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Assessing the effectiveness of energy policies in accelerating renewable energy-based mini-grid deployment: A case study

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ABSTRACT

Recent global initiatives to increase renewable energy capacity have presented a pathway to simultaneously meet future electricity demands and achieve decarbonization. However, emerging economies have seen marginal growth partly because of ineffective energy policies enacted to propagate the adoption of these renewable energy technologies. Using Ghana as a case study, this research focused on assessing the impact of energy policies on deploying renewable energy technologies, specifically focusing on renewable energy-based hybrid mini-grids. The weighted sum multi-criteria decision and SWOT analysis methods were used to evaluate the policies' effectiveness. The results highlighted that numerous energy policies implemented across Ghana did not fully promote mini-grid development. The study showed that only the renewable energy master plan and the scaling-up renewable energy program had clearly defined strategies for mini-grid development. The study revealed that financial constraints, complex implementation strategies and limited monitoring mechanisms are the main reasons why the policies are ineffective in promoting the industry in Ghana.

Introduction

According to the International Energy Agency (IEA), 507 GW, representing a 50 % increment in global renewable electricity capacity, were added between 2022 and 2023 (IEA, 2023a). Solar photovoltaic (PV) and wind energy installations are expected to increase this capacity further in the next five years. Nonetheless, 60 % of electricity generated globally in 2023 came from fossil fuels (IEA, 2023b). The IEA estimates that this percentage must drop to 30 % by 2030 to be on track to meet net zero emissions (IEA, 2023b).

However, the drive for decarbonization requires more energy consumption, especially in developing nations. A report by the International Renewable Energy Agency (IRENA) (IRENA, 2015) indicates that if the business-as-usual (BAU) scenarios are followed, nearly a billion people will still lack clean energy access by 2030. The declining cost of RE technologies presents an alternative pathway to meet future electricity demands without adversely affecting the environment. United Nations (UN) estimates that RE resources can supply 65 % of global electricity by 2030 and decarbonize 90 % of the power sector by 2050 (The United Nation, 2024). The motivation to rely on RE for future electricity demands does not stem from only cost and CO_2 emissions reductions but also fosters economic growth, mainly by providing low to medium-skilled jobs in rural areas (Adelaja, 2020).

Global RE initiatives have seen tremendous traction in recent years. As reported by the IEA, more than 60 % of 2.8 trillion USD was invested in clean energy technologies in 2023 (IEA, 2024). However, these investments were spearheaded by a few developed economies, including China, the European Union, the USA and Japan. Although there were notable investments in India, Brazil, and the Middle East, there was marginal progress in emerging markets and developing economies, which will require a sevenfold increase in investment by the early 2030s based on the IEA report (IEA, 2023c). For instance, Africa contributed to only 1.27 % of the global solar installations in 2019, with South Africa, Egypt, Morocco and Tunisia accounting for 80 % of the share (Afful-Dadzie et al., 2022).

Nevertheless, Ghana, a Sub-Saharan African country, has made notable progress to improve RE electricity access. As a signatory to the Paris Agreement and an ardent promoter of the Sustainable Development Goals (SDGs), the Government of Ghana (GoG) has shown a clear signal towards investing in clean energy by integrating RE sources into

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the country's generation mix. Since 2015, the GoG has focused on electrifying the remaining 15 % of the unserved population with RE-based hybrid mini-grids. The goal was to deploy 55 and 300 systems by 2020 and 2030, respectively (Ackah et al., 2020). However, nine years later, mini-grids have not contributed significantly to the generation capacity, and the existing systems face numerous challenges.

Well-laid long-term strategies and government policies that support the sector's expansion are required to address the current hurdles. Therefore, transparent and impactful regulations must be enforced to encourage the adoption of renewable energy technologies. These may include legal frameworks that promote market-based participation, cost-reflective tariff structures, educational programs, technology transfer and financial support mechanisms.

These policies must emphasize flexibility, efficiency and cost-effectiveness (IRENA, 2014). Additionally, the policies must address critical areas like supply and distribution, energy demand, environmental protection and project development (ASEAN Centre for Energy, 2016). Like clean energy investments, emerging and developing nations need to catch up with adopting effective RE policies. A 2019 global renewable energy status report shed light on the stern contrast between low-income and high-income countries in adopting RE policies (Adelaja, 2020). In the case of Ghana, RE received little attention until the RE Act was enacted in 2011 (Ashong, 2016). The Act paved the way for the transformation of the RE sector and presented a plan to manage the country's RE resources.

A substantial amount of research has been conducted on energy studies globally, including numerous studies focusing on energy policies in Ghana. Afful-Dadzie et al. (Afful-Dadzie et al., 2022) assessed the benefits of private sector participation in implementing Ghana's renewable energy master plan (REMP) using the stylized generation expansion planning model. They argued that private investors were crucial to execute the plans successfully but would require financial incentives. Their research showed that private sector participation in power generation could save US $265 million annually. Amo-Aidoo et al. (Amo-Aidoo et al., 2022) used the Low Emissions Analysis Platform (LEAP) modelling to investigate how an appropriate renewable energy policy could drive the growth of solar energy in Ghana. The visionary supply scenario was the best option to meet RE targets by 2030. This scenario had the potential to offset thirteen million metric tonnes of CO_2. Ashong conducted a qualitative assessment of the implementation of RE policies for large-scale electricity deployments in Ghana (Ashong, 2016). He found that though the country was promoting seven of the eleven most globally popular RE policies, monitoring and evaluating these policies was not optimum. Obeng-Darko advocated for policymakers to consider educating rural dwellers on the benefits of decentralized power systems to enhance their acceptance (Obeng-Darko, 2018). He made this argument after assessing Ghana's policy trends on renewable energy for decentralized electrification. Sakah et al. investigated the effectiveness of strategies in Ghana's RE Act towards RE technologies deployment (Sakah et al., 2017). They attributed the unsatisfactory performance of the strategies to partial policy implementation, lack of market-driven support schemes, inaccessible funds and pricing issues. After conducting a comparative analysis of best practices in other countries, they enumerated some countermeasures.

In other regions, Dorman and Shah tackled how energy policy and foreign aid shaped RE development in Small Island Developing States (SIDS) (Dornan & Shah, 2016). The results revealed that RE targets in SIDS could only be achieved with development assistance because of a lack of funds from state-owned utilities and limited private-sector participation. A study by Moustapha and Qian (2021) used the propensity score matching method to show that the Ecowas Renewable Energy Policy had a significant and positive impact on the primary energy supply in West Africa, and it is crucial in achieving the Sustainable Energy for All goals. Chen et al. (Chen et al., 2014) compared renewable energy policies in Japan, South Korea and Taiwan using SWOT analysis. The study identified the need to improve cooperation among the countries to foster regional cooperation and compete globally.

The importance of measuring the effectiveness of energy policies should be emphasized. In that respect, Gungah et al. (Gungah et al., 2019) studied the effectiveness and efficiency of Nigeria's RE legal and policy framework. Shem et al. (Shem et al., 2019) used Multi-Criteria Decision Analysis (MCDA) to analyze the effectiveness of Vietnam's energy policies towards low carbon emissions. Fraundorfer and Rabitz (Fraundorfer & Rabitz, 2020) analyzed the effectiveness of Brazil's domestic renewable energy policy in instrument design and coherence. Gatto and Drago used data from the World Bank's SDG7 Tracking: The Energy Progress Report and a statistical approach to measure energy policy effectiveness in 230 countries (Gatto & Drago, 2021). Other studies (Adelaja, 2020; Ali et al., 2017; Byrnes et al., 2013; IRENA, 2012; Mezher et al., 2012) reviewed the barriers to energy policy implementation in other parts of the world.

The literature review highlights the extensive research into energy policies worldwide in recent years. However, most of the studies centred on renewable energy systems in general without specifically focusing on the impacts of energy policy implementation on RE-based mini-grids. This serves as the motivation for this research and the gap in literature our study intends to fill.

The research aims to evaluate the effectiveness of RE policies in Ghana within the context of its national energy policies and commitments to international agreements like the Paris Agreement. This study seeks to assess the impact of the chosen policies on deploying renewable energy technologies, specifically focusing on RE-based hybrid mini-grids to electrify unserved populations in remote locations.

The objectives include:

- Identify current energy policies in Ghana that promote RE-based mini-grid development.
- Analyze the degree to which Ghana's RE policies have been implemented since the enactment of the RE Act in 2011, particularly about the government's target to deploy RE-based hybrid mini-grids.
- Determine the effectiveness of these policies in achieving their intended outcomes, such as increasing the share of RE in the national energy mix and improving electricity access in unserved areas.

