rating-Agencies-in-Shaping-Multilateral-Finance.pdf*.

417 Muñoz et al., *Expanding Renewable Energy for Access and Development.*

Figure 32: Leveraging a sponsor credit rating



Source: Milken Institute.[418]

4.2. Building Local Capabilities to Plan, Procure, and Finance IPPs

In addition to providing the necessary funding infusion, MDBs and DFIs are also critical to building local capabilities and means to progressively seed independence from foreign aid and shield against currency risk. These efforts should target ministries of finance or planning and their capacity to prepare and plan for the investment, utilities and their capacity to run competitive auctions, ministries of mines and energy to leverage the vast mining sector in Africa as an anchor demand for investment, and the local financial sector (banks and institutional investors as well as the creation of a bond market). These are discussed below.

4.2.1. Preparing and Planning for the Investment (Ministries of Finance/Planning)

In developing countries, infrastructure project preparation costs generally range from 5 to 10% of the total project investment.[419] Many countries, including in Africa, have set up central dedicated project development funds (PDFs) for conducting feasibility studies and transaction advisory support for projects. These PDFs are usually set up under PPP units, most often sitting at the Ministries of Finance or Planning. Externally funded project preparation facilities have also been set up by MDBs to help fund governments' preparation costs (see Section 4.1.5 above on Africa50 Fund).

However, even in Africa, the government budget still covers 70% to 80% of this project preparation funding.[420] This situation may lead to either abuse of government spending on inefficient project preparation if there is no rigorous budgetary oversight (see Box 18 on how South Africa remedied the problem) or renouncing project preparation funding due to a lack of government budget. Both situations should be closely monitored and addressed by MDBs and DFIs until sound and sustainable administration and budgeting of project preparation are in place.[421]

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[418] MacLean and Olderman, *Innovative Financing Models for Energy Infrastructure in Africa.*

[419] Stephanie Barker and Matthew Jordan-Tank, "Project Preparation - Financing Project Preparation: How Can Governments Effectively Utilise Project Preparation Financing Sources?" *Global Infrastructure Hub Blog* (blog), March 19, 2019, *https://www.gihub.org/blog/financing-project-preparation-governments-effectively-utilise-financing/.*

[420] Ibid.

[421] A possibility to explore could be for these preparation costs to be reimbursed by the project proponent at financial close (Source: World Economic Forum (WEF), *A Call for Infrastructure Development Through Unsolicited Proposals: Tapping Into Private-Sector Innovation to*

Box 18: South Africa's Budget Facility for Infrastructure (BFI)

In South Africa, the BFI was created to improve project preparation and delivery of large infrastructure projects. It serves as a financing facility, but it is fully integrated into the national budget system. Its objective is to inform the government and policymakers on the actual funds utilized towards project preparation and ensure a transparent allocation of fiscal resources.[422]

4.2.2. Utilities and Competitive Tenders

Moreover, despite the success of IFC's Scaling Solar program, capacity-building in designing and conducting competitive tenders and auctions remains critically needed to "a bring a high degree of transparency and predictability, enhance market confidence and facilitate price discovery."[423]

Without adopting the rigor of competitive bidding, countries are plagued with unsolicited bids that are a conduit for corruption and system inefficiency.[424]

Thanks to IFC's Scaling Solar program and a well-organized auction process, in December 2019, Ethiopia reached one of the lowest prices (USD 0. 2526/kWh with Saudi Arabia's ACWA IPP)[425] on the continent outside of Tunisia (USD 0.24/kWh with Norwegian IPP Scatec Solar)[426] (see Box 19).

Improve Infrastructure Delivery, World Economic Forum Community Paper (2020)), *http://www3.weforum.org/docs/WEF_UPs_Note_2020.pdf.*

422 Stephanie Barker and Matthew Jordan-Tank, "Project Preparation - Financing Project Preparation: How Can Governments Effectively Utilise Project Preparation Financing Sources?"

