

The Influence of Global and Regional Climate Policies on Solar Mini-grid Implementation in Ghana

Tracy Asamoah-Boateng

University of Aberdeen, Scotland.

Corresponding author: asamoah.tracy@yahoo.com

DOI: <https://doi.org/10.62154/ajesre.2025.021.01016>

Abstract

The present global energy transition's fundamental goal is to minimise climate change by reducing energy-related CO₂ emissions. The developed nations are the primary contributors to the development and implementation of climate change mitigation measures. Regardless, the implementations have proven to be slow for developing countries despite the availability of renewable energy sources and new technologies to utilise them. There is limited evidence on how the global climate policies on finance including the African regional policies have influenced the development of green energy projects in developing countries, particularly Ghana. The study aims to analyse the policies concerning climate change emanating from global and regional levels to determine their impact on the development of green energy projects, mainly solar mini-grids in Ghana. A qualitative approach was used through document analysis to analyse data from policy documents, energy-related reports and academic literature. Document analysis ensures easy accessibility and provides a firsthand understanding of policy processes. The paper found that one of the major challenges the recent COPS (26-29) faced was the lack of commitment to the financial pledges by the developed countries to the developing countries to fund clean energy initiatives. This has invariably contributed to the gap in solar mini-grid implementations as Ghana has not benefited much from the green climate finance. The paper recommends that world leaders and policymakers commit to the climate green financing agreements and ensure smooth management and disbursement of funds to support developing countries in their clean energy projects.

Keywords: Solar Mini-Grid Implementation, Climate Change, Climate Policies, Greenhouse Gas Emissions, Fossil Fuels, Green Financing.

Introduction

The present global energy transition's fundamental goal is to minimise climate change by reducing energy-related CO₂ emissions (Nyansapoh et al., 2023). As a result, several technologies and approaches are being developed and deployed to minimise reliance on fossil fuels while increasing the use of renewable energy, energy storage, smart grids, and carbon capture (Oyewo et al., 2023). Combinations of these technologies and methods result in a more sustainable energy system that is more effective, cleaner and resilient to the effects of climate change (Atabaki et al., 2022; Kabeyi & Olanrewaju, 2022).

The two main obstacles to Sub-Saharan Africa's overall development are climate change and a lack of access to energy (Avila et al., 2017; Mungai et al., 2022; Omisore, 2018; Nuru

et al., 2021). During the lockdowns due to the COVID-19 outbreak, the majority of African nations' economies decreased due to a substantial reduction in the usage of electricity by commercial and industrial sectors (Amir & Khan, 2022). Despite the devastating economic impact of the pandemic, it presents a chance for African countries to implement transformative improvements and structural modifications in energy generation and storage (Nsafon et al., 2023). The worsening effects of climate change throughout the continent underscore the necessity of shifting from a regional economy reliant on fossil fuels to one that is fuelled by clean energy (Adzawla et al., 2019).

Global energy and climate policy formulation is predominantly biased towards the Global North (Mele et al., 2021). In addition to historically being accountable for the bulk of greenhouse gas emissions, the developed countries are also the primary contributors to the development and implementation of climate change mitigation measures (Mele et al., 2021; Oreggioni et al., 2021). Regardless, the implementations have proven to be slow despite the availability of renewable energy sources and new technologies to utilise them (Kabeyi & Olanrewaju, 2022). Due to Africa's heavy reliance on diminishing natural resources, investing in renewable energy will help African economies lessen the immediate and long-term socio-economic effects of the COVID-19 pandemic and the current climate crisis (Nsafon et al., 2023). Studies reveal that African countries might not be able to withstand increasing climate change vulnerabilities due to weak adaptive capacity (Rahut et al., 2021). To mitigate the long-term detrimental effects of climate change, the IPCC report on global warming recommends at least 80% uptake of renewable energy sources by 2050 (IPCC, 2018).

The annual United Nations Framework Convention on Climate Change (UNFCCC) brings global leaders and policymakers to agree on ways to address the climate crisis of the 2015 Paris Agreement to limit global temperature rise to 1.5°C (Jiang, 2024). The Paris Agreement is a legally binding international treaty addressing climate change in which member parties are supposed to make plans to adhere to the agreement of limiting global average temperature to 1.5 °C above pre-industrial levels (United Nations Climate Change, 2024). To assist vulnerable communities in developing nations in adapting to the effects of climate change, developed nations committed during the 2009 COP 15 in Copenhagen to provide US\$100 billion annually by 2020 for the adaptation and mitigation of climate change (Feist & Geden, 2023). Despite accounting for over half of the world's population, these countries currently receive only 13% of clean energy finance (Rockefeller Foundation, 2021). Discrepancies between commitments and actual support are not a new issue (Mountford et al., 2021). Nevertheless, many representatives from the Global South believe the situation has reached a critical point (Feist & Geden, 2023). This has sparked an urgent call for robust green financing systems to aid the development of decentralised infrastructure including, off-grid solutions (Bhattacharyya, 2013; Glemarec, 2012; Obi et al., 2025; Okesiji, 2025).

Ghana is no exception as the country needs major renewable energy growth to satisfy its Nationally Determined Contributions (NDCs) commitments (IRENA, 2022). However, there is limited evidence on how the global climate policies on finance including the African regional policies have influenced the development of green energy projects in Ghana. In light of this, the study aims to analyse the policies concerning climate change emanating from global and regional levels to determine their impact on the development of green energy projects in Ghana. This is in relation to the implementation of Distributed Renewable Energy (DRE) systems like solar mini-grids, which address energy issues and reduce the reliance on fossil fuels (Adu-Poku et al., 2023; IRENA, 2019).

Research Questions

The study focuses on addressing the following research questions:

- i. How do Global policies influence the implementation of solar mini-grids in Ghana?
- ii. How do African policies influence the implementation of solar mini-grids in Ghana?

Literature Review

Climate Justice

The climate justice concept gained traction in the 1990s with a primary focus on the reduction of CO₂ emissions, mitigation and adaptation, sharing the costs and benefits of climate change and aiding people affected by it (Lyster, 2015). Climate campaigners contend that the countries that have done the most to cause the climate crisis are better equipped to deal with its aftermath (Kenfack, 2018) and that the poor in the developing nations who have done the least to cause the climate crisis will be the ones who suffer the most from it (Franzki & Olarte, 2013). Furthermore, they contend that the under-representation of those most affected by climate change in global climate decision-making raises procedural justice concerns (Kenfack, 2018). Furthermore, since the next generation will be the most impacted by the disaster but will not be included in the crucial policy-making process, intergenerational justice is one of the most important ethical problems of climate justice (Okereke & Coventry, 2016).

According to Muttitt & Kartha (2020), the current usage of fossil fuels results in situations where people's fundamental rights are violated, and their interests are not protected. This makes the consumption of fossil fuels unjust (Islam, 2024). Basic human rights are violated by climate change and implementing climate justice is one way to uphold the rights that have already been agreed upon (Muttitt & Kartha, 2020; Newell et al., 2021). The idea has made it possible to include concerns about the methods and results of climate policy in the same analytical framework (Figueroa, 2022). It was also mentioned that discussions or arguments over climate justice primarily occur at the international level, in contrast to the establishment of environmental justice in local battles (Ciplet & Roberts, 2017; Lahn, 2018). Heffron et al (2015) identify the international Kyoto Protocol's failure which sparked

protests against climate change and demands for climate justice. However, some governments and cities of nations have also utilised the climate justice framework proving its national, local and global relevance (Ambrey et al., 2017; Zhang et al., 2017).

Energy Transition in Africa

Energy poverty is a significant issue that exacerbates socio-economic inequalities and stifles sustainable development, particularly in low-income and marginalised communities (Aguda, 2024; Sule et al., 2022). Additionally, there is a robust conversation among donors regarding climate-compatible development which promotes actions that achieve the triple win of mitigation, adaptation and poverty alleviation (Cairney et al., 2023). As this view gains traction, international climate policy is viewed as a tool for promoting such development (Newell & Bulkeley, 2017). The International Energy Agency projects that energy consumption in Sub-Saharan Africa will increase by roughly 80% by 2040 (IEA, 2019) with much of this growth being met by an increase in fossil fuel usage unless incentives are put in place for alternative pathways (Newell & Bulkeley, 2017). This has sparked a growing movement towards decentralised renewable energy (DRE) systems, which provide localised, cost-effective and eco-friendly alternatives to traditional grid setups (Obi et al., 2025).