The study will provide valuable insights to key stakeholders that can help Ghana enhance its policy framework to harness RE resources better and meet its energy and sustainability targets. The rest of the paper is organized as follows: Ghana's energy sector section highlights Ghana's energy sector including Ghana's electricity generation outlook and key stakeholders of mini-grid development. Methodology section looks into the methods used to achieve the aim, while Results section presents the results. Discussion section and Conclusion and policy implications section discuss the results and present conclusions and recommendations.

Ghana's energy sector

Ghana's electricity generation outlook

RE (solar, wind, small and large hydro and waste-to-energy) and non-RE (crude oil and natural gas) sources are used to generate electricity in Ghana for residential, industrial, commercial and agricultural purposes. The country relies heavily on thermal sources to meet its electricity demand. Within the last decade, electricity generated from thermal sources has tripled, with the sharpest change occurring in 2015.

This increment was driven by the government's reaction to a severe generation shortfall that befell the nation between 2012 and 2015, resulting in a three-year load-shedding program (Kumi, 2020). Large hydro capacity has remained relatively constant, with only 4 MW added over the same period. Lastly, there has been marginal growth in electricity generated from solar, wind, small-hydro and waste-to-energy sources. The highest RE share was in 2022, accounting for 0.7 % of the generation mix (Energy Commission, 2023). However, these sources have seen an 88 % growth rate within a decade. The most significant leap occurred in 2021 when 63 MW of utility-scale solar PV was added to the grid. An illustration of the installed power generation capacity from the various sources for the last ten decades is shown in Fig. 1.

The level of penetration of other RE sources is illustrated in Fig. 2. Utility-scale RE-based on-grid systems constitute the highest share, representing 69.01 %, while mini-grids from hydro, solar and wind contributed 0.23 %.

In terms of electricity generated, thermal energy sources had the highest share in 2022, as shown in Table 1. However, large hydro had a more significant capacity factor than thermal energy sources, followed by renewable energy sources.

Lastly, a projection of Ghana's future electricity demand shows an uphill trajectory. A study by USAID (2019a) forecasted the country's electricity demand under the BAU and Accelerated Economic Growth scenarios, and the result is illustrated in Fig. 3. It shows a continuous growth in demand in both scenarios due to population growth, urbanization and improvement in quality of life.

Key stakeholders of mini-grid development in Ghana

Four key stakeholders form the core of mini-grid development in Ghana. The stakeholders engage in four distinct areas: 1) the formulation and implementation of policies, 2) regulation, 3) installation and management, and 4) usage of electricity generated from mini-grid systems. In addition, regional and international developmental agencies partner with local institutions to provide essential financial and technical support to the sector's growth. Civil society groups and academic/research institutions research to discover new frontiers in optimizing mini-grid development. Fig. 4 shows a graphical representation of the roles of the key actors.

The Ministry of Energy (MoEn) is responsible for formulating and spearheading government energy policies. The RE department works with other government agencies to provide technical direction in implementing RE-based projects, including mini-grids. The Policy, Planning, Budgeting, Monitoring and Evaluation (PPBME) department under the civil service directorate is responsible for policy formulation, planning, budgeting, monitoring, and evaluation.

Formed in 1997 (PURC, 2024) by Acts of Parliament, the Energy Commission (EC) and the Public Utility Regulatory Commission (PURC) are the two statutory regulatory bodies for the energy sector. EC provides technical guidance for implementing government policies, while PURC regulates energy prices. Unlike PURC, which is fully autonomy, the EC Act empowers MoEn to influence its activities (Sakah et al., 2017). As shown in Table 2, several legislative instruments give the EC and PURC the legal authority to execute their mandates effectively.

From the onset, Volta River Authority (VRA) was responsible for mini-grid power generation and management. At the same time, the Electricity Company of Ghana (ECG) and the Northern Electricity Distribution Company of Ghana (NEDCO) distributed the electricity to customers. However, in 2017, all public utilities were permitted to generate and distribute electricity from mini-grids (Babayomi et al., 2023). Currently, VRA and ECG have concessions for managing sites on island communities along the Volta River and Lakeside communities, respectively. Mini-grid management under these public utilities benefits from lower capital costs due to government funding compared to private concessionaires. Additionally, administrative costs are lower than private concessions because of the higher economy of scale. However, since the tariff is indexed based on the universal national tariff, it is insufficient to meet running costs. Therefore, it requires subsidy to cover the additional cost (ESMAP, 2016).

Regional and international agencies provide valuable financial mechanisms to support mini-grid development in the country. For instance, in 2022, the African Development Bank (AfDB) announced a grant package for a solar PV mini-grid and net metering project under the Scaling-up Renewable Energy Program (SREP) (Shetty, 2022). The Swiss State Secretariat for Economic Affairs (SECO) provided 13.3 million US dollars as a co-financier for this project (Takouleu, 2022). As part of the Ghana Energy Development and Access Project (GEDAP), the World Bank sponsored the installation of RE-based mini-grids in five island communities on the Volta River (Bukari et al., 2021). In 2018, the United States Trade and Development Agency sponsored a comprehensive feasibility study for energy expansion in 67 communities in Afram Plains South, a major agriculture hub of the country (US Trade and Development Agency, 2018). The details of these three major projects are shown in Table 3.

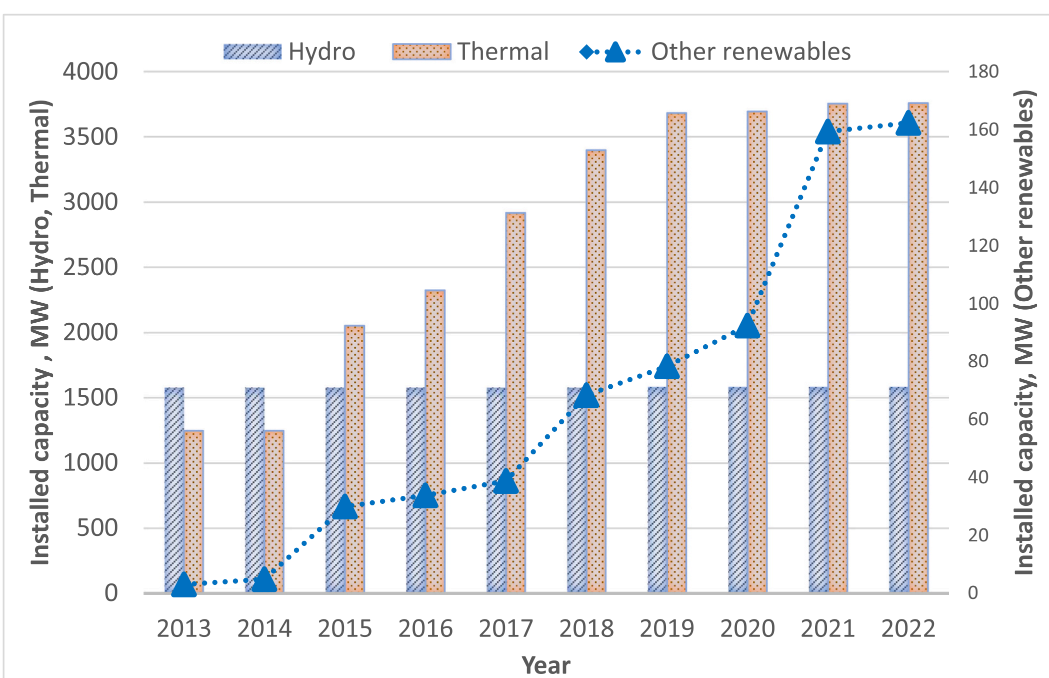

Fig. 1. Cumulative share of installed capacity for renewable and non-renewable energy sources (Energy Commission, 2023).

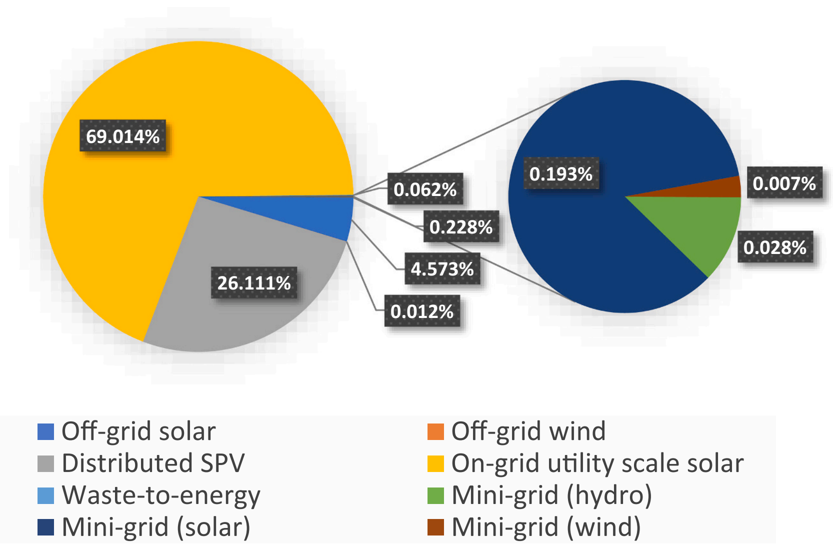

Fig. 2. Distribution of installed generation capacities from renewable energy sources as of 2022 (Energy Commission, 2023).
Note: Off-grid solar are rooftop PV systems that are not grid-tiered. Distributed SPV refers to electricity generated for on-site consumption and interconnected with low-voltage transformers. Mini grids are standalone systems that supply electricity several households in a cluster.

