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Sustainable Energy Discourse: Prosperity and Climate Change Actions in Sub-Saharan Africa

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Abstract

Sustainable development is, by and large, tied to energy services, and as the world's economic growth is realized, the use of energy is also increasing. In the coming decades, most of the energy demand will come from the developing world due to these countries' increased population and economic activities. Energy use will increase in domestic, commercial, and industrial applications. The ongoing shift in energy sources in the transport sector, potentially from fossil fuel dominance to electric-powered vehicles, is likely to come with its own challenges. All these would require a sustainable energy supply. Sub-Saharan Africa (SSA), in particular, is in the midst of facing the challenges of the energy trilemma: ensuring the security and reliable supply of energy, providing energy services at affordable cost, and investing in sustainable options such as renewable energy or decarbonizing fossil fuel assets. Sustainability language speaks to reducing carbon emissions that result in climate change impacts, where SSA is most impacted as it has limited capacity to adapt and deal with these impacts. Looking at this discourse, where there is increasing pressure from the international community to limit climate change impacts through investing more in clean energy options, and the fact that SSA needs to achieve economic growth makes the discourse challenging. Policymakers would need to balance local and international policies on climate change and look at various options to adapt to this via available resources and technology options.

Keywords: *Sustainability, Prosperity, Climate Change, Sustainable Energy, Policies, Sub-Saharan Africa*.

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1. Introduction

The world is experiencing challenging times to balance between human prosperity and the planet's sustainability. Energy is central in both aspects. Human prosperity depends in many ways on the use of energy that is versatile and low-cost. This makes it possible for countries to leapfrog in their economic growth to meet the energy demand that is increasingly becoming high due to the increasing global population and improving human civilization. Conversely, energy, which is an engine for economic and social prosperity, is responsible for three-quarters of the human-induced greenhouse gas (GHG) emissions that cause global warming, resulting in adverse climate change impacts across the globe. Carbon dioxide (CO_2), which is linked to the excessive use of fossil fuels, makes up 74.4 percent of the GHG emissions, followed by methane (CH_4) at 17.2 percent, nitrous oxide (N_2O) at 6.2 percent and the rest of the gases at 2.1 percent.[55]

The African continent is at a crossroads: it needs to prosper in economic space while embracing a transition towards a low-carbon, preferably net-zero economy. There is growing debate on how Africa can navigate these challenges without harming the environment. There are arguments that Africa needs to go up the ladder of pollution before taking initiatives for a low-carbon development path. However, it is fallacious for Africa to follow the same development path as the Western nations. The challenge remains in undertaking a just transition for people and

[55] Hannah Ritchie, Max Roser, and Pablo Rosado, "CO_2 and Greenhouse Gas Emissions," *Our World in Data*, May 11, 2020, https://ourworldindata.org/greenhouse-gas-emissions.

the planet. This short paper highlights the sustainable energy discourse, looking at the issues behind the energy transition, notably facing the sub-Saharan African (SSA) region.

2. Methodology

The methodology employed in this review is a systematic literature review in line with the sustainability of energy discourses, looking at how this is linked with climate actions and the country's prosperity. The materials reviewed include journal articles, books, online news articles, and strategic internet sites. The aim of the review is to provide insight into issues pertaining to the challenges inherent to the sustainable energy discourse, especially looking at the global south with the aim of informing viable policy actions.

3. The Changing Climate and the Global Response

3.1 Greenhouse Gas Emissions

3.1.1 Greenhouse Gas Emission Concentrations

Climate change has been at the center of discussions in the global space. Climate change links many aspects of development. It traces back to the days when civilization started to take a new shape, the times of the Industrial Revolution when human beings began to take advantage of fossil fuels to support the transformation of activities in many sectors, including farming, transportation, communication, and other related economic activities. While using fossil fuels has resulted in unprecedented improvements in human civilization, it has simultaneously been the cause of the destabilization of the planet's stability. It is argued that for many years before the Industrial Revolution, the climate had been at equilibrium where the carbon emissions in the atmosphere had not accumulated. The outflow and inflow of all the carbon to and from soil, vegetation, and atmosphere were balanced.[56]

The problem started with increased human activities that compelled the excessive use of carbon-emitting energy sources, namely, coal, oil and gas. Using these fuels to propel economic activities has distracted the regular carbon cycles and thus hampered emissions equilibrium, resulting in increased carbon concentrations in the atmosphere. It is claimed that carbon has made the earth warmer compared to the last 100 years; it is now over one Celsius warmer.[57]

3.1.2 Where Do Most of Greenhouse Gases Come From?

GHG emissions come from various sources, including farming activities, animals, and energy. However, energy accounts for the majority of carbon emissions. Fossil fuels dominate the world's energy consumption. Coal accounts for 30 percent of the total final energy use[58] and 36.7 percent of the global electricity generation, followed by natural gas, 23.6 percent.[59] The use of coal from 1850 to 2021 has contributed 46 percent of fossil CO_2 emissions; oil contributed 35 percent and natural gas 15 percent.[60] This pattern also can be seen in carbon emissions; as depicted in Figure 1, the energy sector contributes to about three-quarters of the global GHG emissions.[61]

[56] David J. C. MacKay, *Sustainable Energy – Without the Hot Air*, Illustrated edition (England: UIT Cambridge, 2016), 402.
[57] Mathew Hampshire-Waugh, *CLIMATE CHANGE and the Road to NET-ZERO* (London, UK: Crowstone Publishing, 2021), 55.
[58] Michael B. McElroy, *Energy and Climate: Vision for the Future* (New York: Oxford University Press, 2016), 85.
[59] IEA, "Key World Energy Statistics 2021" (Paris: IEA, September 2021), 30, https://www.iea.org/reports/key-world-energy-statistics-2021.
[60] Pierre Friedlingstein et al., "Global Carbon Budget 2022," *Earth System Science Data* 14, no. 11 (November 11, 2022): 4826, https://doi.org/10.5194/essd-14-4811-2022.
[61] Hannah Ritchie, Max Roser, and Pablo Rosado, "CO_2 and Greenhouse Gas Emissions," *Our World in Data*, May 11, 2020, https://ourworldindata.org/co2-emissions.