In Africa, transitioning to a low-carbon pathway involves more than just substituting polluting electricity sources with renewables (Ouedraogo, 2020). Development plans must have a direct influence on the energy transition paths which are consistent with climate objectives. Africa has contributed less than 3% of global energy-related CO₂ and has the lowest emissions per capita (IEA, 2022). However, owing to their overall lower level of development and low adaptive capacity, African countries are among the most vulnerable to the effects of climate change (Mungai et al., 2022; Omisore, 2018; Nuru et al., 2021). Klein et al (2017) asserted that international agreements make high promises; however, there is little evidence to indicate how the promises translate into an effective flow of funds for marginalised areas, especially in developing countries. Most studies tend to focus more on climate mitigation efforts, and many highlight on how decentralised and low-carbon energy technologies can serve as the basis for African countries' energy systems (Alstone et al., 2015; Dagnachew et al., 2017; Hargroves et al, 2023; Zalengera et al., 2020).

It is therefore critical to assess the influence of climate funding on economic growth, poverty reduction and the reduction of the reliance on fossil fuels. In light of this, the study focuses on the implementation of DRE systems like solar mini-grids. This investigates how DRE systems can improve clean energy access in Sub-Saharan Africa, empower local communities and promote climate justice.

DRE Systems

DRE systems are renewable-based stand-alone off-grid systems that traditionally supply modern energy services to rural households (Harish, 2022). They provide basic services such

as lighting and cooking to off-grid communities (Stephanie et al., 2024). One component of the DRE systems is solar photovoltaic (PV) (Babayomi et al., 2023). In Sub-Saharan Africa, solar photovoltaic energy generation is not a new occurrence as it has been utilised in development initiatives for rural electrification since the 1960s. Most of the solar photovoltaic projects in Sub-Saharan Africa have been off-grid systems intended for rural and urban people (Baurzhan & Jenkins, 2016). The most common distributed solar solutions include residential systems, task lights, and solar lanterns. Solar Home Systems (SHSs) are the most popular solar solutions among middle-class and upper-class homes in developing countries (Pode, 2013). Nonetheless, obtaining investment money is still significantly hampered by the absence of sustainable company financing, particularly in the case of the capital-intensive PAYG model, where the distributor assumes most of the risks. Grimm et al (2017) contend that although off-grid (SHSs and Pico-PV systems) offer significant advantages to their users, their capacity to generate enough energy for useful purposes is constrained.

In light of this, rural-level mini-grids have gained a lot of attention because they can provide adequate capacities for beneficial uses (motive power) without requiring the large capital expenditures associated with extending high-voltage transmission lines. This allows them to bridge the gap between on-grid and off-grid electrification at the home level (Peters et al., 2019). As part of the Sustainable Energy for All (SE4ALL) project of the United Nations, the Global Tracking Framework seeks to guarantee that 70% of new connections in rural areas are supplied by decentralised solutions with two-thirds of these coming from mini-grid installations (World Bank, 2014). Mini-grids are unquestionably essential to achieving the UN SE4All Initiative's and SDG 7's 2030 goal of universal access to energy (SE4All, 2012). Among the various approaches to rural electrification, mini-grids are featured as a bridge in the lost connection between large-scale national grid systems and small-scale systems like SHSs and lanterns (IRENA, 2016).

Technical Components of Mini-grids

Mini-grids are designed for small-scale electricity generation ranging from 10kW to 10MW (Energy Sector Management Assistance Programme (ESMAP), 2000). These systems distribute electricity to a limited number of customers through a distribution grid (ESMAP, 2000; IRENA, 2016). They can operate independently from national electricity transmission networks and provide high-quality electricity to concentrated settlements (ESMAP, 2000; IRENA, 2016). Figure 1 shows a diagram of various components of a typical mini-grid system which constitute the production, distribution and end-user (United States Agency for International Development (USAID), 2023).

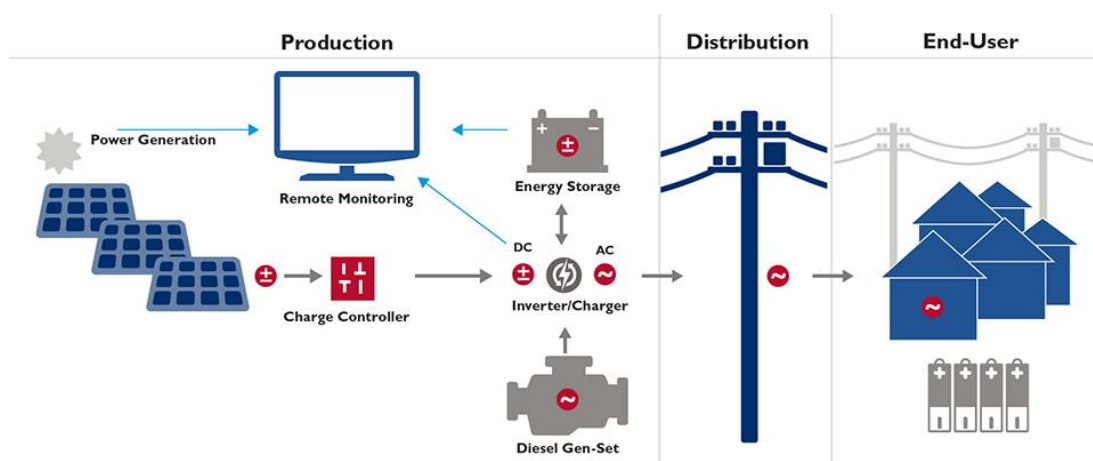


Figure 1: Various components in a mini-grid system (Source: USAID, 2023)

Ghana Renewable Energy and Mini-grid Experience

For the past decade, Ghana has become a net emitter of CO₂ emissions and the effects are expected to exacerbate environmental problems disproportionately affecting women and vulnerable communities, specifically in rural areas (Republic of Ghana, 2015). In the last recorded year as of 2019, Ghana was the world's 139th largest producer of annual CO₂ emissions (Boyle, 2024). Thus, adopting renewable energy sources is essential to maintaining access to electricity, mitigating the negative effects of CO₂ emissions and preventing global warming from above 2°C (Kabeyi & Olanrewaju, 2022). In energy generation, Ghana generates 64% of its electricity from fossil fuels, mostly natural gas and crude oil. Hydropower (36%, mostly from the Akosombo dam) and grid-connected solar PV (0.6%) make up renewable energy capacity (IRENA, 2022). In 2007, the Ghana Energy Development and Access Project (GEDAP) was approved by the World Bank Board. At evaluation, the project's anticipated total cost was US\$210.6 million of which US\$90 million was funded by the International Development Association and US\$5.5 million by the Global Environment Facility (Bukari et al., 2021). The State Secretariat for Economic Affairs (SECO, Switzerland), the African Development Bank, the Africa Catalytic Growth Fund, the Government of Ghana and the Electricity Company of Ghana (ECG) were additional financiers. The Global Partnership on Output-based Aid's contributions raised GEDAP's overall funding to US \$227.5 million (Bukari et al., 2021). The programme has three targets: the sectors institutional performance and suitability, the improvement of electricity distribution and the increase in the share of electricity from renewable energy sources (Bukari et al, 2021).

Regarding the increase in the share of electricity from renewable energy sources, there has been remarkable success despite technical and financial issues in the power sector which the GEDAP program primarily aimed to resolve. Ghana's access expansion policy prioritises grid extension in rural areas and off-grid alternatives for island communities (particularly

Volta Lake) (ESMAP, 2017; Energy Commission, 2021). In 2015, under the GEDAP program, the World Bank Group funded the provision of 5 pilot mini-grids (Nuru et al., 2021; Saddari et al., 2024).

Methodology

The methodology employed for this study was document analysis. This methodical process involves examining or evaluating documents to produce empirical knowledge and understanding (Bowen, 2009). Documents are easily accessible providing researchers with a firsthand understanding of policy processes (Cardno, 2018). Developing the aims of the study precedes the actual collection of documents (Rapley & Rees, 2018). This guides the overall research design which includes the approach for selecting, gathering and analysing data as well as ensuring that the study's various components work together cohesively (Van den Bulck et al., 2019). It is also vital to assess whether the study's overarching objectives are primarily descriptive, interpretative, causal or critical (Van den Bulck et al., 2019).