Table 1
Installed capacity, electricity generated and capacity factor of various energy sources for the year ending 2022 (Energy Commission, 2023).

Source	Installed capacity (MW)	Electricity generated (MWh)	Capacity factor (%)
Large hydro	1584	8,192,000	59.04
Thermal	3758	14,810,000	44.99
Other renewables	162.3	162,000	11.39

These agencies also provide technical support to key stakeholders. Agencies such as the Ecowas Centre for Renewable Energy and Energy Efficiency (ECREEE), United Nations Development Programme (UNDP) and German Corporation for International Cooperation (GIZ) sponsor technical workshops and trainings tailored to equip stakeholders with the requisite skills to implement these projects.

Methodology

This section outlines the methodology adopted by the authors to achieve the goal of the study as illustrated in Fig. 5.

Policies that promote mini-grid deployment

Firstly, RE-related policies were retrieved from government and international agencies' portals. Policies, programs and strategies were retrieved from the official online portals of MoEn and EC. Reports and articles related to mini-grid development in Ghana were retrieved from databases of the World Bank, IRENA, IEA and AfDB. Then, two exclusion criteria were applied to filter out the irrelevant policies. First, we excluded policies that commenced before the RE Act was enacted. Next, the authors conducted a content analysis to filter out policies and strategies that are unrelated to Ghana's mini-grid development.

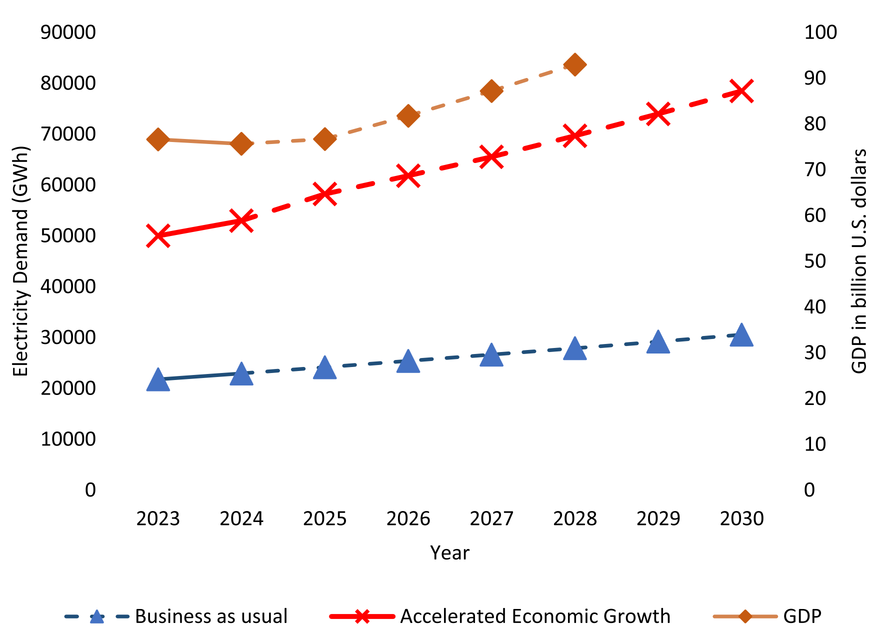

Fig. 3. Ghana's projected GDP and electricity demand under BAU and AEG scenarios (Statista, 2024; USAID, 2019a).

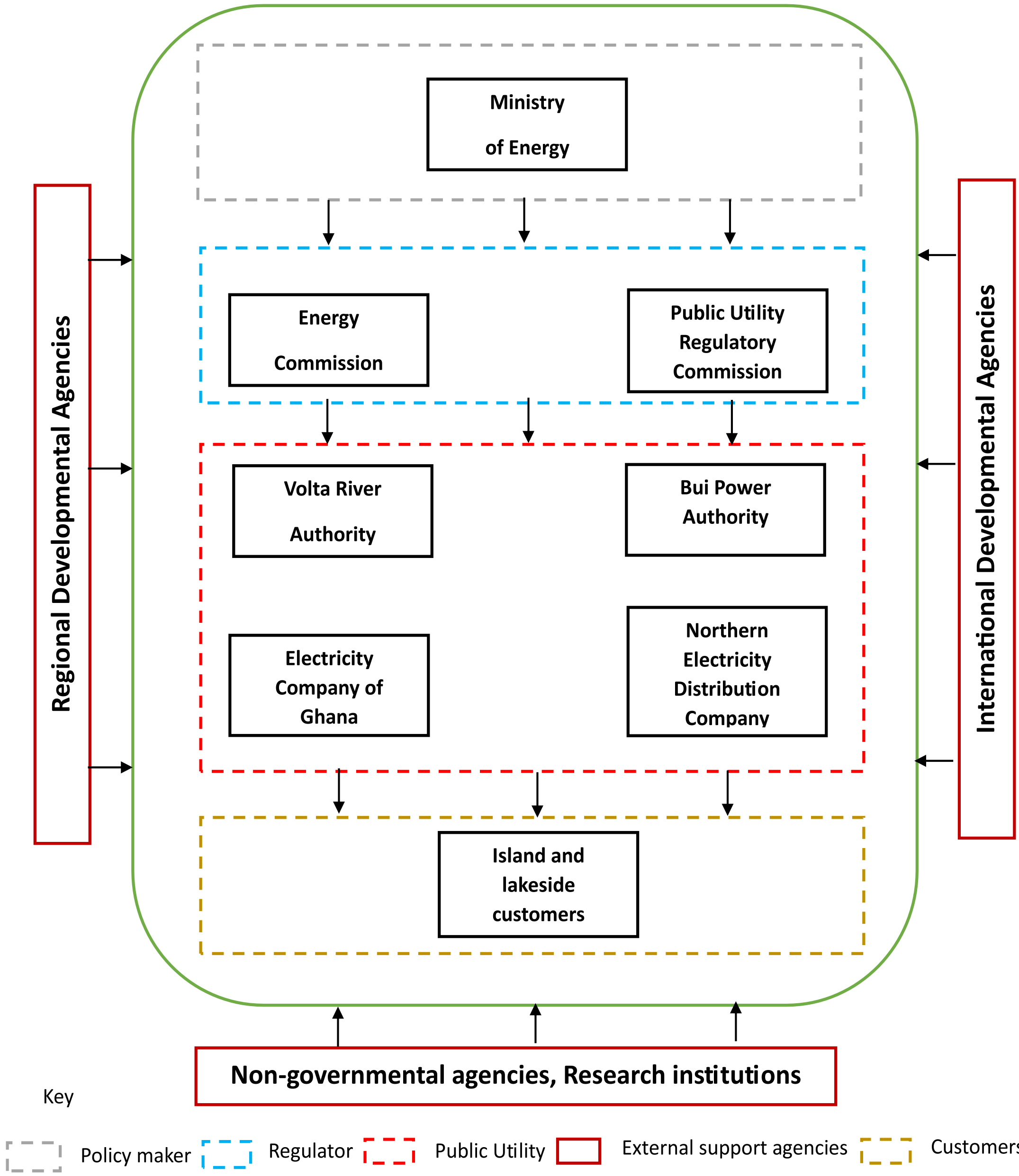

Fig. 4. Key stakeholders of Ghana's mini-grid industry.

Multi-criteria decision method

According to IRENA, energy policies can be evaluated using effectiveness, efficiency, equity and institutional feasibility (Santika et al., 2020). In this study, the effectiveness of the policies was assessed using an MCDM. This method is used to quantify qualitative data obtained after policies are analyzed and provide a hierarchical rating (Shem et al., 2019). Among the various MCDM techniques, the authors used the weighted sum method (WSM) to allow for a simplified and flexible model. The model used was adopted from a framework provided by DCLG (2009) and utilized by Shem et al. (2019). The steps used in the MCDM are presented in Fig. 6.

Step 1: The authors conducted a comprehensive review to identify relevant policies that directly promoted mini-grid development in Ghana.

Step 2: A set of criteria were identified from literature to serve as a yardstick to assess the policies. Seven criteria were chosen as shown in Table 4.

Step 3: The policies were ranked on a one- to- five scale based on specific, predefined criteria related to their implementation feasibility, cost-effectiveness, environmental impact, social acceptance, and alignment with strategic objectives (Shem et al., 2019). This scale provides a framework to objectively assess the success and impact of the various policy options. Each policy was evaluated across these seven criteria, as detailed in Table 5. This quantitative assessment allowed the experts to measure and compare each policy's effectiveness systematically.