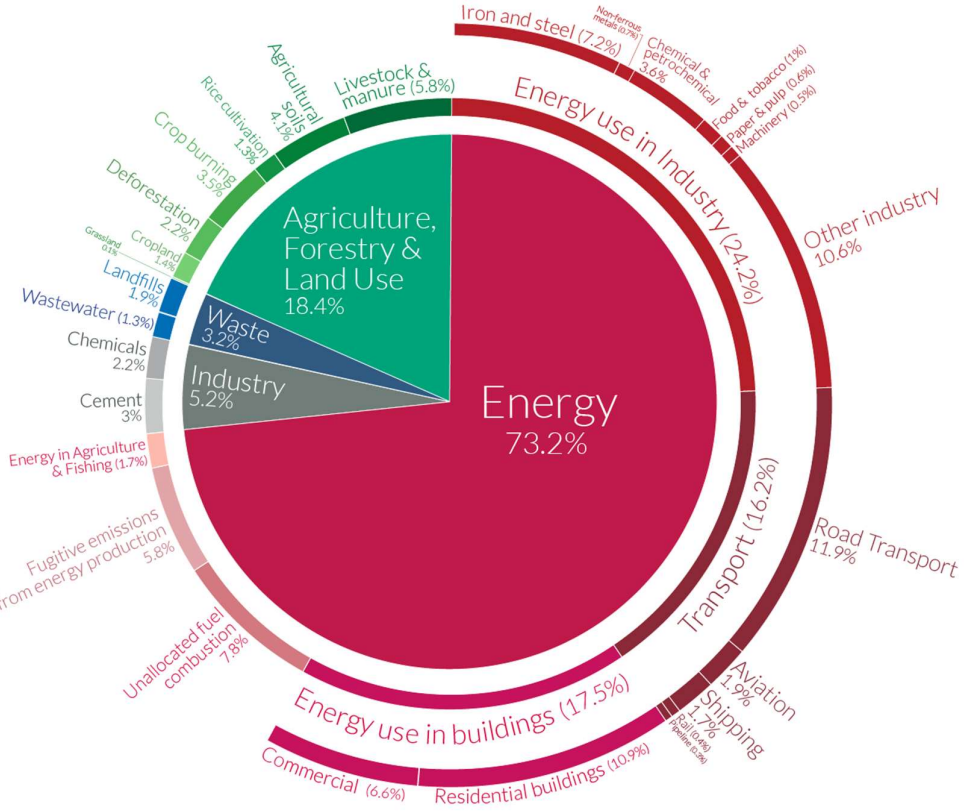

Figure 1: Global Greenhouse Gas Emissions by Sectors

Source: Ritchie (2020)

Looking at the carbon emissions pattern, it is evident that those countries that are at the top of using fossil fuels are equally responsible for most of the global GHG emissions. China and the United States (US) of America are the two countries that consume most of the global fossil fuels, about 50 percent of the global coal; they are also in the top four countries holding most of the global coal reserves: US (23%), Russia (15%), Australia (14%) and China (13%).[62] These two countries are also consuming most of the global oil. Consequently, the two countries are responsible for 42 percent of the global GHG emissions.[63] Africa is responsible for about three percent of the global GHG emissions,[64] and the continent uses less fossil fuels than developed nations.

3.2 The Actions: Why Is It Important for Sub-Saharan Africa?

Adverse climate change impacts have been experienced across the globe: extreme weather events, increasing heatwaves, floods, and sporadic rains, among others. Sub-Saharan Africa is prone to be affected the most in various ways, including temperature changes, extreme heat, precipitation changes, aridity and potential evapotranspiration. Other impacts, among others, include sea level rise, human health, immigration, and conflict.[65] Sporadic and unpredictable rains have been experienced over the past decades, impacting agricultural yields. The region is

[62] "BP Statistical Review of World Energy 2021," *BP*, no. 70 (2021): 47, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2021-oil.pdf.
[63] Mengpin Ge, Johannes Friedrich, and Leandro Vigna, "4 Charts Explain Greenhouse Gas Emissions by Countries and Sectors," *World Resources Institute*, February 6, 2020, https://www.wri.org/insights/4-charts-explain-greenhouse-gas-emissions-countries-and-sectors.
[64] Hannah Ritchie, Max Roser, and Pablo Rosado, "CO_2 and Greenhouse Gas Emissions," *Our World in Data*, May 11, 2020, https://ourworldindata.org/emissions-by-fuel.
[65] Olivia Serdeczny et al., "Climate Change Impacts in Sub-Saharan Africa: From Physical Changes to Their Social Repercussions," *Regional Environmental Change* 17, no. 6 (August 1, 2017): 1585–1600, https://doi.org/10.1007/s10113-015-0910-2.

dependent on seasonal subsistence farming. Famine is experienced in countries like Somalia, Ethiopia, Kenya, and along the Sahel region. Floods and such extremely hazardous events are increasingly experienced in this region; for instance, the recent flood and mudslide killed almost 400 people in the eastern Democratic Republic of Congo (DRC).[66] Although extreme weather events are experienced in most parts of the world, sub-Saharan Africa is affected the most as they have less capacity to adapt and address these challenges. Technology, skills, and other necessities are lacking in the region.

Against this background, sub-Saharan Africa must leapfrog in proactively addressing the shift towards a low-carbon future economy. The main challenge that Africa is facing is the lack of technology and financial resources to embrace a just transition. Africa needs to leapfrog towards unlocking the extreme energy poverty to support its economic growth. Africa experiences the lowest per capita energy consumption. While the US's per capita energy consumption is around 250 kWh per day per person, the European bloc has an average of 125 kWh per person per day; countries in Africa live in a marginal situation whereby their annual per capita consumption is similar to Europe's daily per capita consumption. Shockingly, Sub-Saharan Africa has countries like South Sudan and Niger that consume about 50 kWh per year per person. Per capita consumption of energy in sub-Saharan Africa, excluding South Africa, is 180 kWh, compared to 13,000 kWh per capita in the US and 6,500 kWh in Europe.[67] Sub-Saharan African countries are also lagging in access to electricity; out of the 733 million people lacking access to electricity globally, 568 million are from sub-Saharan Africa.[68] Amid these challenges, the COVID-19 pandemic, Russia's invasion of Ukraine, and related inflation have made the continent increasingly poor, with as many as 450 million people in the sub-Saharan African region.[69] This makes it difficult for the region to progress in socio-economic and technological terms to fight against catastrophic climate change events.

3.3 International Climate Actions: Do They Help Africa in Any Way?

3.3.1 The Kyoto Protocol

International climate change policies started in the late 1990s when the international community realized that the levels of GHG emissions were reaching an unmanageable state and that there should be a deliberate effort to reverse the trend, essentially referring to the state during the pre-industrial era. In 1997, countries met in Kyoto, Japan, and instituted an international agreement called the **Kyoto Protocol**.[70] The ratification of the Kyoto Protocol was voluntary; the US, which is the country responsible for most of the cumulative GHG emissions, did not ratify. The principles of the Kyoto Protocol were centered on making the countries responsible for GHG emissions (industrialized countries) invest in carbon-free interventions that reduce GHG emissions in developing countries. This was under the Clean Development Mechanism (CDM) scheme. However, Kyoto mechanisms that tried to globalize the efforts to curb climate change, much as it helped in some ways to reduce GHG emissions, were found not to be suitable owing to differentiated global dynamics and country priorities.[71] The mechanisms encouraged **offsetting** of the GHG emissions. The offsetting issue is criticized as not helping, per se, addressing GHG emissions as it is regarded as shifting emissions from one place to another.[72] What is required is a complete shift of practices to low- or zero-emissions.