The documents were analysed qualitatively from policy documents and energy-related reports supported by academic literature. This approach is known as triangulation. It is worth noting that a rigorous qualitative methodological approach requires triangulation to increase research reliability and validity (Bans-Akutey & Tiimub, 2021; Johnson & Onwuegbuzie; 2004). Triangulation employs many ways in the research to extract the necessary information while critically assessing findings (Casey & Murphy, 2009), thereby establishing validity and reliability (Bans-Akutey & Tiimub, 2021). Triangulation of data can help researchers to corroborate findings across datasets and thus reduce the impact of potential biases that can exist in a single method (Donkoh & Mensah, 2023). In the study, data from policy documents and academic literature were corroborated to present findings from the climate agreements. The data was analysed using thematic analysis. Thematic analysis is an order of processes that focuses on identifying recurring themes or concepts in a textual data set (Riger & Sigurvinsdottir, 2016). Many qualitative approaches focus on the act of organising information into themes (Riger & Sigurvinsdottir, 2016). This analytical approach was chosen because the analysis process takes into account a more thorough, methodical re-reading and evaluation of the data.

The analysis began with setting the boundaries of the study and the criteria for the selection of documents. The study searched online for documents on climate financing agreements for developing countries on green projects for the four most recent COPS which were COP 26, COP 27, COP 28 and COP 29. The second search was the African policies on DRE systems. The next was Ghana's climate and energy policies. The second stage in the analysis involved searches for keywords within the documents which had detailed information on the themes. Table 1 shows the themes and their corresponding policy documents and reports chosen.

Table 1: Themes and the corresponding policy documents and reports.

Themes	Policy documents
Climate financing agreements for developing countries COPS (26-29)	AFDB, (2021), Climate Change Committee, (2021); Climate Change Committee, (2022); Climate Change Committee, (2024); Climate Policy Initiative, (2022); Green Energy Africa Summit, (2024); OECD, (2024); UNDP, (2022); United Nations Climate Change, (2023); United Nations Climate Change, (2024)
African policies on DRE systems	African Power Platform, (2015); African Renewable Energy Initiative, (2023); African Union, (2022); European Parliamentary Research Service, (2022); European Union, (2017); ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE), (2013); ECREEE, (2023), IEA, (2022); IEA, (2024); USAID, (2016)
Ghana's climate and energy policies	Environmental Protection Agency, (2020); Energy Commission, (2019); Energy Commission, (2021), Ministry of Energy, (2021); UNDP, (2023); World Bank, (2022)

Results and Discussion

Global Climate Finance Commitments

The section analyses the four most recent COPS, which are COP 26, COP 27, COP 28 and COP 29 and their relationship with DRE projects.

COP 26 declaration in 2021 was concluded with nations adopting the Glasgow Climate Pact, aiming to turn the 2020s into a decade of climate action and support (Climate Change Committee, 2021). The Adaptation Fund pledged US\$356 million, and the Least Developed Countries Fund received US\$413 million. Nations agreed to reaffirm their duty to fulfil the pledge of US\$100 billion annually from developed nations to fund developing countries on measures to curb greenhouse gases (Climate Change Committee, 2021). In the Africa session of COP 26, the Desert to Power Programme from the Global Energy Alliance for People and Planet (GEAPP) was implemented to bounce back from COVID-19 in Sahel regions in Africa (AFDB, 2021). The Climate summit did not achieve its key goals (Helen et al., 2021). One major issue was the Loss and Damage Funding plan which was abandoned (Mountford et al., 2021). In addition, the COP 26 did not achieve the goals of putting a price on carbon, ending fossil fuel subsidies and delivering on the promise of US\$100 billion a year in climate finance for developing countries (Broom, 2021). The insufficient funds affect the pace of the implementation of DRE projects mostly in the rural off-grid communities in Sub-Saharan Africa. In addition, Ghana happens to be part of Sub-Saharan Africa but not part of the Sahel regions to benefit from the GEAPP program from the COP 26. Hence, the evidence of a slow-paced implementation of DRE projects, which influences their ability to fulfil the climate policy in reducing the reliance on fossil fuels.

The COP 27 outcome in 2022 on the climate finance plan known as the Sharm el-Sheikh Implementation Call for developed countries to provide resources for the second replenishment of the Green Climate Fund (Climate Change Committee, 2022). All countries welcomed the recent pledges made to the Adaptation Fund of US\$211.58 million, the Least Developed Countries Fund of US\$70.6 million and the Special Climate Change Fund totalling US\$35.0 million (Climate Change Committee, 2022). From the Africa event, the Africa Mini-grids Program was launched with funding of US\$50 million country-led technical support initiative that aims to drive the solar-battery mini-grids sector and increase electricity availability in 21 countries (UNDP, 2022). A new "Loss and Damage Fund" was agreed upon by representatives of low- and middle-income countries to assist them in paying for the costs associated with the effects of climate change (Masood et al., 2022), but was not finalised until COP 28 (Zarkik, 2022). Developed countries made little progress towards meeting the promise made as part of the COP26 Glasgow Climate Pact to double adaptation funding from 2019 levels by 2025 (Zarkik, 2022). A strategy for implementing this target was not agreed upon as intended, leaving parties with less confidence that it will be met by 2025 (Depledge et al., 2022). The inability of the doubling of the adaptation fund created a huge funding gap for a year. In relation to the Africa Mini-grids program from the COP 27, Ghana was not part of the 21 countries benefiting from the scheme. Due to that, Ghana could not benefit from the implementation of the renewable energy projects. This would slow down the role solar mini-grids play in Ghana in fulfilling the climate policy to lessen greenhouse emissions from fossil fuel sources.

The COP 28 declaration in 2023 concluded on the first "Global Stocktake" of the world's efforts to address climate change under the Paris Agreement (United Nations Climate Change, 2023). The new funding for Loss and Damage was finally agreed on was US\$661 million. The Green Climate Fund received a boost in funding at COP28 with total pledges now standing at a record US\$12.8 billion from 31 countries, with further contributions expected (United Nations Climate Change, 2023). From the African session, a US\$200 million Clean Energy Supply Chain effort was launched with the World Bank, the African Development Bank and the International Finance Corporation to create a network of mini-grids, solar household systems and clean cooking solutions for rural and peri-urban areas (Green Energy Africa Summit, 2024). A number of governments announced new contributions totalling US\$661 million (Beauchamp & Józefiak, 2023). Other programmes, notably the Green Climate Fund and the Adaptation Fund have been fundamentally under-resourced from the start and climate finance has risen at an annual pace of only 7%, which is less than half of the cumulative annual growth of 21% that is necessary until 2030 (Climate Policy Initiative, 2022). In order for the Loss and Damage Fund to be successful, the magnitude of the financing will need to be expanded, as what has been pledged so far constitutes a mere 0.2% of what is truly needed (Woodman-Hardy, 2024). The implementation of the Loss and Damage Fund in COP 28 would provide great relief for

vulnerable communities in developing countries on the condition that the pace is steady in relation to the disbursement and replenishment of funds. The reason is that the Green Climate Fund and Adaptation Fund have not performed well and the same management of funds in place of these funds might replicate their *modus operandi* for the Loss and Damage Fund. With regard to the Clean Energy Supply Chain effort from COP 28, the fund for supplying decentralised solutions like mini-grids does not explicitly define the countries to benefit from the DRE systems. This creates uncertainty for countries' ability to implement renewable energy systems which invariably hinders their role in fulfilling the Paris Agreement by minimising the reliance on fossil fuels.