423 International Energy Agency (IEA), *Africa Energy Outlook 2019*.

424 Cabré M. Muñoz et al., *Expanding Renewable Energy for Access and Development*.

425 Aleksandra Dimitrova, "ACWA Power Signs PPAs for 250 MW of Solar Projects in Ethiopia," *Renewables Now*, December 23, 2019, *https://renewablesnow.com/news/acwa-power-signs-ppas-for-250-mw-of-solar-projects-in-ethiopia-681240*.

426 Jean Marie Takouleu, "Ethiopia: ACWA Power Secures Gad and Dicheto Solar Power Plants Contract", *Afrik21,* September 19, 2019, *https://www.afrik21.africa/en/ethiopia-acwa-power-secures-gad-and-dicheto-solar-power-plants-contract*.

Box 19: Scaling Solar program

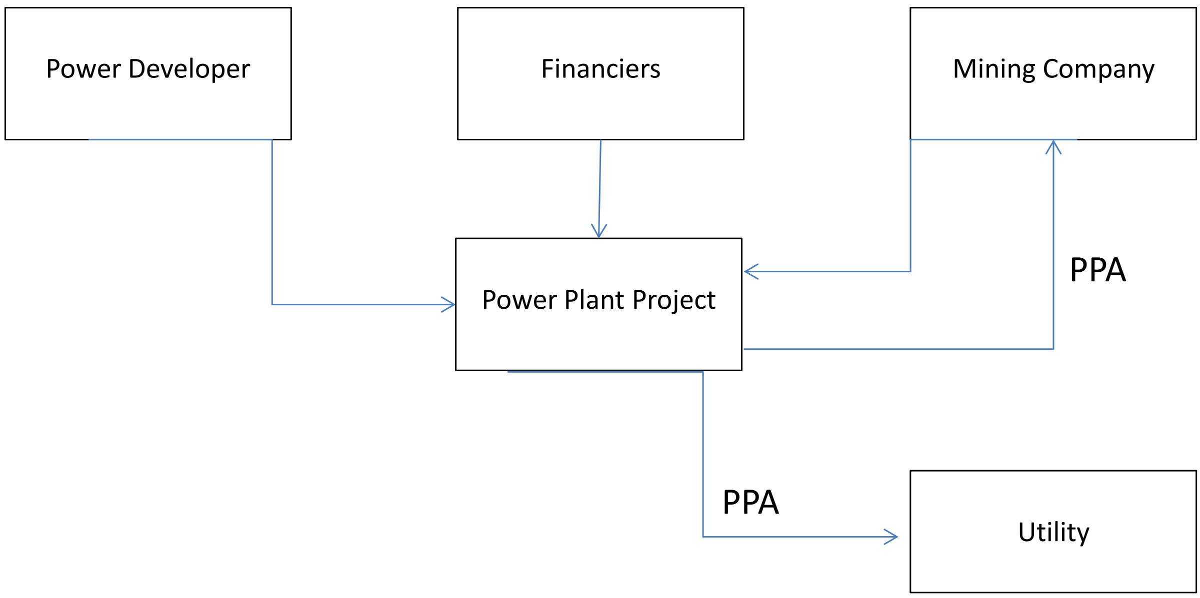
The Scaling Solar program offered by the IFC is a one-stop-shop offering a variety of World Bank services to deliver competitive solar pricing from private IPPs in as little as two years. From the beginning, the program works with participating governments and developers to ensure that the project has documentation and de-risking solutions.

The process starts with a client government signing into a formal advisory mandate with the IFC Corporate Transaction Advisory Department. The project preparation and structuring follow a set of template documents, including a term of reference for hiring consultants, the PPA, Government Support Agreement (GSA), and financing documents. While these templates are customized depending on the project and host country, the goal of the Scaling Solar program is to normalize the templates throughout multiple projects in a variety of countries, standardizing the process in a way that reduces project preparation and transaction costs to make solar power competitive.[427] While the IFC helps the client with the procurement process using tendering documents, bidders have access to advantageous terms for debt financing, political risk insurance, and partial risk guarantees.

4.2.3. Leveraging Mining Sector Investment in Africa (Ministries of Mining and Energy)

As shown in Figure 3 in Section 3.1.2, there are several models possible to leverage mining's infrastructure demand to build a robust energy system. One of these is outlined in Figure 33 because it is particularly suitable to attract IPPs.