3.3.2 Paris Agreement and Its Mechanisms

The new approach that was adopted in 2007, first mentioned in the Bali action plan during the eighteenth conference of the party (COP 18) in Doha, recognized the fact that countries need to define their specific strategies

[66] "Flash Floods and Landslides Hit Eastern Democratic Republic of Congo - Democratic Republic of the Congo," ReliefWeb, May 8, 2023, https://reliefweb.int/report/democratic-republic-congo/flash-floods-and-landslides-hit-eastern-democratic-republic-congo.
[67] AfDB, "Light Up and Power Africa – A New Deal on Energy for Africa," Text, African Development Bank - Building today, a better Africa tomorrow (African Development Bank Group, June 7, 2019), https://www.afdb.org/en/the-high-5/light-up-and-power-africa-%E2%80%93-a-new-deal-on-energy-for-africa.
[68] IEA et al., *Tracking SDG 7: The Energy Progress Report* (Washington DC: World Bank, 2022), https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2022-full_report.pdf.
[69] IEA, "Africa Energy Outlook 2022" (Paris: IEA, June 2022), 36, https://www.iea.org/reports/africa-energy-outlook-2022.
[70] "What Is the Kyoto Protocol?," UNFCCC, accessed May 24, 2023, https://unfccc.int/kyoto_protocol.
[71] Nicole Grunewald and Inmaculada Martínez-Zarzoso, "Did the Kyoto Protocol Fail? An Evaluation of the Effect of the Kyoto Protocol on CO2 Emissions," *Environment and Development Economics* 21 (March 16, 2015): 1–22, https://doi.org/10.1017/S1355770X15000091.
[72] "The Biggest Problem with Carbon Offsetting Is That It Doesn't Really Work," Greenpeace UK, May 26, 2020, https://www.greenpeace.org.uk/news/the-biggest-problem-with-carbon-offsetting-is-that-it-doesnt-really-work/.

for supporting the efforts to curb climate change, the so-called Nationally Appropriate Mitigation Actions (NAMA), this resulted into countries to determine their climate actions contributions under the framework of Nationally Determined Contributions (NDCs).[73] There is also a favored policy instrument to climate mitigation efforts embracing the one-fits-all mode where carbon prices or/and mitigation targets are set across aboard. While this is economically correct, it is politically challenging to implement.[74] The current climate change mitigation efforts are implemented under the auspices of **the Paris Agreement**,[75] which set ambitious climate targets to limit the global temperature rise by 1.5 degrees Celsius by the mid-century.

3.3.3 The Sustainable Development Goals and Climate Actions

In 2015, the United Nations developed the Sustainable Development Goals (SDGs), a framework for improving people's lives and mitigating the adverse anthropogenic climate change impacts. Specific goals that directly address climate change include Goal 13 (Climate Action), which calls for integrating measures to prevent climate change within development frameworks; Goal 14, which addresses life below water; and Goal 15, which addresses life on land.[76]

The international climate change efforts, on paper, seem to be good. However, it is hard to tell whether it benefits the developing world, especially sub-Saharan Africa. Since their inception, there has been little benefit to the marginalized communities. Plans are still in the custody of developed and industrialized nations. There has been a persistent call from the international community for Africa to champion the energy transition agenda toward more dependence on cleaner energy sources. However, looking at the continent's economic situation, it is undisputed that they cannot leapfrog to investing in cleaner energy without being handheld by the developed nations. This is especially true when looking at investments required for the transition. The records on renewable energy investments between the years 2000 and 2020 show that Africa has only a small share of investment, amounting to two percent of the global renewable energy investment.[77] This trend questions the motives of the international community toward African flourishment. Most countries have articulated their climate action plans through the NDCs; however, many actions identified in the NDCs lack the detail to determine wholly transformative potential.[78] On top of that, they lack financing to implement them, and little funding is made available to these countries.

4. Energy and Sustainable Future Discourse

Future sustainability will depend much on the nature of energy generation and consumption. Dependence on fossil fuels has tremendously supported unlocking the potential for human flourishing. Fossil fuels have supported humans in discovering means to unlock the potential to increase productivity and the civilization we see today. It can be argued that the US and China have been economic superpowers due to the support of fossil fuels. However, this development trajectory that happens at the expense of the planet's instability cannot continue. Future sustainability will depend on switching from fossil fuels to cleaner energy sources, decarbonizing existing carbon-intensive technologies and sources, and efficient energy consumption practices.

[73] "Nationally Appropriate Mitigation Actions (NAMAs)," UNFCCC, accessed May 9, 2023, https://unfccc.int/topics/mitigation/workstreams/nationally-appropriate-mitigation-actions#Capacity-Building-for-NAMA-Preparation-and-Impleme.

[74] Claudia Octaviano, Sergey Paltsev, and Angelo Costa Gurgel, "Climate Change Policy in Brazil and Mexico: Results from the MIT EPPA Model," *Energy Economics* 56 (May 2016): 600–614, https://doi.org/10.1016/j.eneco.2015.04.007.

[75] "The Paris Agreement," UNFCCC, accessed May 24, 2023, https://unfccc.int/process-and-meetings/the-paris-agreement.

[76] United Nations, "CLIMATE & SDGS SYNERGIES," in *Maximizing Co-Benefits by Linking Implementation of the Sustainable Development Goals and Climate Action* (GLOBAL CONFERENCE ON STRENGTHENING SYNERGIES BETWEEN THE PARIS AGREEMENT ON CLIMATE CHANGE AND THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT, UN City, Copenhagen, Denmark: United Nations, 2019), https://sustainabledevelopment.un.org/climate-sdgs-synergies2019.

[77] IRENA and AfDB, "Renewable Energy Market Analysis: Africa and Its Regions" (Abu Dhabi and Abidjan: International Renewable Energy Agency and African Development Bank, January 2022), 89.

[78] Taryn Fransen et al., "The State of Nationally Determined Contributions: 2022" (Washington, DC: World Resources Institute, October 19, 2022), https://doi.org/10.46830/wrirpt.22.00043.