Step 4: In assessing the effectiveness and sustainability of policy interventions, allocating appropriate weights to different evaluation criteria plays a critical role. This step highlights the relevance of each criterion to the main goal of the MCDA. In this

Table 2
Legislative instruments used by EC and PURC to execute their mandates (PURC, 2023).

Legislative instrument	Year enacted	Legislative code	Enforcing agency	Objectives
Solar Panel regulations	2022	LI 2449	EC	Regulate the manufacture, importation, and use of solar panels to help mitigate climate change issues.
Renewable Energy Batteries regulations	2022	LI 2452	EC	Promote efficient use of RE batteries by enforcing available standards, labelling RE batteries, and creating a RE product register.
Inverters regulations	2022	LI 2461	EC	Enforce standards, label, and register models of inverters.
Consumer service regulations	2020	LI 2413	PURC	Enforce a transparent regulatory framework that provides dependable, efficient, adequate, and non-biased electricity service.
Electrical Wiring Regulations	2011	LI 2008	EC	Set procedures to enforce standards of electrical wiring on premises
Renewable Energy Act	2011	LI 832	EC/PURC	Develop and manage the sustainable use of RE for heat and electricity production.
Electricity supply and distribution regulations	2008	LI 1935	EC/PURC	Provide guidelines for electricity supply and distribution.

policy evaluation, weights were assigned using a structured method that relied on expert judgment. Five experts, with their details shown in Table 6, independently determined the weights for each criterion. This individualized approach ensured that the insights and evaluations from each expert were considered independently, reducing bias and fostering a thorough and nuanced analysis of the criteria.

Following this, the average weight for each criterion was calculated based on these individual assessments. The final weights, which collectively summed up to 100 %, represented the relative importance of each criterion. These allocation weights are illustrated in Fig. 7.

Step 5: In this step, the overall weighted score for each policy was calculated using Eq. (1).

$$S_i = w_1 s_{i1} + w_2 s_{i2} + \ldots + w_n s_{in} = \sum_{j=1}^{n} w_j s_{ij} \tag{1}$$

where Si represents the overall score for each option (policy)*, option i* on criterion *j* is represented by *sij,* the weight for each criterion is represented by *wj* and the number of criteria is represented by *n,* which is seven for this study.

SWOT analysis

After ranking the policies, a SWOT analysis was conducted to examine the top two policies' strengths, weaknesses, opportunities and threats. The internal assessment focused on identifying the strengths and weaknesses of mini-grid deployment, while the external assessment determined the opportunities and threats.

Results

Evolution of mini-grid-related RE policies

Twelve policies related to mini-grid development were initially retrieved. After applying the second exclusion criterion, seven policies were selected for inclusion in the MCDM analysis. It was important to examine the evolution of policies implemented by previous governments, which served as the foundation for the current policies. A timeline of significant past and current policies related to mini-grid development is presented in Fig. 8.

Past policies

The National Electrification Scheme (NES) commenced in 1989 to kickstart the national electrification drive in the bid to achieve universal electricity access by 2020 (Energy Commission, 2019a). The scheme's main aim was to limit urban migration by improving socio-economic development in rural areas. Before the NES was formulated, the National Energy Board was established under the Provisional National Defence Council regime in 1983 to coordinate, among other things, renewable energy projects (Atuguba & Tuokuu, 2020). In 2003, the Ghana Poverty Reduction Strategy and RE Development and Management Programme were introduced. The former, a three-year policy, focussed on diversifying the generation mix with renewables and promoting private sector participation in the energy sector. At the same time, the latter addressed RE development challenges and proposed measures that could be implemented to accelerate RE penetration. Then, the Strategic National Energy Plan (SNEP) was implemented between 2006 and 2020 to develop a sustainable medium to long-term energy plan. The MoEn adopted the National Energy Policy (NEP) in 2010. It

Table 3
Details of three significant projects sponsored by developmental agencies (USAID, 2019a).

Project	Sponsor	Year announced	Expected year of operation	Objective	Deliverables	Project cost (million US $)	Status
GEDAP	The World Bank	2007	2015	1. Increase the share of electricity from renewable sources. 2. Improve the operational efficiency of the electricity distribution system	Deploy pilot mini grids in five island communities on the Volta Lake	210.55	Fully operational since November 2017
SREP	CIF, SECO	2015	2025	Increase access to clean and reliable electricity services and support low-carbon socioeconomic development.	Develop thirty-five mini-grids in the Volta Lake.	85.18	Open competitive bidding in progress
US Trade Development Agency	Export-Import Bank of the US	2018	Not Defined	Expand energy access to communities in Afram Plains South	1. Conduct a detailed analysis of the energy demand of the Afram Plains 2. Design mini grids	TBC	Feasibility

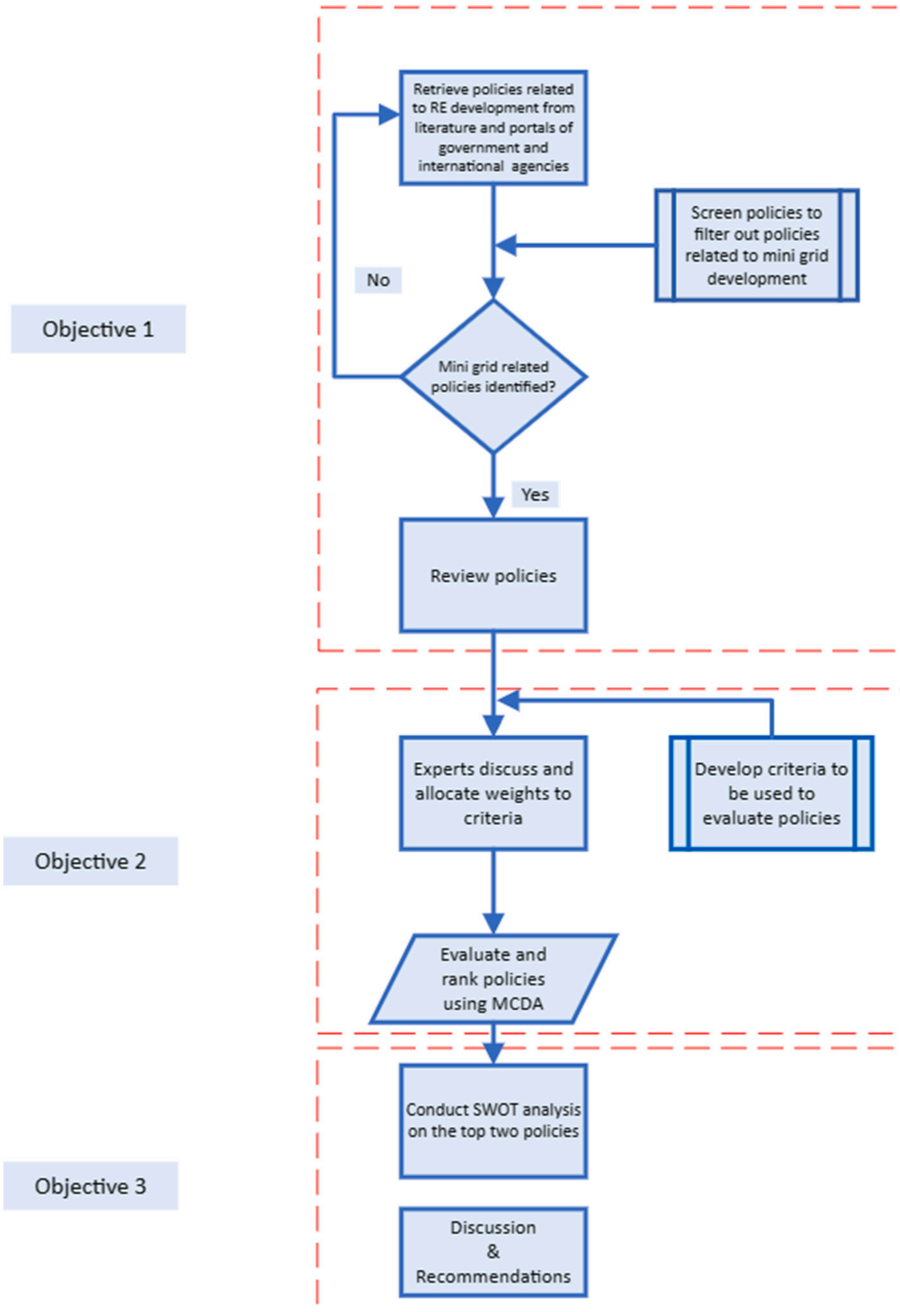

Fig. 5. Flowchart of methodology.

focused on creating an enabling environment for energy sector investment and incentives to promote RE development and utilization.