Figure 33: Structuring the financing of a power plant leveraging the mining company's demand



Source: CCSI framework.

In this model, the mining company can facilitate the investment as:

- *Investment Initiator*, whereby the mining company facilitates the investment by bringing strong developers, EPC contractors, lenders, investors, and advisers. The mining company's commercial incentives to keep costs down would facilitate the use of more competitive contractors.

[427] International Finance Corporation (IFC), *Scaling Solar: The Complete Package*, (Washington DC: IFC, 2018), *https://www.ifc.org/wps/wcm/connect/f4df6171-1018-4003-ad9d-938ce4866c15/scaling-infra-solar-08.pdf?MOD=AJPERES&CVID=mSCZFCY*.

- *Equity Investor*, whereby the mining company could also contribute to meeting the equity requirements of the project.
- *Partial off-taker*, whereby the mining company offtakes a certain proportion of the power, making the deal bankable as the mining company most often is a credible off-taker, so the company's overall balance sheet and creditworthiness can help to underpin the deal.[428] The deal would be covering more than the mine's needs, leveraging economies of scale and enabling the less-credit-worthy utility to be an off-taker as well. Alternatively, if the utility's participation endangers the bankability of the deal, the mine could be the sole off-taker while selling back excess energy to the grid (assuming this is allowed under the electricity law as it should be).

As discussed in Section 2.1.2, this model is not new, and MDBs and DFIs could usefully assist the Ministry of Mines and Energy in structuring these deals.

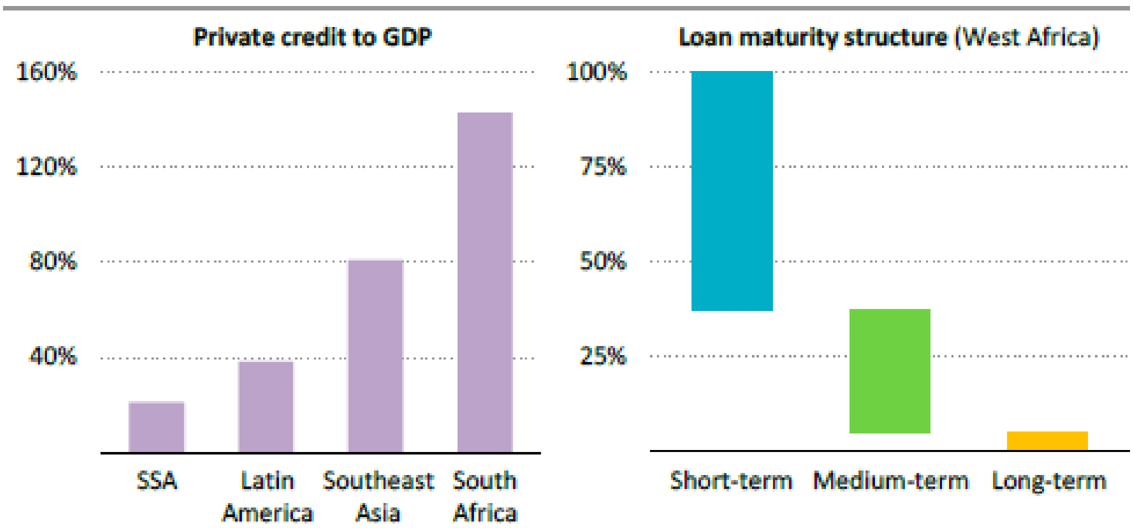
4.2.4. Local Financial Sector and Actors

Local banks

The MDBs and DFIs also have a major role to play in strengthening the local financial sector, to sustain a flow of long-term financing to infrastructure projects (through an on-lending facility, for instance) that is shielded from currency risk (whereby the utilities will incur cost in foreign currencies while receiving revenues in local currency). Despite some progress, access to financing for infrastructure remains insufficient in all countries besides South Africa (see Figure 34).[429]

Figure 34 also shows that there is currently a mismatch between the tenure of credit and tenure of investment in many bank credit policies.[430]

Figure 34: Private credit and loan maturity of the local banking sector in sub-Saharan Africa, 2016–2017



Source: International Energy Agency.[431]

The challenge with existing local bank financing for infrastructure projects is that local banks prefer high-yielding, short-term investment tools as lower-risk alternatives to the longer-term loans necessary for infrastructure investment.