4.1 Energy Generation

The world depends mainly on fossil fuels. Oil holds the largest share of the global primary energy, as shown in Table 1, accounting for 33.1 percent, followed by coal, 27%, and natural gas, 24.2 percent.[79]

Table 1: Fuel Shares of Primary Energy and Contributions to Growth in 2019

Energy source	Consumption (exajoules)	Annual change (exajoules)	Share of primary energy	Percentage point change in share from 2018
Oil	193.0	1.6	33.1%	-0.2%
Gas	141.5	2.8	24.2%	0.2%
Coal	157.9	-0.9	27.0%	-0.5%
Renewables*	29.0	3.2	5.0%	0.5%
Hydro	37.6	0.3	6.4%	-0.0%
Nuclear	24.9	0.8	4.3%	0.1%
Total	**583.9**	**7.7**		

*Renewable power (excluding hydro) plus biofuels

Source: BP Statistical Review 2020

Coal has the largest share of global electricity generation, by 36 percent.[80] The other challenging part of the energy lies in industrial processes; heat energy is primarily generated from fossil fuels, notably coal. A large share of electricity generation also comes from fossil fuels. China, for instance, generates 64 percent of its electricity from coal.[81] The situation is the same for most emerging economies in Asia and the Pacific, where coal and gas contribute to most of the electricity generation.[82] These countries are also responsible for most of the global emissions. Asia-Pacific, the region home to five of the ten largest emitters in the world (China, India, Indonesia, Japan, and South Korea), accounts for over 50 percent of the global GHG emissions,[83] primarily contributed by the development practices that depend on fossil fuels.

Many emerging economies either invest in new coal power plants or their fleet still has many years of existence. China's carbon dioxide emissions account for 26.95 percent of the world's total emissions, more than 85.5% of the total emissions of the second-largest carbon emitter.[84] Its economy mainly relies on fossil fuels, thus validating the argument that its emissions will still have to pick up for a while before they start falling. To change this discourse, China must do industrial restructuring to improve energy consumption and energy restructuring to reduce dependence on coal.[85]

The situation in Africa is not exceptional.[86] In 2019, most electricity was generated from natural gas and coal, followed by hydropower. This discourse does not reflect a sustainable future. Sub-Saharan Africa struggles with

[79] "BP Statistical Review of World Energy 2020," *BP*, no. 69 (2020): 4, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf.
[80] IEA, "Electricity Sector" (Paris: International Energy Agency, September 2022), https://www.iea.org/reports/electricity-sector.
[81] IEA, "Electricity Mix in China, Q1 2020" (Paris: International Energy Agency, October 26, 2022), https://www.iea.org/data-and-statistics/charts/electricity-mix-in-china-q1-2020.
[82] Elisa Papadis and George Tsatsaronis, "Challenges in the Decarbonization of the Energy Sector," *Energy* 205 (August 15, 2020): 5, https://doi.org/10.1016/j.energy.2020.118025.
[83] "Asia and the Pacific's Climate Bank," text, Asian Development Bank (Asian Development Bank, February 22, 2023), https://www.adb.org/climatebank.
[84] Dawei Wang, Wenxing Shen, and Shengliang Zhang, "Regional Forecast of China's Carbon Emission Peak in 2030 and Analysis of Influencing Factors," June 16, 2021, 3, https://doi.org/10.21203/rs.3.rs-627141/v1.
[85] Wang Wei et al., "The Sustainable Development of a Low-Carbon System Using a System Dynamics Model: A Case Study of China," *Journal of Renewable and Sustainable Energy* 15, no. 1 (January 4, 2023): 6–7, https://doi.org/10.1063/5.0130437.
[86] Papadis and Tsatsaronis, "Challenges in the Decarbonization of the Energy Sector," 5.

extreme energy poverty that trickles down to other spheres of life. Africa is a greenfield, in a better position to leapfrog investing in clean energy for a sustainable future. However, the levels of investment in new technologies impend the continent's ability to cope with the necessary transition.

Technological developments are also to blame for leapfrogging toward clean energy sources. The US's recent discovery of shale oil has been an unprecedented milestone in the energy sector markets and security; it has encouraged many countries to work out the possibilities of investing in this new technology to access low-cost energy. Through fracking technology, the US is now generating far cheaper domestic oil than that available in the Middle East.[87]

4.2 Energy Consumption

Energy consumption is increasingly becoming a concern due to increased population, human civilization and economic development; all require reliable and affordable energy. Fossil fuels hold the necessary attributes to meet this demand. However, this is argued to be unsustainable; the world must investigate ways to manage the energy demand and embrace investing in clean energy sources. Managing energy demand must be examined across all sectors: Transportation, industry, and buildings.

4.2.1 Transport Sector

Globally, the **transportation** sector is responsible for about 23 percent of total energy-related greenhouse gas emissions and 13 percent of global greenhouse gas emissions.[88] The transportation sector will need to be restructured to shift from dependence on oil towards embracing electrification, improving engine performance and using alternative fuels like hydrogen and biofuels.

4.2.2 Industry Sector

Industrial activities also significantly contribute to the global GHG portfolio, accounting for 19 percent of global greenhouse gas emissions.[89] Industries must improve their processes to invest in renewable sources such as geothermal and biomass-based Combined Heat and Power (CHP) systems. Some countries have taken some initiatives on fuel switches in industries to avoid dependence on electricity for industrial processes, which is highly inefficient due to the losses of energy transformation, and to use natural gas. Natural gas, much as it is not a sustainable option, can serve in a transition state toward a cleaner future industrial process. In Tanzania, for instance, all the cement factories are now connected to natural gas. However, these transformations are primarily driven by economic rather than environmental factors; in any case, they help transition from highly polluting energy sources like coal.

4.2.3 Building Sector

Energy consumption in the **building sector** is also on the high side. Energy accounts for over three-quarters of GHG emissions in cities. This is mainly due to keeping the houses warm or cool and supplying them with the necessary electricity.[90] The Intergovernmental Panel on Climate Change (IPCC) report estimates that the global emissions from residential and commercial buildings contribute to eight percent of global greenhouse gas emissions.[91] The sustainable future will require embracing low-carbon building practices along the entire value chain, from looking at the embodied energy of the building materials to typologies that support natural ventilation, using energy-efficient appliances, and integrating renewable energy for heat and electricity applications in houses.

4.3 Policy Implications

Countries must balance economic growth and energy choices to achieve a sustainable future. Some countries like China and India will have to forego their pace of economic growth. The global political economy will also need

[87] McElroy, *Energy and Climate*.
[88] UN-HABITAT, "Hot Cities: Battle-Ground for Climate Change" (United Nations Human Settlements Programme, 2011), https://unhabitat.org/sites/default/files/2012/06/P1HotCities.pdf.
[89] UN-HABITAT.
[90] UN-HABITAT, "Cities and Climate Change: Global Report on Human Settlements 2011" (London and Washington, DC: United Nations Human Settlements Programme, March 14, 2011).
[91] UN-HABITAT, "Hot Cities: Battle-Ground for Climate Change."

to be aligned to supporting the poor and developing countries, such as those in the sub-Saharan Africa region, to leapfrog towards investment in clean energy technologies in both the demand and supply side of the chain. The most pertinent challenge in a sustainable future energy discourse for sub-Saharan Africa is to embrace inclusiveness and go with the principle of **leaving no one behind** while being mindful of the climate impacts.