The COP 29 in 2024 concluded on the New Collective Quantified Goal on Climate (NCQG) Finance to mobilise US\$300 billion per year from the industrialised countries which is to be met by 2035. This was a compromise solution and some developing nations expressed frustration and disappointment (United Nations Climate Change, 2024). The initial Global Stocktake from last year's COP28 was not expanded upon (Climate Change Committee, 2024). To help achieve the Paris Agreement's temperature goal, significant and immediate action is needed, particularly to move away from fossil fuels (United Nations Climate Change, 2024). Adaptation efforts were emphasised about the significance of viable grant-based financing for vulnerable economies (United Nations Climate Change, 2024). Africa's key priorities for COP 29 were ensuring that the continent's requirements were reflected in the NCQG and getting funding for adaptation and resilience, just transition and loss and damage (Africa Policy Research Institute, 2025). This is because the African clean energy space represents a massive opportunity for meeting critical climate goals for the global community, only if backed by the right investment in clean energy solutions (ESI Africa, 2023). COP 29 failed to address Africa and the Global South's financial demands of US\$1.3 trillion, as the US\$300 billion annual climate finance objective was deemed inadequate (Adeniyi, 2025). The previous green finance deals emerging from COPS (26-28) have not seen adequate disbursement of funds for the implementation of the DRE systems in developing countries. However, the Organisation for Economic Co-operation and Development (OECD) (2024) found that the UNFCCC goal exceeded the annual US\$100 billion goal for the first time in 2022 as developed nations mobilised a total of US\$115.9 billion in climate finance for developing countries. This achievement comes two years after the 2020 target year (OECD, 2024). The upcoming COP 30 will reveal the progress of the developed countries. In recent times, Ghana has developed structures and policies in place for clean technologies. These include the 2019 Renewable Energy Master Plan, which aims to accomplish the share of renewable energy from 42.5 MW in 2015 to 1363.63 in 2030 (Energy Commission, 2019) and the National Energy Policy, which aims by 2030 to develop mini-grid electrification options for islands, lakeside and remote rural communities (Ministry of Energy, 2021). However, this cannot be realised without a proper funding mechanism in place.

Regional Policy

There is a direct linkage between global climate policies and regional climate policies. The Paris Agreement informs all the policies of the African region and the national level. Twelve African nations, which together produce about 40% of the continent's CO₂ emissions, are among the roughly 70% of CO₂-emitting nations that committed to achieving net zero emissions by the middle of the 21st century in 2022 (IEA, 2024). Being signatories to the Paris Agreement, most African countries are well-positioned to benefit from technological spillovers and draw in more climate finance (IEA, 2022). All 55 member states, which represent all countries in the African continent, are signatories to the Paris Agreement (African Union, 2022). This has led to international organisations from developed countries like USAID partnering with the African Union in 2016 to reduce carbon emissions (USAID, 2016) and the European Union reinforcing its commitment to support the African Union in fulfilling its mandates under the Paris Agreement in 2017 (European Union, 2017). Therefore, the birth of the first African Union Climate Resilient Strategy Plan (2022-2032), which builds upon the African Renewable Energy Initiative (AREI) 2015 (European Parliamentary Research Service, 2022). These policies being directly connected make the climate change plans possible aiming at reducing greenhouse emissions by enforcing the implementation of DRE systems.

AREI 2015 was launched by the African Heads of State and Government on climate change at COP 21 in Paris to create integrated solutions that enhance access to clean energy services, improve human well-being, and put African countries on the path to sustainable and climate-friendly growth (African Power Platform, 2015). AREI received funding of US\$10 billion from the international community aimed at installing 10 GW of renewable energy in 2020 (African Power Platform, 2015). AREI aims to generate at least 300 GW by 2030 (African Renewable Energy Initiative, 2023). The initial goal for funding of US\$10 billion for renewable energy projects for the AREI has been achieved by providing energy access and ensuring economic development. Regardless, Ghana as part of African countries, has not yet benefited from the implementation, although two projects have been labelled with Ghana and other countries as beneficiaries. The main challenge is that the next tranche of funds to be received for 2020-2030 to enable the implementation of the 300 GW renewable energy projects is uncertain and no commitment has been made yet, considering we have 5 more years to 2030.

The AU heads of state adopted the first continental Climate Change and Resilient Development Strategy and Action Plan (2022-2032), acknowledging that climate adaptation policies were not well implemented across the continent because they were mainly country-specific (European Parliamentary Research Service, 2022). With the technical and financial support of the EU, the strategy supports African countries' commitments under the Paris Agreement, presenting a unified voice towards COP 27 (Chevallier and Chesterman, 2022). The annual adaptation costs in developing nations are

anticipated to be between US\$140-300 billion in 2030 and US\$280-500 billion in 2050. However, this may be a significant underestimation (African Union, 2022). The strategic intervention Axis 2 in the Strategy and Action plan, Adopting Pathways Towards Transformative Climate Resilience Development considers the growth of innovative low-cost energy-saving technologies such as mini-grids (African Union, 2022). The AU Climate Change and Resilient Development Strategy and Action Plan (2022-2032) that has been implemented is at its early stage and its achievement cannot be measured yet. Another issue is with funding which has not been explicitly defined. It was discovered that the disbursement ratio of climate-related projects from 2014 to 2018 was as low as 56% for mitigation and 46% for adaptation (compared to 96% for other development projects). This ratio shows whether approved projects received funding and were implemented as planned or encountered difficulties in practice. This calls for a more rigorous funding mechanism, considering the uncertainty in the estimation highlighted in the AU Climate Change and Resilient Development Strategy and Action Plan.

In 2010, the ECOWAS Renewable Energy Policy (EREP) was implemented. The objective of this strategy is to guarantee a greater utilisation of renewable energy sources including solar, wind, small-scale hydro, and bioenergy, for the supply of grid electricity and the provision of energy services to rural regions (ECREEE, 2023). It calls for raising the percentage of rural residents serviced by decentralised renewable electricity services such as mini-grids and stand-alone systems to 22% by 2020 and 25% by 2030 to implement DRE solutions (ECREE, 2013). The EREP policy seeks to assist ECOWAS member countries in developing adequate regulatory frameworks for the development of renewable energy technologies and services. This helps to strengthen regional integration in the renewable energy sector. A case in point is the major contribution in the DRE sector in Ghana, where the Energy Commission received support with the drafting of Mini-grids regulations.

Climate Finance Commitments and Climate Justice

According to Khan et al (2020), ensuring climate justice in adaptation financing can be achieved by implementing a fair process that involves all relevant parties. This process should involve raising Adaptation Funds based on responsibility for climate impacts allocating the funds in a way that prioritises the most vulnerable (Khan et al., 2020). Developing countries and civil society groups who frequently criticise international assistance methods for perpetuating the neo-colonial agenda of affluent nations, advocated for the COP to supervise the funds with fair and impartial representation as stipulated in articles 11 and 11.2 in the Adaptation Fund (Khan et al., 2020). Green finance is becoming increasingly important for the most vulnerable countries which suffer a double burden as a result of climate change (Pelling & Garschagen, 2019). In many circumstances, they not only have the least capacities and resources to manage and adapt but also experience negative consequences (Doshi & Garschagen, 2020).

Impacts and Gaps in Ghana's Mini-grid Implementation

Ghana's Fourth National Communication to the UNFCCC in 2020 proposed shifting the country's electrical generation to a mix of hydropower, natural gas, renewables, and nuclear power by 2030 (Environmental Protection Agency, 2020). As part of Ghana's commitment to the Paris Agreement, all signatories must submit NDCs outlining their plans to assist in meeting the global goal of 1.5°C, adapt to climate effects, and secure adequate funding to support these efforts (UNDP, 2023). NDCs must be updated every five years, with growing ambition based on each country's capabilities and capacity (UNDP, 2023). The updated NDC was submitted in 2021 to the UNFCCC. The updated NDC 2021 aims to fulfil Ghana's obligations under the Paris Agreement and in general, acts as a guide for transforming the country's economy into a low-carbon one (World Bank, 2022). The Programme of Actions (PoAs) and policy measures that will be applied in the energy sector for solar DRE systems are listed in Table 2, together with the State entities in charge of carrying out or contributing to the execution of each PoA.

Table 2: Detailed Policy Actions for Solar DRE Systems in the NDC 2021 (Source: World Bank, 2022)

Policy Actions	PoA	Target 2025	Target 2030	Status	Lead Institution
Promote clean rural household lighting	Replace all rural, non-electric lanterns with solar ones by the year 2,000,000	932,500 solar lanterns	2,000,000 solar lanterns	Conditional	Ministry of Energy
By 2030, 10% of the generating mix should come from modern renewable sources.	Install 300 MW distributed solar PV	100 MW	300 MW	Conditional	Energy Commission
	Create 300 solar mini-grids, or 14.22 megawatts. Reach 527.1 MW of installed solar power capacity for utility-scale use.	50 mini-grids	300 mini-grids	Conditional	Ministry of Energy
		240 MW	527.1 MW	Conditional	Energy Commission, PURC, NPA

From the updated NDC in Table 2, the implementation of mini-grids is conditional upon financial support from either international donors or the private sector. From 2165 MW in 2010 to 5288 MW in 2020, Ghana's total installed electrical generation capacity, including distributed generation, grew at an average annual rate of 9.3% (Energy Commission, 2021). Excluding huge hydroelectric projects (Akosombo, Kpong, and Bui), the installed

generation capacity (kW) of renewable energy from electricity generation capacity (Energy Commission, 2021) is presented in Table 3.