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[428] "The credibility of the mine as an off-taker should be carefully assessed. For instance, some miners are junior companies with an undiversified portfolio. In this situation an IPP would be inherently taking on some country/project specific risk, without the cushion of a multinational balance sheet." Perrine Toledano et al., *Framework to Approach Shared Use of Mining-Related Infrastructure*, 40.

[429] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[430] Ibid.

[431] Ibid.

Enabling long-term financing by local banks is one of the measures that India took in 2014 to spur investment in infrastructure. For instance, local banks were exempted from the statutory liquidity ratio and enabled to lend for up to 25 years while giving the option to refinance the loan every five years (through bond markets or selling to other banks).[432]

The first reason for this is a lack of syndicated loans structured with local banks. The participation of local banks, when not jointly partnered with international development or commercial banks, creates a level of risk that is often difficult for local banks to overcome.[433] The second reason relates to a lack of liquidity. Trapped by existing obligations and the upper limit thresholds set by government operating budgets, local banks are out of cash.[434]

In this area, MDBs and DFIs "can help by acting as a catalyst, for example by providing guarantees, refinancing or on-lending mechanisms"[435] and incentivize local banks to engage in riskier and longer-term operations.[436] This is what is attempted by the 2019 World Bank's Regional Off-Grid Electrification Project in the Sahel and West Africa: line of credits and guarantees are given to local banks to encourage them to lend.[437]

One success story in that matter is M-Kopa—headquartered in Nairobi, Kenya—the global leader in "pay-as-you-go" off-grid energy to enable affordable consumer financing for solar-powered systems. Three DFIs syndicated a local currency loan facility with two local subsidiaries of Standard Bank. [438]

The refinancing facilitated by the World Bank of the Kenya Power and Lighting Company (KPLC) is another case in point. The World Bank restructured USD 500 million of existing commercial debt into two longer-term commercial loans with lower interest rates. In addition, the World Bank provided USD 250 million of International Development Association (IDA) concessional credit (to continue operating while paying the debt) and USD 200 million of IDA guarantee in case of default on the commercial loan. This structure enabled the lead arranger to be joined not only by international banks but also local banks.[439]

Local pension funds and institutional investors

Alongside local banks, local pension funds and institutional investors more broadly can also become actors of local financing for infrastructure. However, outside of Senegal and South Africa, investment vehicles are limited, and institutional investors lack the expertise to run credit risk evaluation, so they prefer to invest in established real-estate holdings, short-term bank deposits, and risk-free government securities.[440]

Here, too, DFIs could intervene to bring technical assistance to reinforce the investment capacity. By some account, when foreign investors co-invest with local pension funds, they might feel more protected from political interference than under a DFI guarantee.[441] Thus technical assistance targeted at these institutions could drain more private

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[432] African Development Bank (AfDB), *African Economic Outlook 2018.*

[433] Jacqueline Irving and Astrid Manroth, *Local Sources of Financing for Infrastructure in Africa: A Cross-Country Analysis*, Policy Research Working Paper 4878 (Washington DC: World Bank, March 2009), *http://documents1.worldbank.org/curated/en/767731468204565483/pdf/WPS4878.pdf*.

[434] Russell Duke, "Africa's Financial Infrastructure," *National Standard*, *https://www.nationalstandardfinance.com/news/africas-financial-infrastructure*.

[435] International Energy Agency (IEA), *Africa Energy Outlook 2019*.

[436] In these arrangements local banks should also adhere to the social and environment performance standards of the MDBs and DFIs.