5. Energy and Prosperity: Intertwined

5.1 Energy Scenario in sub–Saharan Africa

Todd Moss, the Founder and Executive Director of the Energy Growth Hub and non-resident fellow at the Centre for Global Development, in his Article "Ending global energy poverty – how can we do better?" articulates what he calls mistakes in achieving the United Nations Sustainable Development Goal number seven (UN SGD 7). The goal calls for affordable access to affordable, reliable, sustainable, and modern energy for all by 2030.[92] The argument is that the global policies on energy transition are failing the African continent as the keywords access, sustainability, modern, affordable, and reliable do not reflect what the continent needs the most.

Access has often been equated to household electricity supply. Access to electricity does not necessarily help in addressing energy poverty as the energy consumption between the African countries and those in the developed world is incomparable; in sub-Saharan Africa, the average electricity consumption is less than 50 kWh per year per person; this is equivalent to only one-day consumption per person in the developed world. The inequality is outrageous. It is then paramount to focus on advocating for the productive use of electricity alongside access. Under the same auspices, **affordability** and **reliability** can be misleading. In most sub-Saharan African countries, electricity and energy, in general, are neither affordable nor reliable. Even the approach of decentralized energy systems in the form of distributed energy systems, such as solar home systems and small mini-grids, does not seem to do justice to socio-economic flourishment.[93]

An unreliable power supply hampers industrial production, and most of these countries are experiencing regular power cuts; recently, this includes South Africa, which was always exceptional in the bloc. South Africa's case is interesting as it can prove the argument that dependence on coal power plants may hamper countries' sustainability.[94] There is also a question of modern energy and sustainability. It can be argued that it is unjust to subject African countries to energy targets and look at what Africans need to unlock themselves out of energy poverty. While there is no justification for polluting and dependence on finite resources to support economic growth, there is a need to reexamine how the African continent can participate in the energy transition agenda given the prevailing extreme energy poverty.

5.2 Sustainable Energy Discourse for Sub-Saharan Africa: Reality Check

5.2.1 Resources

Sub-Saharan Africa is endowed with untapped **hydrocarbons**. Oil-rich countries like Angola rely heavily on oil products for their economies; whether this benefits the entire population is a question of governance beyond this paper's analysis. Nevertheless, the fact remains that this is the backbone of their economy. Thirteen percent of the global natural gas resource is available in Africa and seven percent of the global oil resource. However, a large part of it remains untapped.[95] I would argue that, if these resources were in the US, for instance, they would have been tapped, or at least plans to exploit them would have been laid down. **Coal** reserves are also available in Africa, but the share, compared to global resources, is relatively small, and most of it is found in South Africa, which holds 0.9 percent of the global share of coal-proved reserves.[96] Apart from South Africa, whose electricity generation depends on coal by 90 percent, other African countries have not been able to fully utilize this resource. Some industries use it in direct heat applications.

[92] Todd Moss, "Ending Global Energy Poverty - How Can We Do Better?," World Economic Forum, November 5, 2019, https://www.weforum.org/agenda/2019/11/energy-poverty-africa-sdg7/.
[93] Hannah Mottram, "Injustices in Rural Electrification: Exploring Equity Concerns in Privately Owned Minigrids in Tanzania," *Energy Research & Social Science* 93 (November 1, 2022): 102829, https://doi.org/10.1016/j.erss.2022.102829.
[94] Colleen Goko, "Eskom Deepens Power Supply Cuts as More Generating Units Fail," *Bloomberg.Com*, May 7, 2023, https://www.bloomberg.com/news/articles/2023-05-07/eskom-deepens-power-supply-cuts-as-more-generating-units-fail.
[95] IEA, "World Energy Outlook Special Report," 22.
[96] "BP Statistical Review of World Energy 2021," 46.

Natural gas is gaining traction in contributing to the continent's energy mix; it has proved to be Africa's most reliable and low-cost energy source to leapfrog its economic growth. "Reducing reliance on fossil fuels, which currently provide over three-quarters of all the electricity generated in Africa, will be central to cutting CO_2 emissions and improving energy security. Natural gas was the largest source in 2020, contributing 40% of total power generation, followed by coal (30%)."[97] In 2020, oil, gas, and coal dominated Africa's energy generation mix. The continent's energy mix is shown in Figure 2.[98]

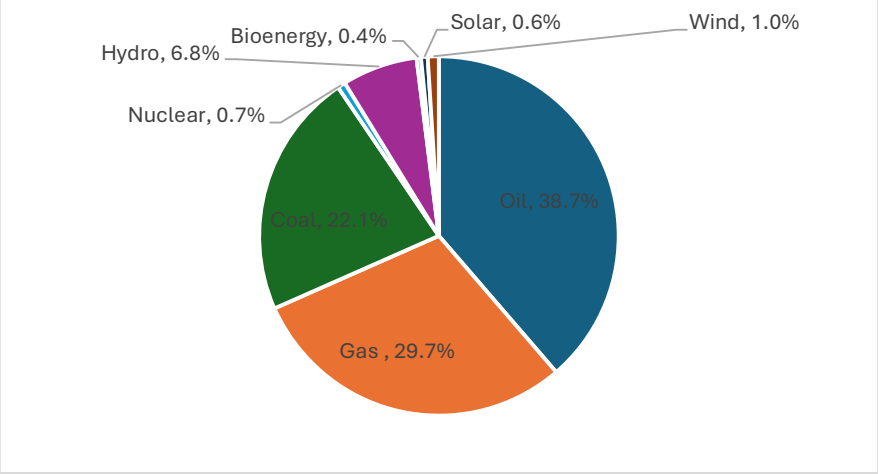

Figure 2: Africa's Energy Generation Mix in 2020

Source: African Review Report, PWC 2021

It has been evident that dependence on fossil fuels will not be sustainable for the future of this continent, looking at energy security, environmental sustainability, and economic perspectives. Thus, there is a need to look for investments in clean and domestic energy sources.

Several renewable energy options can provide sub-Saharan Africa's current and future energy demand. The practical ones include solar, wind, hydropower, geothermal and biomass energy; this presents an opportunity for electricity generation and heat applications. Africa is estimated to be home to 60 percent of the best global solar resources; conversely, only one percent has been developed.[99] Most of this resource is available in the sub-Saharan region, near the equator.