Table 3: Renewable energy installed generation capacity (kW) (Source: Energy Commission, 2021)

Year	Off-grid			On-grid			Mini-Grid			Installed
	Solar	Wind	Dist. SPV	Utility Solar	W2E	Hydro	Wind	Solar	Wind	
2013	–	–	495	2500	–	–	–	–	–	2995
2014	1350	–	443	–	–	–	–	–	–	1793
2015	4003	20	700	20,000	100	4000	–	256	11	29,090
2016	1238	–	2266	–	–	–	–	–	–	3865
2017	678	–	4266	–	–	–	–	58	–	5002
2018	4	–	6641	20,000	–	–	–	–	–	26,645
2019	–	–	6426	–	–	45	–	–	–	6471
2020	–	–	6472	16,540	–	–	–	–	–	23,012
Total	7273	20	28,068	59,040	100	4045	0	314	11	98,871

Note: Dist. SPV = Distributed Solar PV, W2E = Waste-to-Energy

As seen in Table 3, there have been a limited number of solar mini-grid implementations from 2013 to 2020 with generating capacity amounting to 314 kW which were in 2015 and 2017. The year 2015 had the highest installed capacity of 256 kW, as that was the year the 5-pilot mini-grids in the island communities through the Ministry of Energy were implemented (SNV, 2021). In 2015, under the GEDAP program, the World Bank Group funded the provision of 5-pilot mini-grids (Nuru et al., 2021; Saddari et al., 2024). These solar systems have a total capacity of around 200kW and are projected to offer 24-hour electricity to around 3,500 residents of the five island villages in the South-Eastern part of Ghana. Regardless, in early 2025, there were three mini-grid implementations on three island communities in the Ada East of the Greater Accra Region of Ghana, with a capacity of 253.26 kW (Energy News Africa, 2025). The gaps in solar mini-grid implementations reveal how Ghana has not benefited much from the green climate finance.

Conclusion

The analysis of the four most recent COPS (26-29) revealed that climate finance commitments agreed upon by developed countries to support developing countries have not been adequately implemented. In addition, it was found that there was mismanagement in the disbursement and management of funds, resulting in a slow pace in the implementation of green energy projects. Climate justice promotes equal distribution of advantages and obligations related to climate change mitigation, adaptation, and funding. Nevertheless, access to funding is one of the major issues hindering developing countries from getting access to DRE systems like solar mini-grids. Ghana being a

developing country and a member of the African Union, which represents the regional level, is also a signatory to the Paris Agreement. As part of Ghana's commitment to the Paris Agreement, the country must submit an NDC outlining its plans to assist in meeting the global goal of 1.5°C. However, in the country's NDC, there is a condition for financial support from international organisations and the private sector to enable the implementation of solar mini-grids. The study reveals inadequate funding, hence, a gap in the implementation of solar mini-grids from 2013 to 2020, as reported by the Energy Commission.

Recommendation

World leaders and policy-makers must ensure smooth management and disbursement of funds to support developing countries in their energy projects. Most of the DRE projects are capital-intensive, and without proper funding mechanisms in place for their implementation, developing countries would not be able to achieve their goal of reducing their reliance on fossil fuels. Therefore, increasing access to funding from international organisations for the government of Ghana can scale up the implementation of solar mini-grids to all off-grid rural communities.

Recommendation for future research

The study recommends empirical studies to investigate how well different mini-grid finance models work in diverse socioeconomic and geographical settings. These studies could investigate the effects of funding mechanisms on project sustainability, end-user affordability, and long-term operational effectiveness, including public-private partnerships, community-based finance, donor support and results-based financing. Comparative studies between nations or regions would also help determine which funding arrangements work best for expanding mini-grids, lowering financial risks, and improving energy access results.

References

- Adeniyi, D. (2025). The broken promise of loss and damage finance: Can Europe help?. <https://ecdpm.org/application/files/9217/3815/6775/The-broken-promise-loss-damage-finance-Can-Europe-help-ECDPM-briefing-note-191-2025.pdf>
- Adu-Poku, A., Aidam, G. S. S. K., Jackson, G. A., N'tsoukpoe, K. E., Kponyo, J. J., Messan, A., ... & Kemausuor, F. (2023). Performance assessment and resilience of solar mini-grids for sustainable energy access in Ghana. *Energy*, 285, 129431. <https://doi.org/10.1016/j.energy.2023.129431>
- Adzawla, W., Sawaneh, M., & Yusuf, A. M. (2019). Greenhouse gasses emission and economic growth nexus of sub-Saharan Africa. *Scientific African*, 3, e00065. <https://doi.org/10.1016/j.sciaf.2019.e00065>
- Africa Policy Research Institute. (2025). A continent in focus: COP29 outcomes and implications for Africa. <https://afripoli.org/a-continent-in-focus-cop29-outcomes-and-implications-for-africa>

- African Development Bank Group (AFDB). (2021) COP26 - Accelerating the Implementation of the Desert to Power Programme to build back better from Covid. <https://www.afdb.org/en/news-and-events/multimedia/video/cop26-accelerating-implementation-desert-power-programme-build-back-better-covid-full-event-48588>
- African Power Platform. (2015). Framework for transforming Africa towards a renewable energy-powered future with access for all. <https://www.africanpowerplatform.org/resources/620-a-framework-for-transforming-africa-towards-a-renewable-energy-powered-future-with-access-for-all.html>
- African Renewable Energy Initiative. (2023). *Africa Renewable Energy Initiative*. <https://www.arei.info/eng>
- African Union. (2022). African Union Climate Change and Resilient Development Strategy And Action Plan (2022-2032). [https://au.int/sites/default/files/documents/41959-doc-CC Strategy and Action Plan 2022-2032 08 02 23 Single Print Ready.pdf](https://au.int/sites/default/files/documents/41959-doc-CC%20Strategy%20and%20Action%20Plan%202022-2032%2008%2002%2023%20Single%20Print%20Ready.pdf)
- Aguda, O. O. (2024). An Examination of the Impact of Energy Transition on Marginalized Communities in the Global South. *East African Journal of Law, Policy and Globalization*, 1(2). <https://journal.kiut.ac.tz/index.php/eajlpg/article/view/114>
- Alstone, P., Gershenson, D., & Kammen, D. M. (2015). Decentralized energy systems for clean electricity access. *Nature climate change*, 5(4), 305-314. <https://doi.org/10.1038/nclimate2512>
- Ambrey, C., Byrne, J., Matthews, T., Davison, A., Portanger, C., & Lo, A. (2017). Cultivating climate justice: Green infrastructure and suburban disadvantage in Australia. *Applied Geography*, 89, 52-60. <https://doi.org/10.1016/j.apgeog.2017.10.002>
- Amir, M., & Khan, S. Z. (2022). Assessment of renewable energy: Status, challenges, COVID-19 impacts, opportunities, and sustainable energy solutions in Africa. *Energy and Built Environment*, 3(3), 348-362. <https://doi.org/10.1016/j.enbenv.2021.03.002>
- Atabaki, M. S., Mohammadi, M., & Aryanpur, V. (2022). An integrated simulation-optimization modelling approach for sustainability assessment of electricity generation system. *Sustainable Energy Technologies and Assessments*, 52, 102010. <https://doi.org/10.1016/j.seta.2022.102010>
- Avila, N., Carvallo, J. P., Shaw, B., & Kammen, D. M. (2017). The energy challenge in sub-Saharan Africa: A guide for advocates and policy makers. *Generating Energy for Sustainable and Equitable Development*, Part, 1, 1-79. [https://www.aler-renovaveis.org/contents/lerpublication/oxfam rael 2017 jan the-energy-challenge-in-sub-saharan-africa-a-guide-for-advocates-and-policy-makers-part-1.pdf](https://www.aler-renovaveis.org/contents/lerpublication/oxfam%20rael%202017%20jan%20the-energy-challenge-in-sub-saharan-africa-a-guide-for-advocates-and-policy-makers-part-1.pdf)
- Babayomi, O. O., Olubayo, B., Denwigwe, I. H., Somefun, T. E., Adedoya, O. S., Somefun, C. T., ... & Attah, A. (2023). A review of renewable off-grid mini-grids in Sub-Saharan Africa. *Frontiers in energy research*, 10, 1089025. https://ui.adsabs.harvard.edu/link_gateway/2023FrER...1089025B/doi:10.3389/fenrg.2022.1089025
- Bans-Akutey, A., & Tiimub, B. M. (2021). Triangulation in research. *Academia Letters*, 2(3392), 1-7. <https://doi.org/10.20935/AL3392>
- Baurzhan, S., & Jenkins, G. P. (2016). Off-grid solar PV: Is it an affordable or appropriate solution for rural electrification in Sub-Saharan African countries? *Renewable and Sustainable Energy Reviews*, 60, 1405-1418. <https://doi.org/10.1016/j.rser.2016.03.016>
- Beauchamp, E., & Józefiak, I. (2023). Defining a Monitoring, Evaluation, and Learning System for the Global Goal on Adaptation. <https://www.iisd.org/system/files/2023-05/global-goal-on-adaptation-monitoring-evaluation-learning-framework-cop-28.pdf>
- Bhattacharyya, S. C. (2013). Financing energy access and off-grid electrification: A review of status, options and challenges. *Renewable and Sustainable Energy Reviews*, 20, 462-472. <https://doi.org/10.1016/j.rser.2012.12.008>

- Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative research journal*, 9(2), 27-40. <https://doi.org/10.3316/QRJ0902027>
- Boyle, B. (2024). Overview of carbon emissions produced by Ghana. <https://www.emission-index.com/countries/ghana>
- Broom, F. (2021). Developing countries 'deeply frustrated' by COP26 outcome. SciDev. net-Environment. <https://www.scidev.net/global/news/developing-countries-deeply-frustrated-by-cop26-outcome/>
- Bukari, D., Tuokuu, F. X. D., Suleman, S., Ackah, I., & Apenu, G. (2021). Ghana's energy access journey so far: a review of key strategies. *International Journal of Energy Sector Management*, 15(1), 139-156. <https://doi.org/10.1108/IJESM-02-2020-0008>
- Cairney, P., Timonina, I., & Stephan, H. (2023). How can policy and policymaking foster climate justice? A qualitative systematic review. *Open Research Europe*, 3, 51. <https://doi.org/10.12688/openreseurope.157192>
- Cardno, C. (2018). Policy Document Analysis: A practical educational leadership tool and a qualitative research method. *Educational Administration: Theory & Practice*, 24(4), 623-640. <https://eric.ed.gov/?id=EJ1305631>
- Casey, D., & Murphy, K. (2009). Issues in using methodological triangulation in research. *Nurse researcher*, 16(4). <https://doi.org/10.7748/nr2009.07.16.4.40.c7160>
- Chevallier, R., & Chesterman, S. (2022). Enhancing the operationalization of the African Union's climate change and resilient development Strategy and action Plan (2022-2032). <https://hdl.handle.net/10568/126214>
- Ciplet, D., & Roberts, J. T. (2017). Climate change and the transition to neoliberal environmental governance. *Global environmental change*, 46, 148-156. <https://doi.org/10.1016/j.gloenvcha.2017.09.003>
- Climate Change Committee. (2021). COP26: Key outcomes and next steps for the UK. <https://www.theccc.org.uk/wp-content/uploads/2021/12/COP26-Key-outcomes-and-next-steps-for-the-UK-Final.pdf>
- Climate Change Committee. (2022). COP27: Key outcomes and next steps for the UK. <https://www.theccc.org.uk/wp-content/uploads/2022/12/COP27-Key-outcomes-and-next-steps-for-the-UK.pdf>
- Climate Change Committee. (2024). COP29: Key outcomes and next steps for the UK. <https://www.theccc.org.uk/publication/cop29-key-outcomes-and-next-steps-for-the-uk/#:~:text=COP29%20was%20held%20in%20Baku,the%20period%20through%20to%202035>
- Climate Policy Initiative. (2022). Global Landscape of Climate Finance: A Decade of Data. Authors: Baysa Naran, Jake Connolly, Paul Rosane, Dharshan Wignarajah, Githungo Wakaba and Barbara Buchner. <https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-a-decade-of-data/>
- Dagnachew, A. G., Lucas, P. L., Hof, A. F., Gernaat, D. E., de Boer, H. S., & van Vuuren, D. P. (2017). The role of decentralized systems in providing universal electricity access in Sub-Saharan Africa—A model-based approach. *Energy*, 139, 184-195. <https://doi.org/10.1016/j.energy.2017.07.144>
- Depledge, J., Saldivia, M., & Peñasco, C. (2022). Glass half full or glass half empty?: the 2021 Glasgow Climate Conference. *Climate Policy*, 22(2), 147-157. <https://doi.org/10.1080/14693062.2022.2038482>
- Donkoh, S., & Mensah, J. (2023). Application of triangulation in qualitative research. *Journal of Applied Biotechnology and Bioengineering*, 10(1), 6-9. <https://doi.org/10.15406/jabb.2023.10.00319>

- Doshi, D., & Garschagen, M. (2020). Understanding adaptation finance allocation: Which factors enable or constrain vulnerable countries to access funding?. *Sustainability*, 12(10), 4308. <https://doi.org/10.3390/su12104308>
- ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE). (2013). ECOWAS Renewable Energy Policy. http://www.ecreee.org/sites/default/files/documents/ecowas_renewable_energy_policy.pdf
- ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE). (2023). ECOWAS Renewable Energy Policy. <http://www.ecreee.org/page/ecowas-renewable-energy-policy>
- Energy Commission. (2021). National Energy Statistics: Securing Ghana's Future Energy Today. Energy-Outlook-for-Ghana-2021.pdf
- Energy news Africa. (2025). Ghana: Energy Minister Commissions \$2.3 Million SECO-Funded Mini-Grid Project in Ada East Municipality. <https://energynewsafrika.com/ghana-energy-minister-commissions-2-3-million-seco-funded-mini-grid-project-in-ada-east-municipality/>
- Energy Sector Management Assistance Programme (ESMAP). (2000). ESMAP Minigridd Design Manual. https://www.esmap.org/sites/esmap.org/files/TR_minigriddesignmanual21364.pdf
- Energy Sector Management Assistance Programme (ESMAP). (2017). Ghana: Mini-Grids for Last-Mile Electrification. https://www.eca-uk.com/wp-content/uploads/2017/08/ESMAP-Ghana_Mini_grids_for_last_Mile_Electrification_Optimized.pdf
- Environmental Protection Agency (EPA). (2020). Ghana's Fourth National Communication to the United Nations Framework Convention on Climate Change. https://unfccc.int/sites/default/files/resource/Gh_NC4.pdf
- Environmental Protection Agency (EPA). (2021). Ghana's Third Biennial Update Report to United Nations Climate Change. https://unfccc.int/sites/default/files/resource/gh_BUR3_1282021_submission.pdf
- ESI Africa. (2023). COP 28: Financing Africa's pathway to net zero energy systems. <https://www.esi-africa.com/africa/cop28-financing-africas-pathway-to-net-zero-energy-systems/>
- European Parliamentary Research Service. (2022). The African Union's first climate strategy and EU-Africa climate cooperation. [https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/738201/EPRS_BRI\(2022\)738201_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/738201/EPRS_BRI(2022)738201_EN.pdf)
- European Union. (2017). Paris Agreement: The European Union and the African Union reaffirm their strong commitment to full implementation. https://www.eeas.europa.eu/node/27399_en
- Feist, M., & Geden, O. (2023). Climate negotiations in times of multiple crises: Credibility and trust in international climate politics after COP 27. <https://doi.org/10.18449/2023C10>
- Figueroa, R. M. (2022). Environmental justice. In *The Routledge companion to environmental ethics* (pp. 767-782). Routledge. <https://www.taylorfrancis.com/chapters/edit/10.4324/9781315768090-75/environmental-justice-robert-melchior-figueroa>
- Franzki, H., & Olarte, M. C. (2013). Understanding the political economy of transitional justice: A critical theory perspective. In *Transitional justice theories* (pp. 201-221). Routledge. <https://doi.org/10.4324/9780203465738-19>
- Glemarec, Y. (2012). Financing off-grid sustainable energy access for the poor. *Energy policy*, 47, 87-93. <https://doi.org/10.1016/j.enpol.2012.03.032>
- Green Energy Africa Summit. (2024). COP 28 Delivered Clean Energy Deals for Africa. <https://greenenergyafricasummit.com/articles/cop-28-delivered-clean-energy-deals-for-afric>
- Grimm, M., Munyehirwe, A., Peters, J., & Sievert, M. (2017). A first step up the energy ladder? Low cost solar kits and household's welfare in rural Rwanda. *The World Bank Economic Review*, 31(3), 631-649. <https://doi.org/10.1093/wber/lhw052>