[437] World Bank Energy and Extractives Global Practice, *Regional Off-Grid Electrification Project (P160708) Appraisal Document*, (World Bank, March 2019), *http://documents1.worldbank.org/curated/en/541231554150233127/pdf/Western-Africa-Regional-Off-Grid-Electrification-Project.pdf.*

[438] Rentia van Tonder, "Powering The Continent Through a Sustainable Approach," (Powerpoint presentation, Standard Bank, November 2019), *https://unfccc.int/sites/default/files/resource/Session6_RentiaVanTonder_Power_sustainable_finance2019.pdf*.

[439] Teuta Kacaniku, Prajakta Chitre, and Pankaj Gupta, "Financial Solutions Brief: Kenya KPLC Refinancing,"(World Bank, January 2018), *http://pubdocs.worldbank.org/en/880731518200592587/Briefs-Guarantees-KenyaKPLCRefinancing.pdf*.

[440] Jacqueline Irving and Astrid Manroth, *Local Sources of Financing for Infrastructure in Africa: A Cross-Country Analysis.*

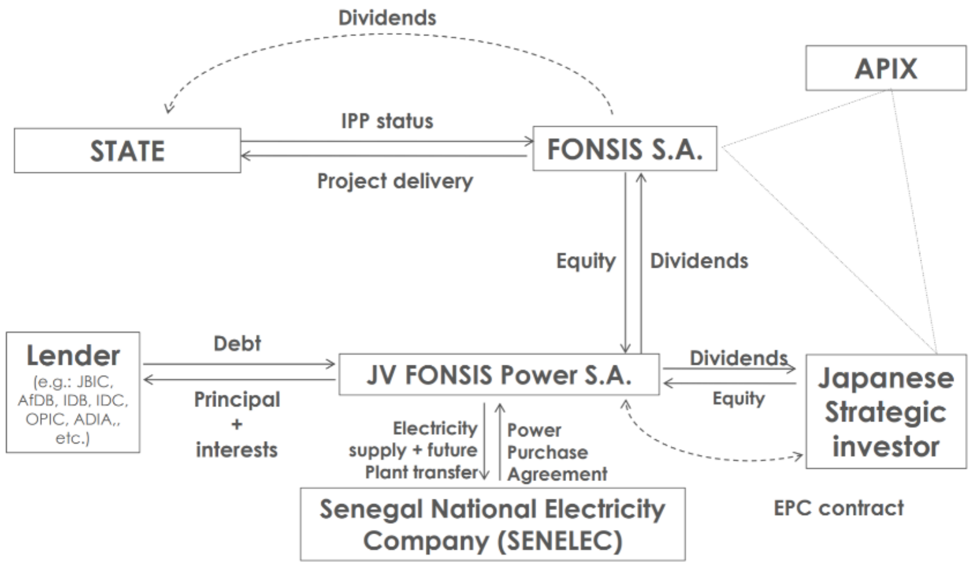
[441] Max Messervy, Alex Bernhardt, Daniel Bond, and Aymeric Saha, *Investment in African Infrastructure: Challenges and Opportunities* (Mercer, September 2018), *https://www.mmc.com/content/dam/mmc-web/insights/publications/2018/dec/innovations-in-infrastructure/Investment-in-African-Infrastructure/gl-2018-wealth-investment-opportunities-in-african-infrastructure-full-report-mercer.pdf*.

finance into infrastructure development. Senegal's FONSIS is an interesting case in point that might deserve further study for replicability assessment purposes (see Box 20).

Box 20: FONSIS

Fonds Souverain d'Investissements Stratégiques (or The Sovereign Fund for Strategic Investments, FONSIS) was created in 2012 as a limited liability corporation; it is an investment holding company focused on creating financial returns while acting as a private equity investor on behalf of the Senegalese government. FONSIS works to boost domestic investment opportunities and optimize state assets while also increasing its own revenue for greater impact in the near future. FONSIS has a hurdle rate of 12% and participates in projects under this rate only under specific conditions. Investment is always through equity co-investment from private investors and non-recourse debt from commercial and development banks. [442] The figure below shows the general financial structuring for solar projects taken up by FONSIS.[443] FONSIS has equity in 120 MW of solar energy (four projects) in Senegal. [444]

Figure 35: Project finance through FONSIS



Source: African Development Bank.[445]

Local infrastructure project bond markets

A solid institutional investor base is also necessary to enable the development of infrastructure project bonds. Both Kenya and Nigeria are successful examples of where project bonds are being issued by project companies and bought by institutional investors. In Nigeria, all corporate bonds are tax-exempt, while in Kenya, there are specific exemptions for infrastructure bonds.[446] These bonds are usually issued by an SPV for a stand-alone project and repaid from the cash flows of that project.