Conversely, it is in this region that electricity per capita consumption is the lowest. Wind resources are also available in the SSA; however, they cannot be compared to Europe and other Western countries that enjoy better wind resources. The wind resource in Africa is estimated to be able to generate almost 180,000 terawatt hours (TWh) per year, which is claimed to be enough to satisfy the entire continent's electricity demands 250 times over. Africa has tapped only 0.01 percent of its potential and the installed capacity in the continent is less than one percent of the global installed wind capacity.[100]

It has often been argued that solar and wind potential can provide the energy needed for the continent. Estimations by the International Energy Agency (IEA) show that by 2030, solar and wind will potentially be able to provide up to 27 percent of the continent's electricity needs.[101] However, there is an unanswered question as to whether this resource will support Africa in leapfrogging toward industrialization. At least with the current technology, these sources are short of necessary attributes for industrial applications offered by fossil fuel sources: low-cost,

[97] IEA, "World Energy Outlook Special Report," 89.
[98] PwC, "Africa Energy Review 2021: The Global Race to Net Zero by 2050 Is Accelerating. Will Africa Realise a Just Transition or Become a Stranded Asset?" (PwC, November 2021), https://www.pwc.com/ng/en/publications/africa-energy-review.html.
[99] IEA, "World Energy Outlook Special Report," 17.
[100] Munyengeterwa Linda and Sean Whittaker, "Powering Africa's Sustainable Development through Wind," *World Bank Blog* (blog), June 24, 2021, https://blogs.worldbank.org/climatechange/powering-africas-sustainable-development-through-wind.
[101] IEA, "World Energy Outlook Special Report," 90.

versatile, dependable, and reliable. Wind and solar are diffuse, intermittent, and non-dispatchable. Most industrial processes that drive the economy need process heat that wind and solar cannot competitively generate. The solution to this would be to have affordable means of storing energy. Energy storage also has its challenges; for the batteries, the cost is still prohibitive, and for pumped storage, the continent lacks surplus power to support the pumped storage functionality as it still suffers from suppressed demand. There has been a growing claim that the solar energy cost has been dwindling, where wind and solar technology costs have experienced shrinking by 10-35% every time the installation doubles,[102] and that it is now cost competitive with fossil fuels looking at the Levelized Cost of Energy (LCOE).[103] However, this is true if the externality costs are considered; the snag in considering externality costs is to potentially add the cost of energy through taxation; this conflicts with one essential attribute of energy: the low-cost aspect.

Globally, **hydropower** has been the most preferred source of electricity generation; in 2011, it accounted for 79 percent of the electricity generated from renewable energy sources.[104] It provided 16% of Africa's electricity output in 2020, with 90% of hydropower generation located in SSA, mainly in Angola, DRC, Ethiopia, Mozambique and Zambia.[105]

For a long time, most of the SSA countries have relied on hydropower; the region is becoming short of environmentally and ecologically acceptable sites. Most suitable sites have been developed; the remaining ones entail the construction of big dams that fall short of environmental sustainability. Damming distracts the course of the natural flow and harms aquatic lives. Additionally, climate change, which has caused drought in the region, has hampered hydropower generation. However, even in the sustainable future scenario, hydropower remains a cornerstone, with several large-scale projects currently under development to provide affordable and dispatchable electricity.

Geothermal is also increasingly gaining traction, with some countries like Kenya having these systems in operation. However, the technology depends on geological and geographical conditions that cannot be found in many places.[106]

Biomass energy presents a promising opportunity to provide energy for future demand in the African continent. Biomass offers multiple forms of energy necessary for different uses in households and industrial processes. For instance, the CHP technology using bagasse in the sugar industry has been one of the dependable sources of energy in industrial applications. On the other hand, bioenergy presents an opportunity to provide fuels for transportation, namely biodiesel and biofuels. SSA has vast land that can support the growing fuel plants. However, the challenge will remain in the production value chain of the biofuels that require water use to grow them and inherent concerns over food security. Biofuels have low energy density, which makes them challenging, especially for heavy-duty vehicles. Today, 99 percent of transportation fuels in Africa come from oil, and only 0.1 percent is from biofuels.[107] Changing this equation will need dedicated policies and strategies supported by the necessary financing. With the continent struggling with basic needs, this does not seem to materialize in the foreseeable future.

In SSA, there is a potential to develop **Concentrated Solar Power** (CSP) to generate most of its electricity needs, as there is good potential in the Sahel region. However, this is not without challenges; the locations where CSP technology can be implemented are usually remote and will need significant investments in power evacuation infrastructure.

Nuclear is regarded as one of the potential energy sources that can support a sustainable future as it is a clean energy source and does not emit carbon. With increased tension about a sustainable future, the talk of nuclear energy has received renewed attention. It is claimed that, from 2020 to 2040, nuclear power avoided 2–3 percent of total global GHG emissions annually.[108] Nuclear, much as it is a clean and energy source that can unlock Africa from energy poverty, attracts international attention. The attention from the potentially catastrophic events such as that of Fukushima in Japan, the disposal of radioactive waste, and the potential for nuclear proliferation.

[102] Hampshire-Waugh, *CLIMATE CHANGE and the Road to NET-ZERO*, 13.
[103] Hampshire-Waugh, 174.
[104] McElroy, *Energy and Climate*, 172.
[105] IEA, "World Energy Outlook Special Report," 128.
[106] McElroy, *Energy and Climate*.
[107] IEA, "World Energy Outlook Special Report," 75–76.
[108] Nikolaus Muellner et al., "Nuclear Energy - The Solution to Climate Change?," *Energy Policy* 155 (August 1, 2021): 9, https://doi.org/10.1016/j.enpol.2021.112363.

Apparently, only one nuclear power plant exists in SSA and is available in South Africa. Uganda has recently embarked on planning to develop nuclear power plants.[109] With ongoing geopolitical tensions, it does not seem easy for Africa to progress in harnessing its nuclear resources for energy use. This is even more difficult for the continent as it will require significant investments and appropriate plans to invest in the necessary infrastructure to address inherent nuclear technology issues.[110]

5.2.2 Technology Options

Technology will play a critical role in Africa to leapfrog in socio-economic prosperity while embracing appropriate climate actions towards a carbon-neutral future; some of these technological interventions include using electric vehicles, energy efficiency measures and cleaning fossil fuels through Carbon Capture, Storage and Utilization (CCSU). Adopting **electric vehicles** is one of the potential options for Africa to leapfrog in decarbonizing the transport sector; the transport sector, which depends on oil products for more than 90 percent, is a significant contributor to GHG emissions.[111] In this case, shifting from using fossil fuels to running vehicles will support lower carbon emissions. The challenge will remain in the economics of energy storage, which is essential in running electric vehicles. There will also be a challenge of battery disposal; exploring the second life of the batteries could be one option where the used batteries from the vehicles can serve for electrical energy storage for the home systems. However, the good news is that battery technology is advancing, and the cost is increasingly becoming lower. Africa has the necessary minerals to support the battery technology. The IEA argues that "Africa accounts for over 40% of global reserves of cobalt, manganese and platinum – key minerals for batteries and hydrogen technologies. South Africa, the Democratic Republic of the Congo and Mozambique have a significant share of global production today, but many other countries may hold undiscovered deposits."[112] Africa needs to explore ways of taking advantage of these minerals to advance in battery storage systems. Some efforts are already unfolding in some sub-Saharan African countries; for instance, Tanzania plans to establish a new Special Economic Zone near the Dry port close to its commercial capital, Dar es Salaam, where battery manufacturing technology will be explored, among other things. On similar notes, the private sector is also planning to support the efforts, primarily to serve as an electrification component of solar.[113]