Current policies

The national cabinet approved the Energy Sector Recovery Program (ESRP) in January 2019. At that time, the outstanding net sector debt was USD 2.74 billion, representing 5.7 % of 2017's GDP. Without any action, the arrears were forecast to increase further to USD 12.56 billion by the end of 2023 (Ministry of Energy, 2019). The three-phase roadmap focused on restoring the energy sector debts to sustainable levels. The action plans in the first two phases were expected to reduce the annual sector shortfall to USD 589 million by the end of 2023. The third phase aimed to reduce the financial gap in the medium term. The program recommended that the government suspend the issue of licenses for large-scale RE-embedded generation projects. This directive was, however, annulled in April 2023, paving the way for private-sector participation.

The US government supported the GoG to assess current challenges and future opportunities within the power sector. The findings were used to draft the Integrated Power Sector Master Plan (IPSMP), which focused on ensuring a resilient generation capacity to meet future electricity demands at the lowest cost. The REMP was introduced in 2019 to provide a long-term schematic for achieving SDG 7. The REMP, expected to be driven mainly by the private sector, outlined action plans for all the RE technologies (Energy Commission, 2019b). An updated SNEP and NEP were drafted in 2019 and 2021, respectively, to replace the existing ones. These policies were necessary due to the significant changes in the energy sector since the introduction of the previous versions. Notable inclusions are provisions for nuclear power, energy transition and cross-cutting areas. The poor financial health of the

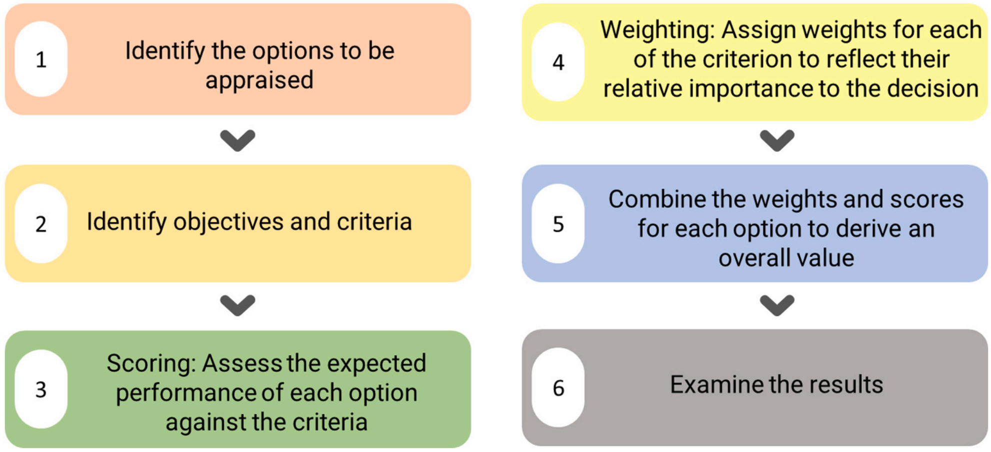

Fig. 6. Steps for the MCDM model.

Table 4
Criteria for MCDM.

Criterion	Name	Description	Ref
Criterion 1	Public support	To what extent do key stakeholders support the policy?	(IRENA, 2014; Stokes & Warshaw, 2017)
Criterion 2	System cost	Can the policy be implemented with minimum financial constraints?	(ASEAN Centre for Energy, 2016; Dornan & Shah, 2016; IRENA, 2014)
Criterion 3	Improvement in equity	The relative impact of the policy on low-income earners and marginalized groups (poverty alleviation, literacy rate, life expectancy, women empowerment)	(ASEAN Centre for Energy, 2016; IRENA, 2016)
Criterion 4	Measurable outputs	Number of RE mini grids deployed and percentage of access	(Santika et al., 2020; Shem et al., 2019)
Criterion 5	Ease of implementation	Are there specific procedures to ease implementation?	(Shem et al., 2019)
Criterion 6	Embedded monitoring mechanism	Is there any monitoring process?	(IRENA, 2012)
Criterion 7	Emissions abatement target	The policy has the potential to reduce GHG emissions in Ghana	(Ali et al., 2017; Shem et al., 2019)

Table 5
Scoring scale for evaluated policy options.

Objective	Criteria	Scoring scale		
		1	3	5
Max	Public support	No support from key stakeholders	Some support from key stakeholders	Full support from key stakeholders
Min	System cost	Low system cost	Medium system cost	High system cost
Max	Improvement in equity	No reference was made to equity improvement	Reference made without specific measures to achieve them	Measures to improve equity stated
Max	Measurable outputs	Specific targets were not given, or no targets were met	Some targets are met	Specific targets made and met
Max	Ease of implementation	Not implemented due to bottlenecks	Some progress made	Successfully implemented
Max	Embedded monitoring mechanism	No monitoring mechanism in place	General monitoring mechanism in place	Specific monitoring mechanisms in place
Max	Emissions abatement target	No emission target is mentioned	Targets mentioned	Targets including mechanisms to achieve included

utilities and high system losses were issues identified that could derail the smooth implementation of the policy.

The National Energy Transition Framework was designed to address the issues related to net-zero carbon transition by 2070. Energy demand was forecasted to increase by 238.37 % of 2022 with 84.3 GW of electricity generation required (Ministry of Energy, 2022). Hence, cleaner and more efficient technologies are required to achieve a net-zero transition and meet energy demand. The Energy Transition Model used to develop the framework considered nuclear power, carbon capture and storage, sustainable aviation fuel, efficient energy processes and efficient end-use appliances as input sources to model different scenarios (Ministry of Energy, 2022). It was identified that the energy transition will not impact agriculture and food security because it requires low arable land. Moreover, it is expected to positively impact women and children by improving healthcare delivery and eradicate child labour (Ministry of Energy, 2022). A summary of the current policies that were included in the MCDA model is shown in Table 7.

Effectiveness of policies

The weighted sum MCDA was used to evaluate the effectiveness of RE policies that promote mini-grid development in Ghana as depicted in Fig. 9. The findings showed that policy effectiveness was not determined by how long the policy had been in place. For instance, the Energy Sector Recovery Program, which was approved in 2018, ranked third last while the Scaling-up Renewable Energy Program commissioned in 2022 was ranked as the best policy.

Further insights from the evaluation matrix (see Appendix A) indicated that the policies that scored below 50 % had lower ratings for financial viability, ease of implementation and embedded monitoring. All the policies had high scores for public support and emissions abatement. A further analysis showed that policies backed by international support and private sector participation performed better.

Table 6
Details of experts involved in MCDA.

Expert #	Background	Expertise	Function	Organization	Years of experience
1	Academia & Industry: Electrical Engineering/ Energy & Environmental Engineering/Energy policy/Energy management	Renewable energy systems modelling and design/Power systems analysis/ Energy policy analysis	Lecturer at the Faculty of Engineering	Koforidua Technical University, Ghana	12
2	Academia: Significant contributions to policy analysis in the energy sector, with a focus on designing and evaluating frameworks that promote sustainable energy development, particularly in rural and off-grid contexts.	Stakeholder engagement to identify key policy challenges and opportunities/multi-criteria decision-making tools to assess policy impacts/ Comparative studies of policy frameworks across countries to identify best practices/ Policy analysis/ Teaching Energy and climate change policy	Professor at the School of Engineering and Energy	Murdoch University, Western Australia	26
3	Academia & Industry: Solar energy/ Wind turbines/Energy policy/Energy management/ Climate change.	Wind energy resource assessment/ Renewable energy system design/ sustainable energy development	Associate Professor at the School of Engineering and Energy	Murdoch University, Western Australia	23
4	Academia & Policymaking: Public policy development, analysis and evaluation/Public policy theory/Government business	Policy analysis/Teaching public Policy/ Government/public policy consultation	Senior academic at the School of Humanities, Arts and Social Sciences	Murdoch University, Western Australia	22
5	Academia & Industry: Engineering, Energy Science and Technology/Policy analysis/ Macroeconomy/Energy-Environment modelling	Climate and energy policy analysis/ modelling	Senior researcher/ Lecturer at the Institute for Climate, Energy & Disaster Solutions	Australia National University, Canberra	14

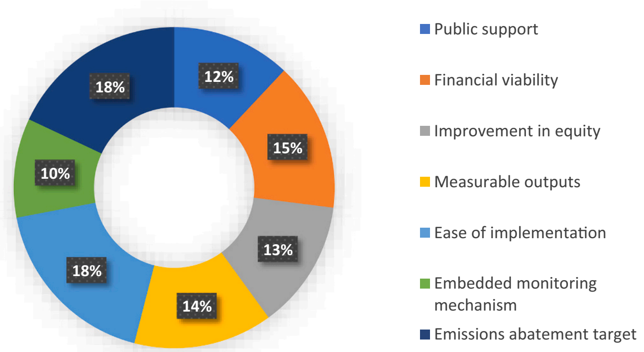

Fig. 7. Weights allocated to each criterion.