[442] Havard Halland and Michael Noel, "Development Finance Frontline: Senegal's Strategic Investments Fund," *World Bank Blogs* (blog), Private Sector Development, April 22, 2016, *https://blogs.worldbank.org/psd/development-finance-frontline-senegal-s-strategic-investments-fund*.

[443] Republic of Senegal, "The Sovereign Wealth Fund of Senegal for Strategic Investments (FONSIS)" (PowerPoint presentation, 1st Japan-Africa Business Forum, Tokyo, June 2014), *https://afdb-org.jp/wp-content/themes/meteo/pdf/50.%20Mr.%20HOTT_FONSIS.pdf*.

[444] "Portfolio Project," Le Fonds Souverain d'Investissements Stratégiques, *https://www.fonsis.org/en/you-are-entrepreneur/portfolio-project*.

[445] Republic of Senegal, "The Sovereign Wealth Fund of Senegal for Strategic Investments (FONSIS)."

[446] "Project Bonds: An Alternative Source of Financing Infrastructure Projects," Deloitte, *https://www2.deloitte.com/za/en/pages/finance/articles/project-bonds-an-alternative-to-financing-infrastructure-projects.html#*.

For corporate issuers, access to domestic capital markets is usually associated with lower costs through lower interest rates and longer maturities as compared to bank loans while providing access to local currency financing, which mitigates foreign exchange risk. From an investor perspective, corporate bond markets offer more attractive return opportunities than bank deposits, as well as diversification opportunities.[447] However, outside of Kenya, Nigeria, Senegal, and South Africa, the capital market or the investor base are still in the early stages.

Here MDBs and DFIs need to intensify efforts to support governments in creating a government bond market that will then create liquidity and higher confidence in the bond market for corporate bonds and project bonds to be issued.[448]

Moreover, many sub-national entities are currently not encouraged by the national governments to borrow or issue bonds,[449] and for some, this is forbidden altogether. South Africa and Nigeria remain an exception, and Nigeria has jumped on the bandwagon more recently. Even in the more decentralized African countries, local governments remain dependent on national transfers instead of developing autonomy in raising revenues. Building the capacity of local governments to finance infrastructure has been key to the infrastructure development of many countries and should be supported by MDBs and DFIs, too.[450]

Once capital markets get deeper, innovative financial instruments can be developed to drain more finance into zero-carbon projects. For instance, infrastructure projects can be pooled in one instrument. While it can attract a larger pool of investors, it also enables the diversification of risk by bundling commercially viable and non-viable projects. India adopted this approach through mutual funds, such as the Infrastructure Investment Trusts (InvITs) promoted by the Securities and Exchange Board of India.[451] Moreover, covered bonds backed by a pool of loans for various infrastructure projects, piloted in the 1990s in Germany and now widely used in Europe,[452] can support bank lending to infrastructure. In covered bonds, bond investors have a claim over a dedicated 'cover pool' of assets and against the issuer itself, which lowers risk and cost.[453] In Africa, Morocco has adapted its legislation to enable banks to issue covered bonds[454] (while South Africa has declined to do so).[455]

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[447] International Monetary Fund (IMF) and The World Bank Group, *Recent Developments on Local Currency Bond Markets in Emerging Economies*, World Bank Staff Note For The G20 International Financial Architecture Working Group (Riyadh: IMF and World Bank, January, 2020), *http://documents1.worldbank.org/curated/en/129961580334830825/pdf/Staff-Note-for-the-G20-International-Financial-Architecture-Working-Group-IFAWG-Recent-Developments-On-Local-Currency-Bond-Markets-In-Emerging-Economies.pdf*.