Energy efficiency is said to be one of the low-hanging fruits that will support the African continent on a low-carbon development path. With the demand projected to increase exponentially with the population and the advancement of economies, ways to reduce the energy demand will be paramount. Analysis shows that energy efficiency alone could support reducing energy losses by up to 40 percent and, in turn, reduce emissions.[114] In Africa, energy efficiency measures apply to both the supply and demand sides of the energy value chain. Most of the energy infrastructure is dilapidated, causing significant losses. These losses are tied to power-generating assets, transmission infrastructure, and end-use appliances. The housing sector also encounters considerable energy losses due to inappropriate designs and orientations.

It has been increasingly argued that Africa should be left to utilize their resources to leapfrog its economic growth, including investing in fossil fuels. However, it can be counterargued that this mentality is fallacious as the continent cannot follow the same development routes as the Western nations, mainly because the times have changed and the technology to leapfrog the low-carbon development path is available. The plausible option is to see how the African continent can use **clean coal** or clean its coal, notably by embracing CCSU technology. The challenge is that CCSU technology is expensive, adding to the investment capex, which most African countries cannot afford; however, this is possible with appropriate policies and international financial support.

[109] Mehmet Ceyhan, "IAEA Delivers Report on Nuclear Power Infrastructure Development to Uganda," Text, International Atomic Energy Agency (IAEA, May 13, 2022), https://www.iaea.org/newscenter/news/iaea-delivers-report-on-nuclear-power-infrastructure-development-to-uganda.
[110] Laura Gil, "Is Africa Ready for Nuclear Energy?," Text, International Atomic Energy Agency (IAEA, September 3, 2018), https://www.iaea.org/newscenter/news/is-africa-ready-for-nuclear-energy.
[111] Godwin Oghenebrozie Atedhor, "Greenhouse Gases Emissions and Their Reduction Strategies: Perspectives of Africa's Largest Economy," *Scientific African* 20 (July 1, 2023): e01705, https://doi.org/10.1016/j.sciaf.2023.e01705.
[112] IEA, "World Energy Outlook Special Report."
[113] "Tanzania: Firm Plans Solar Battery Plant in Mwanza," *Afro News* (blog), July 9, 2021, https://afro.news/2021/07/09/tanzania-firm-plans-solar-battery-plant-in-mwanza/.
[114] IEA, "Energy Efficiency 2020" (Paris: International Energy Agency, 2020), 10, https://www.iea.org/reports/energy-efficiency-2020.

5.2.3 Business Models

SSA suffers the most when it comes to clean energy access. Most of the population without access to electricity globally is found in the SSA. Similarly, access to clean cooking is also at the lowest rate; 922.9 million people lack clean cooking in SSA, equivalent to about 39 percent of the 2.4 billion people who lack clean cooking globally.[115]

Africa, due to its diversity, off-grid solutions that include **mini-grids** and **distributed energy systems** seem to be plausible solutions. However, this is insufficient to cater to proper economic development as these solutions become financially competitive primarily when offering lighting solutions. **Grid extension** is a preferred option to provide versatile energy solutions. For instance, Ghana, Senegal, and Tanzania have the policy to embrace grid extension over other options.[116] However, this is an expensive undertaking, and often, underutilization of energy in rural settings defeats the justification for investing in grid extension. It can be argued that accelerated productive use of energy in rural areas is an appropriate discourse toward sustainable social-economic development.

A sustainable energy future in SSA must also address the energy security aspect. In this case, **regional power interconnections** can be of paramount importance. There are already regional power pools, such as the Eastern Africa Power Pool (EAPP) and Southern African Power Pool (SAPP).[117] However, this must be approached with care, with appropriate policies and legal frameworks that reduce some risks, including geopolitical tensions. The planned **African Single Electricity Market** (AfSEM) is intended to connect energy strategies and action plans on the African continent through the harmonization of regulatory frameworks and by integrating national generation, transmission, and distribution master plans. This could be one of the essential steps to addressing energy access and regulatory issues within the continent.[118]

5.3 Policy Implications

For SSA to leapfrog towards a sustainable energy future, national, regional, and international policies would play a significant role. There will be a need for a paradigm and systemic shift in energy infrastructure investments and the creation of strong institutions. Regional harmonization of the enabling framework could help address some of the challenges some countries face, including weak institutions, financing shortages, and lack of resources, including technology and human capital. The international community plays a critical role in support of Africa's sustainable energy discourse through technology transfer, capacity building, and financing.

6. Net-Zero Pathways in a Nutshell

6.1 The Concept of a Net-Zero Future

A net-zero future can be viewed as embracing sustainability for people and the planet: utilizing the current resources for human flourishing without compromising the future. Energy plays a critical role in the net-zero pathways. It is argued that to achieve a net-zero economy, there must be a paradigm shift from the current use of energy, which largely depends on fossil fuels, to clean energy sources. IEA statistics, presented in Figure 3, show that for the past 46 years (between 1973 and 2019), dependence on fossil fuels, coal, oil, and natural gas has been consistent. Coal, oil, and natural gas accounted for 75.1 percent of the total global electricity generation; things remain pretty much the same in 2019 (43.1 percent), 46 years later![119]

[115] IEA et al., *Tracking SDG 7: The Energy Progress Report*, 62–63.
[116] "Electrifying Africa: Grid Extension Models in Sub-Saharan Africa," energypedia, accessed May 24, 2023, https://energypedia.info/wiki/Electrifying_Africa:_Grid_Extension_Models_in_Sub-Saharan_Africa.
[117] ICA, "REGIONAL POWER STATUS IN AFRICAN POWER POOL" (Tunis: Infrastructure Consortium for Africa (ICA), November 2011), https://www.icafrica.org/en/news-events/ica-news/article/ica-report-regional-power-status-in-african-power-pools-3299/.
[118] African Union, "African Union Launches World's Largest Single Electricity Market (AFSEM)," African Union, June 4, 2021, https://au.int/en/pressreleases/20210604/african-union-launches-worlds-largest-single-electricity-market-afsem.
[119] IEA, "Key World Energy Statistics 2021," 30.