SWOT analysis of the top two ranked policy

This section presents a SWOT analysis of the Scaling-up Renewable Energy Program (SREP) and the REMP. These top two policies were selected for deeper examination due to the significant scoring gap between the second and third-ranked policies, which is much larger than the gap between the first and second-ranked policies. This disparity highlights the distinct performance and strategic positioning of SREP and REMP compared to other policies.

SWOT analysis of Scaling-up Renewable Energy Program

Strength. Availability of funds for implementing of SREP is a notable strength. Though the GoG contributed to the project, developmental agencies met 81.2 % of the project cost (Shetty, 2022). With the steady flow of funds, the implementation will likely go ahead without stalling at a critical stage. Additionally, the funds from donor agencies will reduce pressure on the national budget, which can be directed to other equally important sectors of the economy. Moreover, there are checks and balances to ensure timelines are met. Lastly, credibility is enhanced because the sponsors act as watchdogs to ensure funds are disbursed effectively and used for their intended purpose.

A survey by Nyarko et al. (2023) discovered that the high upfront cost of mini-grid projects is the worst challenge for its expansion and replication. This significant hurdle often leads to long payback periods and makes such projects unattractive. In the case of the SREP, a substantial portion of the capital cost is offset by grants, so there will be less burden on the financial management of the installed systems.

Weaknesses. The lack of an explicit framework to regulate mini-grid development is a significant weakness that negatively impacts the implementation of SREP. EC commenced the development of the framework in 2011. After a long delay, the draft framework was completed in 2017 and sent to key stakeholders for their input. However, at the time of drafting this paper, the framework was yet to be implemented.

The socioeconomic situation of the selected mini-grid sites for the SREP impacts the type of tariff to adopt. Most residents fall under the lifeline customers who, as a national policy, are protected from paying high tariffs. Raising enough revenue to offset running and maintenance costs may be difficult when the systems become operational.

Opportunities. With an ambition to achieve universal electricity access by 2030, the GoG, through a study (ESMAP, 2016), identified mini-grids as the best option for the remaining unelectrified locations. This is because most unserved areas are islands and remote communities distant from the interconnected grid. With mini-grids best suited for these communities, the SREP will create an avenue to create jobs and social amenities to improve the lives and livelihood of the residents.

The GoG is poised to meet the SDGs, and access to electricity plays an essential role. Lessons learned from the World Bank's GEDAP will offer valuable insights for the SREP. Since the same stakeholders in the GEDAP are also involved in the current project, there is a wealth of experience on board in implementing the project.

Threat. The indigene's lack of acceptance of the technology threatens the smooth implementation of the SREP. The residents think that mini-grid is an inferior technology and are willing to wait until the grid arrives at their location. They argue that once they are connected to the mini-grid, they will never be connected to the grid. The knock-on effect is that the residents may not value the system and are unwilling to pay for the services.

Challenges in accessing the sites due to lack of physical infrastructure is another issue of concern. As aforementioned, most of the sites are island communities along the Volta River, which have many tree stumps and debris, making it challenging to operate large boats. It is a logistical headache to move mini-grid components to the site.

Lastly, the lack of clear measures in place upon the arrival of the central grid at the mini-grid sites is a major threat. The mini-grid for

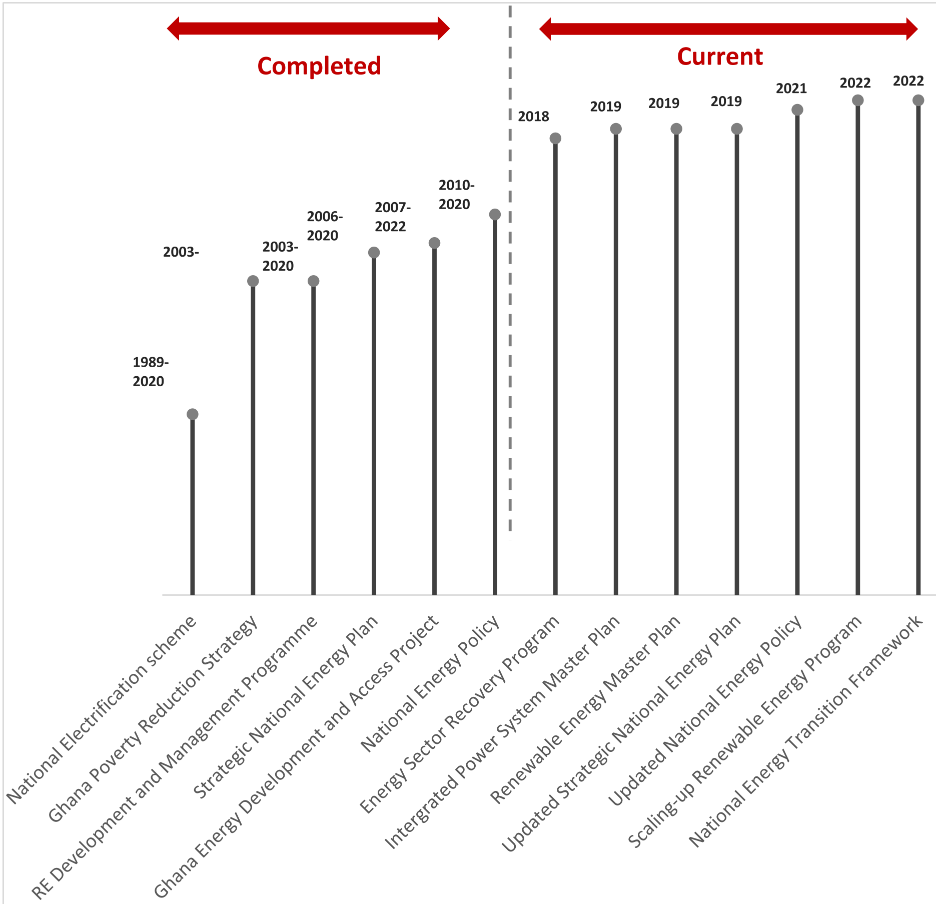

Fig. 8. Evolution of policies related to mini-grid development in Ghana.

Table 7
Summary of RE policies.

Policy/plan name	Year	Objective	Key issues addressed	Strategies
Energy Sector Recovery Program	2019	Ensure financial sustainability of the energy sector.	Debt accrual, unpaid government electricity bills	Timely bill payments, least-cost fuel procurement, competitive policies, cash waterfall mechanism, street lighting tariffs
Integrated Power Sector Master Plan	2019	Plan a resilient power system to support socioeconomic development.	Excess capacity, high fuel costs, distribution losses	Use indigenous resources, develop renewable energy, consider storage solutions, build biomass plants
National Energy Policy	2021	Deploy off-grid renewable solutions for universal electricity access.	Grid extension difficulties, substandard imports	Develop mini-grids, regulatory frameworks, innovative financing, maintenance budgets
Renewable Energy Master Plan	2019–2030	Contribute to universal electricity access in remote communities.	Geographical accessibility, technical expertise, high costs	Special funding for mini grids, promote energy efficiency, integrate standalone systems, ensure proper sizing
Updated Strategic National Energy Plan	2021–2030	Identify energy demand profiles and assess supply options for sustainable energy up to 2030.	Unreliable supply, poor infrastructure	Embed system costs in tariffs, assess long-term energy sources, formulate diverse energy strategies, evaluate impacts and constraints.
Scaling up Renewable Energy Program	2022	Demonstrate economic, social, and environmental viability of low-carbon pathways in the energy sector.	Inadequate demand management, remote populations	Develop mini grids, deploy solar PV units, and build capacity for sustainable energy systems
National Energy Transition Framework	2022–2070	Transition towards carbon neutrality within a secure and efficient energy sector.	Overdependence on fossil fuels, lack of clean cooking access	Mobilize finance, establish public-private partnerships, evaluate economic impacts, stimulate domestic financing for transition technologies

rural electrification policy approved in 2016 stipulated that mini-grids would be integrated into the national grid upon arrival. However, there is no active plan in place to integrate the mini-grids with the central grid seamlessly.