[448] Existing initiatives including the G20's Compact with Africa, the World Bank Group J-CAP Program, the Financial Sector Reform and Strengthening Initiative (FIRST), the IMF/World Bank's Debt Management Facility II and III, and Switzerland's Government Debt and Risk Management Program have recently bolstered technical assistance efforts in building government bond market in emerging or low-income countries. MDBs have even issued bonds in local currencies to catalyze the development of capital markets. For instance, the World Bank has issued bonds in local currencies in 32 countries while the IFC has done so in 20 countries. International Monetary Fund (IMF) and The World Bank Group, *Recent Developments on Local Currency Bond Markets in Emerging Economies*.

The creation of the African Domestic Bond Fund in 2018 by the AfDB and the Mauritius Commercial Bank Group (MCB), the first multijurisdictional fixed income Exchange-Traded Fund (ETF) on the continent, has ignited the government bond market in Africa. "The African Development Bank and MCB Group launch African Domestic Bond Fund," African Development Bank Group, September 17, 2018, *https://www.afdb.org/en/news-and-events/the-african-development-bank-and-mcb-group-launch-african-domestic-bond-fund-18492*.)

[449] For instance, the attempt to issue municipal bond by Dakar city was blocked by the central government. Hugo Halimi, "Untapped Finance for African Cities: Municipal Bonds," *UrbanAfrica.Net*, November 7, 2016, *https://www.urbanafrica.net/urban-voices/untapped-finance-for-african-cities-municipal-bonds*.

[450] Jeffrey Gutman, Amadou Sy, and Soumya Chattopadhyay, *Financing African Infrastructure: Can the World Deliver?* (Brookings Institute, March 2015), *https://www.brookings.edu/wp-content/uploads/2016/07/AGIFinancingAfricanInfrastructure_FinalWebv2.pdf*.

[451] *The Economic Times: India Times,* "Definition of "Infrastructure Investment Trusts," *https://economictimes.indiatimes.com/definition/infrastructure-investment-trusts*.

[452] Spurred by the fact that Basel III makes bank lending more difficult because of liquidity requirements.

[453] Frank Damerow, Sean Kidney, and Stuart Clenaghan, *How Covered Bond Markets Can Be Adapted for Renewable Energy Finance and How This Could Catalyse Innovation in Low Carbon Capital Markets* (Climate Bonds Initiative, May 2012), *https://www.climatebonds.net/files/uploads/2012/05/Climate-Bonds_RE-covered-bonds_22May20121.pdf*.

[454] "Moroccan Covered Bonds: Africa's New Generation of Finance," *International Financial Law Review (IFLR)*, July 9, 2013, *https://www.iflr.com/article/b1lt3b8qhl141z/moroccan-covered-bonds-africas-new-generation-of-finance*.

[455] "South Africa Says No to Covered Bonds," *Global Capital*, May 26, 2011, *https://www.globalcapital.com/article/yv8gjcjndzr3/south-africa-says-no-to-covered-bonds*.

5. Next Steps for 2022

Steps should be taken already in 2022 to ensure that a roadmap for Africa's zero-carbon mass electrification by 2050 is immediately crafted and rolled out.

First, the AU and the AfDB, in coordination with member states and possibly supported by SDSN, should create a high-level international advisory group composed of the main institutions working on strategies for Africa's zero-carbon mass electrification. Such institutions include the IEA, IRENA, GEIDCO, LUT, and KTH, as well as the AfDB's Program for Infrastructure Development in Africa (PIDA), the AU's New Partnership for Africa's Development (NEPAD) agency, the infrastructure programs of the Regional Economic Communities, and the newly launched initiative launched by UNECA, Team Energy.