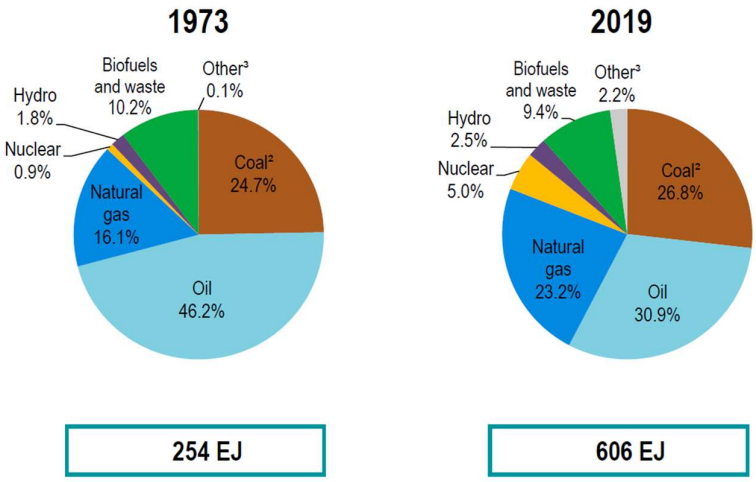

Figure 3: Share of World Total Energy Supply by Source, 1973 and 2019

Source: IEA 2021

Under a net-zero scenario, things have to change; IEA analysis argues that wind and solar will have to cater for more than half of the global total primary energy needs and closer to 80 percent of the global electricity generation.[120] Many solutions must be adopted to achieve a net zero future, such as increased investments in renewable energy, reducing dependence on and cleaning fossil fuels, and managing demand through energy efficiency measures.

6.2 African Perspectives

Africa's contribution to global warming today is relatively small, with a share of about three percent of the global GHG emissions.[121] However, the situation will likely change as the economies and population grow. The continent will find ways to leapfrog on its economic development by exploiting the low-hanging fruits, namely investing in coal and natural gas as they see supporting their economies. In this case, the GHG share from the continent is likely to grow. The sustainable energy future for Africa sees an energy mix that includes coal and natural gas, at least up to 2030.[122] Clean energy will serve the sizeable residential energy demand for the SSA, including using electricity and modern bioenergy.[123] The sustainable energy future for Africa will need appropriate policy actions that specifically require increased investment in the clean energy sector to increase the share of renewables in the energy mix and address the global energy challenges brought by geopolitical tensions such as the war in Ukraine.[124]

7. Conclusions: Policy Landscape

Africa will need to leapfrog in its economic development; in this case, it will need more energy to cater to its increasing population and economic advancement. Africa has a challenge in addressing the issue of energy poverty and inequalities. Enabling access to electricity for all and access to clean cooking solutions will be critical. All these must happen within the auspice of a sustainable future that utilizes clean energy sources and avoids fossil fuels. Policies to support this transformational change must be instituted across the continent, linking with the international community.

[120] IEA, "Net Zero by 2050: A Roadmap of the Global Energy Sector" (France: International Energy Agency, May 2021), 115, https://www.iea.org/reports/net-zero-by-2050.
[121] Hannah Ritchie, "Who Has Contributed Most to Global CO2 Emissions?," Our World in Data, October 1, 2019, https://ourworldindata.org/contributed-most-global-co2.
[122] IEA, "World Energy Outlook Special Report," 65.
[123] IEA, 67.
[124] IEA, 105.

Due to the diverse nature of the continent, policies need to address the local content supported by international goals. Nations will need to tailor policies to address local needs, such as accelerating electrification through appropriate means, investing in energy infrastructure to bring efficiency, and looking at how to serve industrial development with clean energy sources such as bioenergy. Natural gas will remain an essential source of energy to drive industrial growth. However, this should be made to support the transition toward using clean energy sources.

The international community will need to do justice to the continent by making international climate finance available and easily accessible. Statistics show that apart from the push that Africa should embrace a clean energy investment trajectory, only a modest share of international financing, to the tune of two percent of the global renewable energy, went to Africa for two decades, from 2000 to 2020.[125] There is also a tendency for funds pledged for emission mitigation not to be provided in full; for instance, mobilized funding from 2014 to 2018 targeting adaptation was USD 16.5 billion, half of the financing (USD30.6 billion) aimed at reducing emissions.[126]

Implication for further studies

Climate change has been claimed to be real and evident in several areas, affecting social and economic well-being. The approach toward addressing it has been taken rationally so as not to cause harm in these discourses. Most of the claims related to climate change impacts are from the usual suspect sources and mainstream media which can be argued to be affiliated with particular side of the world. It would be interesting to continue conducting studies that reflect the actual situation in the global south, and this is another course of research to understand how best the global south, notably sub-Saharan Africa is prepared to absorb global pressure to embrace the energy transition such that their prosperity is not in jeopardy.

Abbreviations

AfSEM	:	African Single Electricity Market
CCSU	:	Carbon Capture, Storage and Utilization
CDM	:	Clean Development Mechanisms
CHP	:	Combined Heat and Power
CSP	:	Concentrated Solar Power
EAPP	:	Eastern Africa Power Pool
GHG	:	Greenhouse Gases
IEA	:	International Energy Agency
IPCC	:	Intergovernmental Panel on Climate Change
LCOE	:	Levelized Cost of Energy
NDC	:	Nationally Determined Contributions
SAPP	:	Southern African Power Pool
SDGs	:	Sustainable Development Goals
SSA	:	Sub-Saharan Africa

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[125] IRENA and AfDB, "Renewable Energy Market Analysis: Africa and Its Regions," 89.
[126] "This Is How Much Investment Is Needed to Mitigate Climate Change across Africa," World Economic Forum, October 27, 2021, https://www.weforum.org/agenda/2021/10/five-finance-climate-adaptation-africa-falls-short/.

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Biography

Emmanuel G Michael Biririza is an energy expert with experience in sub-Saharan Africa, including technical design, policy, programming, innovative financing, and clean and sustainable energy project implementation. He has worked for various organizations in national and international space: the UN organizations (UNIDO, Tanzania; UNHCR, Tanzania; and UN-HABITAT, Nairobi, Kenya), the African Development Bank, Abidjan, Cote d'Ivoire, the European Union Energy Initiative Partnership Dialogue Facility (EU-EIPDF), in East Africa, UNEP Risoe Centre, in Denmark. In addition, he worked with several national and international organizations as a consultant. He works for NORCAP/Norwegian Refugee Council as a Regional Energy Advosor for East Africa. He pursues a Ph.D. in Global Energy Policy from EUCLID University (Pôle Universitaire Euclide). He holds an MSc in Environmental & Energy Management from the University of Twente in the Netherlands and a BSc (with honours) in Electrical Engineering from the University of Dar es Salaam in Tanzania. He is a certified Professional Engineer with the Engineers Registration Board of Tanzania.