SWOT analysis of Renewable Energy Master Plan

Strength. Lack of coordination when implementing RE projects is usually cited as a major challenge that hinders their successful rollout. However, including a coordinating unit responsible for procurement, fiscal management and reporting duties in the REMP is a notable strength. Apart from the coordinating unit that will implement the plan, the National Steering Committee (NSC), comprising experts from diverse institutions, provides an overall direction and reviews progress made at the end of each cycle. The implementation period is divided into three different cycles. The NSC will review the progress made at the end of each cycle to

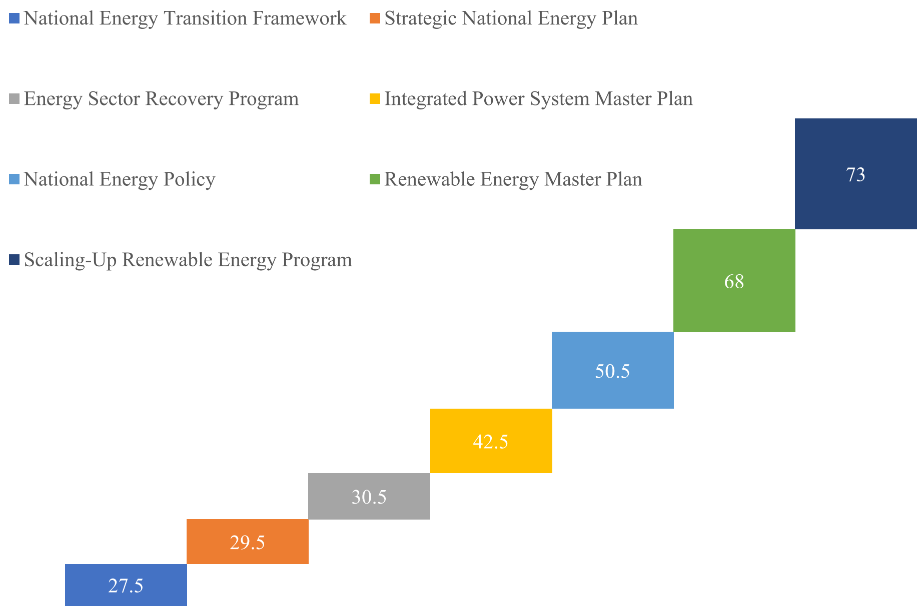

Fig. 9. Hierarchical weighted score of the effectiveness of RE policies.

inform them about ways to improve the implementation of the next cycle.

Including specific targets for each renewable energy technology in the plan places a further premium on a sense of direction. Furthermore, it is easier to track the progress made about each RET, and it helps optimize how resources are distributed to ensure that all the targets are achieved promptly.

RE-based mini-grids are seen as a crucial option to provide electricity access to the remaining unelectrified communities without creating adverse environmental impacts. As such, regional and international developmental agencies provide invaluable support to the GoG in implementing strategies that aim to achieve the SDGs. Over the years, these agencies have demonstrated their commitment to partnering with the government to overcome the challenges in implementing RE technologies. However, these developmental projects require a stable political environment. The country has had its fair share of political turmoil in the past. However, since 1992, when it returned to constitutional rule, there have been eight free and fair elections and successful power transfers.

Weakness. The implementation of most of the proposed strategies hinges on using locally manufactured materials and experts in the industry. However, it is our expert opinion that there are not enough local companies and experts to design, manufacture and assemble the quantity of materials needed to meet the targets set in the REMP. For instance, a study by Nuhu et al. (2022) found that though the production and use of biomass pellets are included in the plan, they are yet to be produced in commercial quantities as of 2023.

As aforementioned, 80 % of the USD 5.6 billion needed to implement REMP is expected from the private sector (Energy Commission, 2019b). In addition, the policy stipulates that it will prioritize private-sector investments. This arrangement can stifle the rapid expansion of mini-grids, as public utilities are solely responsible for implementing mini-grid systems in the country. Institutional hurdles are other issues that hinder the smooth implementation of the plan. Three public agencies were slated to play key roles in meeting the objectives of the plan. While VRA and Bui power authorities have commenced exploring mini-grid systems, the Renewable Energy Authority is yet to be established.

Opportunities. The cost of electricity from RE technologies significantly declined over the years. According to a report by IRENA, between 2021 and 2022, the global weighted average LCOE for newly commissioned onshore wind and utility-scale solar PV projects declined by 5 % and 3 %, respectively (IRENA, 2022). The ongoing reduction in capital expenditure presents an opportunity to economically justify RE projects and attract private investors.

Following the negative impacts of the power crisis discussed in Ghana's electricity generation outlook section, the GoG is committed to diversifying fuel sources for electricity generation to improve energy reliability and security (Ministry of Energy, 2019). Moreover, with an annual electricity demand growth rate of 7.8 % (Energy Commission, 2022), it is important to invest in RE technologies to diversify the generation mix.

Threat. From a financial perspective, high inflation threatens the smooth implementation of the REMP as it poses a considerable risk to private investors. Sticking to a workable budget in such an unpredictable environment is often difficult.

Power supply shortfalls have befallen the country in recent times. The challenge commenced on October 2, 2023, in an almost nationwide power outage. GRIDCo, the nation's sole electricity transmission company, attributed the outage to a 550 MW supply gap at peak time due to limited gas supply (Nunoo & Muia, 2024). The situation is exacerbated by the unsustainable energy sector debt owed to the Independent Power Producers. In such a desperate situation, there is a high likelihood that the energy ministry will halt the implementation of the REMP and channel all resources to tackle the eminent power reliability issue to avoid a full-blown power crisis. Lastly, key financial institutions across the country with the financial capacity to finance such projects perceive RE-based mini-grids as volatile and risky and are unwilling to provide the necessary assistance.

A summary of the SWOT analysis shown in Table 8 buttresses the findings in the MCDA. Both policies have overlapping merits and demerits; however, the SREP urges over the REMP from the financial, implementation and monitoring perspectives. This is largely because of the involvement of developmental agencies that provide funds and access to experts.

Discussion

The study aimed to evaluate GoG's policies that promote mini-grid development, assess their efficacy, and perform a SWOT on the top

Table 8
A synthesis of the SWOT analysis for both policies.

Strength	Weakness
SREP	SREP
✓ Substantial funding for SREP, with 81.2 % covered by development agencies, ensures steady project progress and lessens national budget strain.	✓ Lack of a regulatory framework for mini-grid development hampers SREP implementation.
✓ Checks and balances enhance credibility and ensure effective fund usage.	✓ Socioeconomic challenges at mini-grid sites complicate tariff setting, potentially affecting revenue for maintenance and operations
REMP	REMP
✓ Coordinating unit in REMP ensures effective implementation.	✓ Insufficient local materials and expertise.
✓ NSC reviews and provides direction.	✓ High dependency on private sector funding for mini grids.
✓ Specific targets for RETs optimize resource use.	✓ Institutional hurdles in implementing plans.

Opportunities	Threat
SREP	SREP
✓ SREP supports the GoG's goal for universal electricity access by 2030, especially in remote and island communities.	✓ Resistance from local communities who perceive mini-grid technology as inferior and fear exclusion from the national grid.
✓ Previous experiences from GEDAP provide valuable insights for effective project implementation.	✓ Logistical challenges in transporting components to remote sites.
	✓ Unclear policy on grid integration post-mini-grid establishment.
REMP	REMP
✓ Lowering costs of RE technologies attract private investment.	✓ Financial instability risks investment.
✓ Government commitment to diversify energy sources post-crisis.	✓ Energy sector vulnerabilities could shift focus from REMP.
	✓ Financial institutions view mini-grids as risky.

two ranked policies identified from the assessment.

The findings suggest that although there are several energy policies, very few promote mini-grid development. This confirms our initial hypothesis regarding the lack of attention given to this technology in Ghana. The analysis showed no specific policies tailored solely to improve mini-grid deployment. Among the analyzed policies, the Scaling-up renewable energy program was the closest one, as it was designed for mini-grid deployment and net metering scheme exclusively.

The downside of this revelation is that policy implementors tend to pay more attention to the technologies that serve large communities when they face challenges during implementation. Therefore, remote areas lose out due to the lack of vibrant economic activities. As identified by Sakah et al. (2017), this may lead to partial policy implementation. Based on the penetration level of mini-grids shown in Fig. 2 compared to the ambition to install 300 units by 2030, it is prudent to formulate specific policies to remove the barriers hindering mini-grid deployment.

The analysis also highlighted that some policies have similar objectives and were designed to solve the same issues, suggesting an inefficiency in resource utilization. Policies with similar objectives could be merged to streamline coordination, fund allocation, monitoring and evaluation potentially enhancing policy effectiveness. For instance, the Strategic National Energy Plan can be fused into the National Energy Policy to improve sustainable RE exploration and foster economic growth. In relation to the MCDA, less than half of the policies scored above 50 %, while only one policy scored above 70 %. The results showed that most of the energy policies were ineffective in improving the country's mini-grid development. Financial viability, ease of implementation, and embedded monitoring mechanisms were identified as the top three factors that negatively impacted the smooth implementation of the policies.

The sources of funding including budgetary allocations, levies and grants were clearly stated in the policy documents. However, mini-grids are not allocated with substantive funds, and levies are oftentimes diverted to solve other pressing issues. In addition, the RE fund enshrined in the RE Act is yet to be operationalized after twelve years of its existence. Therefore, mini-grid development relies mainly on grants from foreign developmental agencies. To deal with this limitation, the government can tax non-renewable companies such as oil companies and channel the proceeds to the RE fund. However, this approach can cause controversy since these companies are already burdened with numerous taxes. The authors suggest the GoG consider lowering taxes on RE companies, which would serve as an incentive to attract investors. This approach is extensively used in industrialized countries to help equal the playing field between RE and non-RE companies (Alizadeh et al., 2020).