- Hargroves, K., James, B., Lane, J., & Newman, P. (2023). The role of distributed energy resources and associated business models in the decentralised energy transition: A review. *Energies*, 16(10), 4231. <https://doi.org/10.3390/en16104231>
- Harish, V. S. K. V., Anwer, N., & Kumar, A. (2022). Applications, planning and socio-techno-economic analysis of distributed energy systems for rural electrification in India and other countries: A review. *Sustainable Energy Technologies and Assessments*, 52, 102032. <https://doi.org/10.1016/j.seta.2022.102032>
- Heffron, R. J., McCauley, D., & Sovacool, B. K. (2015). Resolving society's energy trilemma through the Energy Justice Metric. *Energy Policy*, 87, 168-176. <https://doi.org/10.1016/j.enpol.2015.08.033>
- Helen, M., David, W., Lorena, G., Chirag, G., Nathan, C., Mima, H., ... & Rhys, G. (2021). COP26: Key Outcomes From the UN Climate Talks in Glasgow. <https://www.wri.org/insights/cop26-key-outcomes-un-climate-talks-glasgow>
- Intergovernmental Panel on Climate Change (IPCC). (2018). The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. <https://www.ipcc.ch/organization/organization.shtml>
- International Energy Agency (IEA). (2022). World Energy Outlook Special Report. Africa Energy Outlook 2022. <https://iea.blob.core.windows.net/assets/220b2862-33a6-47bd-81e9-00e586f4d384/AfricaEnergyOutlook2022.pdf>
- International Energy Agency (IEA). (2024). Renewables 2023. Analysis and Forecast to 2028. https://iea.blob.core.windows.net/assets/3f7f2c25-5b6f-4f3c-a1c0-71085bac5383/Renewables_2023.pdf
- International Energy Agency (IEA). (2019). Africa Energy Outlook 2019. International Energy Agency, Paris. www.iea.org/reports/africa-energy-outlook-2019
- International Renewable Energy Agency (IRENA). (2016). Innovation Outlook: Renewable Mini-grids. International Renewable Energy Agency, Abu Dhabi. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_Innovation_Outlook_Minigrids_2016.pdf
- International Renewable Energy Agency (IRENA). (2019). Renewable Power Generation Costs in 2019. <https://www.irena.org/publications/2020/Jun/Renewable-Power-Costs-in-2019>
- International Renewable Energy Agency (IRENA). (2022). The Renewable Energy Transition in Africa. Powering Access, Resilience and Prosperity. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/March/Renewable_Energy_Transition_Africa_2021.pdf
- Jiang, T., He, X., Su, B., Havea, P. H., Wei, K., Kundzewicz, Z. W., & Liu, D. (2024). COP 28: Challenge of coping with climate crisis. *The Innovation*, 5(1). <https://doi.org/10.1016/j.xinn.2023.100559>
- Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher*, 33(7), 14-26. <https://doi.org/10.3102/0013189X033007014>
- Kabeyi, M. J. B., & Olanrewaju, O. A. (2022). Sustainable energy transition for renewable and low carbon grid electricity generation and supply. *Frontiers in Energy research*, 9, 743114. <https://doi.org/10.3389/fenrg.2021.743114>
- Kenfack, C. E. (2018). Changing environment, just transition and job creation: perspectives from the south. https://biblioteca-repositorio.clacso.edu.ar/bitstream/CLACSO/14319/1/Changing_environment.pdf
- Khan, M., Robinson, S. A., Weikmans, R., Ciple, D., & Roberts, J. T. (2020). Twenty-five years of adaptation finance through a climate justice lens. *Climatic Change*, 161(2), 251-269. <https://doi.org/10.1007/s10584-019-02563-x>

- Klein, D., Carazo, M. P., Doelle, M., Bulmer, J., & Higham, A. (Eds.). (2017). *The Paris Agreement on climate change: Analysis and commentary*. Oxford University Press
https://digitalcommons.schulichlaw.dal.ca/faculty_books/15/
- Lahn, B. (2018). In the light of equity and science: scientific expertise and climate justice after Paris. *International Environmental Agreements: Politics, Law and Economics*, 18(1), 29-43.
<https://doi.org/10.1007/s10784-017-9375-8>
- Lyster, R. (2015). *Climate justice and disaster law*. Cambridge University Press.
<https://doi.org/10.1017/CBO9781316227534>
- Masood, E., Tollefson, J., & Irwin, A. (2022). COP27 climate talks: what succeeded, what failed and what's next. *Nature*, 612(7938), 16-17. <https://www.nature.com/articles/d41586-022-03807-0>
- Mele, A., Paglialunga, E., & Sforna, G. (2021). Climate cooperation from Kyoto to Paris: What can be learnt from the CDM experience?. *Socio-Economic Planning Sciences*, 75, 100942.
<https://doi.org/10.1016/j.seps.2020.100942>
- Ministry of Energy. (2021). Ghana Energy Policy, 2021: Energy Sector as Engine for Economic Growth and Sustainable Development. <https://www.energymin.gov.gh/sites/default/files/2023-09/2021%20ENERGY%20POLICY.pdf>
- Mountford, H., Waskow, D., Gonzalez, L., Gajjar, C., Cogswell, N., Holt, M., ... & Gerholdt, R. (2021). COP26: key outcomes from the UN climate talks in Glasgow. *World Resources Institute*, 17.
<https://www.wri.org/insights/cop26-key-outcomes-un-climate-talks-glasgow>
- Mungai, E. M., Ndiritu, S. W., & Da Silva, I. (2022). Unlocking climate finance potential and policy barriers—A case of renewable energy and energy efficiency in Sub-Saharan Africa. *Resources, Environment and Sustainability*, 7, 100043. <https://doi.org/10.1016/j.resenv.2021.100043>
- Muttitt, G., & Kartha, S. (2020). Equity, climate justice and fossil fuel extraction: principles for a managed phase out. *Climate Policy*, 20(8), 1024-1042. <https://doi.org/10.1080/14693062.2020.1763900>
- Newell, P., & Bulkeley, H. (2017). Landscape for change? International climate policy and energy transitions: evidence from sub-Saharan Africa. *Climate Policy*, 17(5), 650-663.
<https://doi.org/10.1080/14693062.2016.1173003>
- Newell, P., Srivastava, S., Naess, L. O., Torres Contreras, G. A., & Price, R. (2021). Toward transformative climate justice: An emerging research agenda. *Wiley Interdisciplinary Reviews: Climate Change*, 12(6), e733. <https://doi.org/10.1002/wcc.733>
- Nsafon, B. E. K., Same, N. N., Yakub, A. O., Chaulagain, D., Kumar, N. M., & Huh, J. S. (2023). The justice and policy implications of clean energy transition in Africa. *Frontiers in Environmental Science*, 11, 1089391. <https://doi.org/10.3389/fenvs.2023.1089391>
- Nuru, J. T., Rhoades, J. L., & Gruber, J. S. (2021). Evidence of adaptation, mitigation, and development co-benefits of solar mini-grids in rural Ghana. *Energy and Climate Change*, 2, 100024.
<https://doi.org/10.1016/j.egycc.2021.100024>
- Nyasapoh, M. A., Debrah, S. K., & Twerefou, D. K. (2023). Long-term electricity generation analysis and policy implications—the case of Ghana. *Cogent Engineering*, 10(1), 2209996.
<https://doi.org/10.1080/23311916.2023.2209996>
- Obi, J. N., Ojo, E., & Ujah, C. O. (2025). Decentralised Renewable Energy in Sub-Saharan Africa: A Critical Review of Pathways to Equitable and Sustainable Energy Transitions. *Unconventional Resources*, 100267. <https://doi.org/10.1016/j.uncres.2025.100267>
- Okereke, C., & Coventry, P. (2016). Climate justice and the international regime: before, during, and after Paris. *Wiley Interdisciplinary Reviews: Climate Change*, 7(6), 834-851.
<https://doi.org/10.1002/wcc.419>