With the support of this international group, the AU and the AfDB would undertake the following strategic planning tasks:

- Drawing up a continental timeline and strategy to phase out fossil fuels and redirect national and international resources and incentives to zero-carbon energy investment while ensuring that current fossil fuel exploitation serves African countries' development needs.
- Setting up a working group to update the Africa Mining Vision in light of the opportunities offered by the energy transition. At its core should be skill development policies to seize the rising opportunities of the localization of value chains; the operating principles of shared use of the mining-related infrastructure, in particular in zero-carbon electricity; and the importance of good governance to avoid missing the windfall of the energy transition for Africa's critical minerals.
- Conduct a skill diagnostic for the continent to assess the skills to be developed to seize the opportunities of the energy transition.
- Identifying the regional priority projects that will provide for the trunk infrastructure of the continent, namely, the utility-scale renewable energy projects (solar, hydro, wind, and geothermal) and the regional, continental, and international interconnections.
- Identifying remaining steps to reform regional power pools.
- For the utility-scale generation projects, develop the principles of financing and bankability combining concessional finance, political risk, default, currency guarantees, and private capital, building on successful cases.
- Crafting a strategy to strengthen African utilities in their planning, monitoring, and procurement capabilities and support their financial and operational health.
- Upgrading the policy and legal frameworks related to:
  - Siting policy for renewable energy and land-based solutions;
  - Consultation processes in energy investment;
  - Investment in Information and Communications Technologies;
  - IPP investment in large-scale, mini-grid, or stand-alone generation;
  - Shared use of the power infrastructure of mining and other energy-intensive investments;
  - Local bank lending to infrastructure projects;
  - Standards on EV charging stations;
  - Standards on importing used vehicles to support the phase-out of ICE vehicles.
- Developing an affordability analysis in each country to understand what commercial models and subsidy levels should be promoted for under-the-grid and off-grid communities.
- Develop a communication program on the advantages of renewable energy solutions for the broad Africa citizenry.

Regional power grids and interconnectors have been associated with political battles around transmission pricing and financing, which have stalled the necessary coordination between governments. The work on the above tasks could be plagued and stalled by similar issues. It is thus urgent for the AU to devise politically sensitive solutions to overcome these problems and ensure fast-paced progress.

These tasks could be supported by the Presidential Infrastructure Champion Initiative (PICI). Launched during the 23rd meeting of Heads of State and Government Orientation Committee (HSGOC) in Kampala in 2010, PICI serves the role of providing visibility, removing bottlenecks, and coordinating resources to ensure project implementation. Initially encompassing eight projects, PICI has since grown to include nine total projects, which cover the sectors of transport, energy, ICT, and water.[456] PICI requires five-year implementation updates, which means that every five years, each project must show significant progress, for example, from feasibility studies to implementation.[457] At the core of PICI implementation and monitoring sit pan-African institutions with distinct roles: NEPAD acts as the secretariat and executing agency of the PICI and works closely with the country focal points of the respective states; the African Union Commission (AUC), the regional economic communities (RECs), the AfDB, and the United Nations Economic Commission for Africa (UNECA) monitor countries' progress on the implementation of the PICI projects.[458]

The early-stage Desert to Power initiative sponsored by the AfDB also indicates how institutional arrangements can be made for regional coordination around energy deployment. In September 2019, Heads of States of the G5 Sahel countries endorsed the Desert to Power Initiative and set up a Task Force hosted by the AfDB, steered by the high-level steering committee chaired by the CEO of the Moroccan Agency for Sustainable Energy (MASEN), and composed of Ministers of Energy of the G5 Sahel countries and key partners. The task force will work closely with National Focal Points to support the Ministries of Energy's programs. The Task Force currently leads resource mobilization and engages with potential funding partners; each country will nominate executing entities for each component of the initiative.

[456] "Presidential Infrastructure Champion Initiative (PICI)," PIDA: Virtual PIDA Information Centre, Africa Union Programme for Infrastructure Development in Africa (AU-PIDA), *https://www.au-pida.org/presidential-infrastructure-champion-initiative-pici*.

[457] "Presidential Infrastructure Champion Initiative (PICI)," African Union Development Agency-NEPAD (AUDA-NEPAD), 2019, *https://www.nepad.org/programme-details/1006*.

[458] African Union Commission, New Partnership for Africa's Development (NEPAD), and The Presidency—Republic of South Africa, *Presidential Infrastructure Champion Initiative (PICI) Report* (2015), *https://www.tralac.org/documents/resources/african-union/1554-presidential-infrastructure-champion-initiative-annual-report-2015/file.html*.