Ease of implementation is another aspect that affects energy policy effectiveness. The main concern is that either the policies are altered midway through its implementation or there are no clear technical details on how the strategies will be implemented. With this ambiguity, it is difficult to attract investors. As asserted by Almeshqab and Ustun (2019), international organizations support countries with well-defined energy policies. These policies should traverse the energy trilemma and balance economic growth with energy transition. It starts at the policy design stage, where all relevant stakeholders must be engaged. The policy objectives must be clearly defined and policy elements clearly calibrated (IRENA, 2014). In addition, implementing agencies must coordinate activities and avoid overlap of responsibilities.

Monitoring and evaluating ongoing and completed programs are the third key factor that impacts policy effectiveness. This finding is consistent with the work of Ashong (2016), who suggested that monitoring and evaluating the implementation of large-scale RE policies in Ghana is not optimum. The authors suggest that the GoG could use public funds to contract independent energy audit firms to monitor and evaluate the projects at various stages of implementation to ensure quality assurance.

The SWOT showed that while donor agency funding is beneficial, clear guidelines on how public utilities will maintain the systems to ensure their sustainability after they assume control is needed. Based on the uniform nation tariff policy adopted and the socioeconomic situation of residents at the site, it is incredibly difficult to effectively sustain mini-grid systems using the current public utility-led approach. The authors argue that a concessionary approach, similar to what is practiced in Senegal (USAID, 2019b), can be adapted to enable private sector participation. However, it can only be successful if the mini-grid regulation sets guidelines for tariff setting, quality of supply and service, and grid creep (arrival of the central grid at the site) protocols among other important protocols.

Another aspect that RE policy should address is the need to build local capacity. In the SWOT analysis, unavailable locally manufactured components are seen as a weakness that affect effective policy implementation. To accelerate the transition to a sustainable sector, the country must make a conscious effort to limit the reliance on foreign products and experts and embrace local content.

Energy policy instruments adopted by a government impacts the success or failure of the objectives of energy policies. The choice of instrument is dependent on the country's unique circumstances. The coverage of Ghana's energy policies compares well with countries in global south such as South Africa, Brazil and Chile. However, while major developed economies with high RE penetration use market-based instruments such as the quota system, auctions and tradable green certificates, Ghana's energy policies are mainly driven by fiscal incentives such as grants and subsidies. However, reliance on incentives alone is not sufficient to promote RE deployment (Bersalli et al., 2020; Liu et al., 2019) and could be supported with regulatory based instruments like obligation schemes and codes and standards. Kim J. (Kim, 2020) established in a study that obligation schemes were more effective in mobilizing private investment in developing countries than FiTs.

For long-term solutions, the government can implement less costly and less complex educational policy tools alongside fiscal incentives. By developing a curriculum that aligns with national standards, it can incorporate energy efficiency and sustainable practices. Additionally, public awareness campaigns can be launched to educate rural communities about energy conservation, the effects of energy consumption, and the advantages of renewable energy. These initiatives can help cultivate a culture of sustainability within educational institutions and the broader community, empowering them to make informed decisions regarding energy use and environmental stewardship.

Conclusion and policy implications

This study evaluated the effectiveness of energy policies in promoting RE-based mini grids in Ghana using MCDA, and SWOT analysis.

The research highlighted a significant gap as numerous RE policies implemented across Ghana did not target mini-grid development. This oversight could potentially sideline mini-grid projects, especially under financial constraints that typically favour larger, grid-connected systems. Two exceptional policies are the Scaling-up Renewable Energy Program and the Renewable Energy Master Plan, which clearly defines mini-grid deployment strategies.

The MCDA results revealed that apart from the Scaling-up Renewable Energy Program, most policies fell short in effectively supporting mini-grid development, primarily due to issues related to financing, complexities associated with its implementation, and inadequate monitoring mechanisms. These areas, therefore, require focused improvement in future policy formulations. A limitation of the MCDA is the relatively small number of experts involved in the process. Future studies could evaluate these policies using other indicators such as efficiency, equity, or institutional feasibility and compare their results with this study.

The SWOT analysis underscored the financial challenges facing publicly-funded mini-grid projects, suggesting a greater need for private investment underpinned by robust and urgent mini-grid regulations to enhance investor confidence and ensure effective implementation.

Policy implications

Based on the findings of this study, the authors propose the following strategic recommendations to enhance the implementation of current and future policies to promote RE-based mini-grids in Ghana:

- Develop targeted mini-grid policies: It is crucial to design specialized policies focused exclusively on mini-grid development. These policies should include clear mechanisms for financing, project implementation, monitoring, and evaluation to ensure that mini-grids can compete effectively with other RE technologies like solar home systems and utility-scale systems.
- Strengthen private sector engagement: Given the financial constraints of using public funds for mini-grid projects, policies should focus on facilitating and encouraging private sector investment. This can be achieved by creating a favourable investment climate through incentives, streamlining bureaucratic processes, and offering guarantees or other financial instruments to reduce investment risks.
- Implement and enforce mini-Grid regulations: The current policies will be significantly strengthened with the finalization and enforcement of mini-grid regulations. This step will boost confidence among stakeholders by providing a clear and structured framework that governs all aspects of mini-grid development, including design, construction, operation, and maintenance. Such regulations will ensure consistency, reduce uncertainty, and foster sustainable growth in the sector.
- Enhance Public Participation and Awareness: Engage communities and end-users right from the policy design stage to ensure that the policies are well-understood and supported by the public. This involvement can help tailor solutions to the specific needs of communities and enhance the acceptance and success of mini-grid projects.
- Combat Brain Drain: Address the issue of brain drain by creating opportunities and incentives for skilled professionals to remain in or return to Ghana. This could include better career prospects, competitive salaries, and opportunities for research and development in the RE sector.
- Integrate Mini-Grids with National Energy Planning: Ensure that the current mini-grids are incorporated into national energy planning. This integration should consider the eventual linkage of mini-grids to the national grid or their sustainable operation as standalone systems.
- Promote Capacity Building: Future policies must include investment in training and capacity building to develop local expertise in the design, installation, maintenance, and management of mini-grid systems. This approach not only supports local industry but also reduces the dependence on foreign expertise and technology.
- Regular Policy Review and Adaptation: Establish mechanisms to review current energy policies to reflect changes in technology, market conditions, and socio-economic factors. This dynamic approach will help maintain the relevance and effectiveness of policies over time.

These recommendations aim to strengthen the framework for mini-grid development in Ghana, ensuring that it contributes effectively to the country's RE targets.

Abbreviations

AfDB	African Development Bank
EC	Energy Commission
ECG	Electricity Company of Ghana
GEDAP	Ghana Energy Development and Access Project
GoG	Government of Ghana
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
LEAP	Low Emissions Analysis Platform
MCDA	Multi-Criteria Decision Analysis
MoEn	Ministry of Energy
NEDCO	Northern Electricity Distribution Company of Ghana
NEP	National Energy Policy
NSC	National Steering Committee
PPBME	Policy, Planning, Budgeting, Monitoring and Evaluation
PURC	Public Utility Regulatory Commission
REMP	Renewable Energy Master Plan
SDGs	Sustainable Development Goals
SECO	Swiss State Secretariat for Economic Affairs
SIDS	Small Island Developing States
SNEP	Strategic National Energy Plan National Electrification Scheme
SREP	Scaling-up Renewable Energy Program
UN	United Nations
VRA	Volta River Authority

CRediT authorship contribution statement

Kofi Nyarko: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Tania Urmee:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Jonathan Whale:** Writing – review & editing, Validation, Supervision, Formal analysis. **Yeliz Simsek:** Writing – review & editing, Methodology.

Yvonne Haigh: Writing – review & editing, Methodology.

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Declaration of competing interest

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Appendix A. Score matrix of evaluated policy options

Option/criterion	Public support	System cost	Improvement in equity	Measurable outputs	Ease of implementation	Embedded monitoring mechanism	Emissions abatement target
Preferred value	High	Low	High	High	High	High	High
Integrated Power System Master Plan	4	3	2	2	3	3	3
Energy Sector Recovery Program	3	3	2	2	4	3	2
Renewable Energy Master Plan	4	3	3	3	3	4	3
Strategic National Energy Plan	3	4	3	2	3	3	3
National Energy Policy	4	3	4	2	3	2	3
National Energy Transition Framework	4	4	3	2	2	2	3
Scaling-Up Renewable Energy Program	4	2	2	3	3	3	4

Data availability

Data will be made available on request.

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