- Okesiji, S. O. (2025). Decentralized Renewable Energy Systems: A Pathway to Climate Resilience in Low-Income Regions. *Sustainability and Climate Change*, 18(2), 119-131. <https://doi.org/10.1089/scc.2025.0014>
- Omisore, A. G. (2018). Attaining Sustainable Development Goals in sub-Saharan Africa; The need to address environmental challenges. *Environmental development*, 25, 138-145. <https://doi.org/10.1016/j.envdev.2017.09.002>
- Oreggioni, G. D., Ferraio, F. M., Crippa, M., Muntean, M., Schaaf, E., Guizzardi, D., ... & Vignati, E. (2021). Climate change in a changing world: Socio-economic and technological transitions, regulatory frameworks and trends on global greenhouse gas emissions from EDGAR v. 5.0. *Global Environmental Change*, 70, 102350. <https://doi.org/10.1016/j.gloenvcha.2021.102350>
- Organisation for Economic Co-operation and Development (OECD). (2024). Climate Finance and the USD 100 billion goal. <https://www.oecd.org/en/topics/climate-finance-and-the-usd-100-billion-goal.html>
- Ouedraogo, N. S. (2020). Transition pathways for North Africa to meet its (intended) nationally determined contributions ((I) NDCs) under the Paris Agreement: a model-based assessment. *Climate Policy*, 20(1), 71-94. <https://doi.org/10.1080/14693062.2019.1685449>
- Oyewo, A. S., Sterl, S., Khalili, S., & Breyer, C. (2023). Highly renewable energy systems in Africa: Rationale, research, and recommendations. *Joule*, 7(7), 1437-1470. <https://doi.org/10.1016/j.joule.2023.06.004>
- Pelling, M., & Garschagen, M. (2019). Put equity first in climate adaptation. *Nature*, 569(7756), 327-329. <https://doi.org/10.1038/d41586-019-01497-9>
- Peters, J., Sievert, M., & Toman, M. A. (2019). Rural electrification through mini-grids: Challenges ahead. *Energy Policy*, 132, 27-31. <https://doi.org/10.1016/j.enpol.2019.05.016>
- Pode, R. (2013). Financing LED solar home systems in developing countries. *Renewable and Sustainable Energy Reviews*, 25, 596-629. <https://doi.org/10.1016/j.rser.2013.04.004>
- Rahut, D. B., Aryal, J. P., & Marennya, P. (2021). Ex-ante adaptation strategies for climate challenges in sub-Saharan Africa: Macro and micro perspectives. *Environmental Challenges*, 3, 100035. <https://doi.org/10.1016/j.envc.2021.100035>
- Rapley, T., & Rees, G. (2018). Collecting documents as data. *The SAGE handbook of qualitative data collection*, 378-391. <https://doi.org/10.4135/9781526416070.n24>
- Republic of Ghana.(2015). Ghana's Third National Communication Report to the United Nations Framework Convention on Climate Change (UNFCCC). <https://unfccc.int/resource/docs/natc/ghanc3.pdf>
- Riger, S., & Sigurvinsdottir, R. (2016). Thematic analysis. *Handbook of methodological approaches to community-based research: Qualitative, quantitative, and mixed methods*, 33-41. <https://psycnet.apa.org/record/2016-04165-004>
- Rockefeller Foundation. (2021). Historic Alliance Launches at COP26 to Accelerate a Transition to Renewable Energy, Access to Energy for All, and Jobs. <https://www.rockefellerfoundation.org/news/historic-alliance-launches-at-cop26-to-accelerate-renewable-energy-climate-solutions-and-jobs/>
- Saddari, N., Derkyi, N. S. A., & Peprah, F. (2024). Towards sustainable and affordable energy for isolated communities: A technical and economic comparative assessment of grid and solar PV supply for Kyiriboja, Ghana. *Solar Compass*, 10, 100072. <https://doi.org/10.1016/j.solcom.2024.100072>
- SNV. (2021). Lighting-up Isolated communities in Ghana with Mini-grids. <https://snv.org/update/lighting-isolated-communities-ghana-mini-grids>

- Stephanie, N., Abubakar, J. A., & Ademola, O. F. (2024, March). The impact of stand-alone systems in Nigeria's energy distribution sector and present-day challenges faced. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1322, No. 1, p. 012010). IOP Publishing. https://ui.adsabs.harvard.edu/link_gateway/2024E&ES.1322a2010S/doi:10.1088/1755-1315/1322/1/012010
- Sule, I. K., Yusuf, A. M., & Salihu, M. K. (2022). Impact of energy poverty on education inequality and infant mortality in some selected African countries. *Energy Nexus*, 5, 100034. <https://doi.org/10.1016/j.nexus.2021.100034>
- Sustainable Energy for All (SE4All). (2012). A Global Action Agenda. Pathways for Concerted Action toward Sustainable Energy for All. <https://www.seforall.org/system/files/gather-content/SEFA-Action-Agenda-Final.pdf>
- United Nations Climate Change. (2023). COP28 UAE. <https://www.cop28.com>
- United Nations Climate Change. (2024). COP29 UN Climate Conference Agrees to Triple Finance to Developing Countries, Protecting Lives and Livelihoods. <https://unfccc.int/cop29>
- United Nations Development Programme. (2022). Minigrids for Africa': Calling for energy access for all Africans at COP27. <https://www.undp.org/energy/blog/minigrids-africa-calling-energy-access-all-africans-cop27>
- United Nations Development Programme. (2023). What are NDCs and how do they drive climate action? <https://climatepromise.undp.org/news-and-stories/NDCs-nationally-determined-contributions-climate-change-what-you-need-to-know>
- United States Agency for International Development (USAID). (2016). USAID Announces New Partnership with African Union Commission to Reach Paris Agreement Goals in Africa. <https://www.usaid.gov/press-release/usaid-announces-new-partnership-african-union-commission-reach-paris-agreement-goals-africa#:~:text=Fifty%2Dfour%20countries%20in%20Africa,and%20adapt%20to%20climate%20change>
- United States Agency for International Development (USAID). (2023). What are the technical components of a mini-grid? <https://www.usaid.gov/energy/mini-grids/technical-design/components#:~:text=Mini%2Dgrid%20energy%20generation%20technologies,are%20either%20renewable%20or%20nonrenewable>
- Van den Bulck, H., Puppis, M., Donders, K., & Van Audenhove, L. (Eds.). (2019). *The Palgrave handbook of methods for media policy research*. London: Palgrave Macmillan. <https://www.palgrave.com/gp/book/9783030160647>
- Woodman-Hardy, A. (2024). Is the Loss and Damage Fund all that it promises to be? <https://environment.blogs.bristol.ac.uk/2024/02/01/is-the-loss-and-damage-fund-all-that-it-promises-to-be>
- World Bank. (2014). Sustainable Energy for All (SE4ALL), "Global tracking framework" <https://openknowledge.worldbank.org/handle/10986/16537>
- World Bank. (2022). Climate Change Law in Ghana: Analysis of National Legal Frameworks for Climate Action and Development. <https://openknowledge.worldbank.org/server/api/core/bitstreams/be9a2ac1-4b9c-597e-bb33-4ef086cdd0ff/content>
- Zalengera, C., To, L. S., Sieff, R., Mohr, A., Eales, A., Cloke, J., ... & Batchelor, S. (2020). Decentralization: the key to accelerating access to distributed energy services in sub-Saharan Africa? *Journal of Environmental Studies and Sciences*, 10(3), 270-289. <https://doi.org/10.1007/s13412-020-00608-7>

- Zarkik, A. (2022). COP27: a brief account of contemporary climate adaptation and mitigation policies, a view from the south. *Policy Center for the New South*, Salé, 1. https://www.policycenter.ma/sites/default/files/2022-11/PB_63-22_Zarkik.pdf
- Zhang, Y. X., Chao, Q. C., Zheng, Q. H., & Huang, L. (2017). The withdrawal of the US from the Paris Agreement and its impact on global climate change governance. *Advances in Climate Change Research*, 8(4), 213-219. <https://doi.org/10.1016/j.accre.2017.08.005>