Title Page

Title: Off-grid electrification using renewable energy: missed windows of opportunity for small wind policy in Kenya

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Abstract

Different pathways have been used to achieve rural electrification in developing countries, including grid connections, stand-alone solutions and mini-grids. While mini-grids in many cases are identified as the optimal option, the factors that influence the choice of technology are not well-defined. This paper investigates the effect of policies on the choice of technology for rural electrification, and specifically, the limited use of small-scale wind-powered technology for electrifying marginal areas in Kenya. We used the Multiple Streams Framework to analyse data on the dynamics of policy related to small wind for rural electrification in Kenya. The analysis identifies a constellation of factors that disfavoured a policy window that could enhance the use of small wind in rural electrification. The factors include the absence of policy targets, data and feasibility studies, and limited skills and capabilities. Addressing these factors could be an important step in opening a policy window for policy change towards small wind, particularly, solar/wind hybrids in rural electrification. More broadly, we argue for the need to increase awareness on policy gaps on small wind to achieve universal access to electrification in rural and marginalized areas.

Keywords: *Choice of technology, Multiple streams framework, Policies, Rural Electrification, Small wind, Solar PV*

1. Introduction

Energy access in Africa has progressed slowly in comparison to population growth (Corfee-Morlot, 2018), and access to electricity is low at 48% of the population (Babayomi et al., 2023). This is attributed to unreliable electricity infrastructure and the high cost of connecting predominantly rural populations (Kinally et al., 2022). Rural electrification (REL) in developing countries is mainly through stand-alone power systems, mini-grids and central grids (Hansen & Xydis, 2020). Small-scale renewable electricity systems are increasingly becoming suitable complements to centralized electrification through off-grid practices (Rothfuß & Boamah, 2020). The definition of small varies with technology type and specific application in different environments and country. In the United States, less than 100 kW is small, while in the United Kingdom, it is less than 500 kW (Van Treuren, 2016; Torres-Madroñero et al., 2020; Clarke, 2018). This paper adopts the United

States definition of systems less than 100 kW, mostly used to offset the electricity bills or backup the grid in homes, farms and small businesses.

Many governments in low-income countries are keen to enhance access to electricity for purposes of improving health and education, generating income, increasing productivity, reducing inequality and enhancing the quality of life (Lahimer et al., 2013). The choice of technology (CoT) in REL is not always explicit and depends on several factors including policy as explained in subsequent sections.

While several countries around the world have succeeded in developing small wind, this has not been the case for Kenya. The country's successes in developing large wind are not replicated in SWT. This is explained by variances in innovation and diffusion dynamics between the two technologies (Hansen et al., 2018). Greater deployment of SWT could be achieved through hybrid systems, i.e. combining with solar or diesel fuel options (Leary et al., 2018). Solar Photovoltaic (PV)/diesel mini-grids have been dominant in Kenya (Johannsen et al., 2020) despite the benefits of small wind/ diesel solutions which offer 24-hour power with reduced fuel use (Leary et al., 2018) – something solar PV/ diesel does not. Kenya's experience in small wind technology highlights the complexity of decision-making in choosing a technology to solve energy access issues and the importance of facilitatory policy to address this.

The paper has five sections: section 2 presents the literature; section 3 discusses the methodology; section 4 is the Multiple Stream Framework (MSF) analysis of off-grid electrification in Kenya and section 5 is the discussion, conclusions and policy implications.

2. Literature review

2.1. Choice of technology for rural electrification

The CoT for REL is a multidimensional problem involving various actors and factors, with key considerations on technical, economic, social, environmental and policy/regulation aspects (Rahman et al., 2013). Whether solar or wind is used mainly depends on the resource assessment (quantity, availability, cost, sustainability and potentially conflicting uses of either wind or solar)[1]. The CoT for REL also depends on many other factors including policy and institutional frameworks and the socioeconomic setup in the rural areas. Other factors include the characteristics of the local community, availability of the energy resource, the existing infrastructure, placement from the main grid, load types, geographic conditions, and how available and mature the selected technology is (Rahman, 2014).

Solar PV technologies have been championed as key tools for sustainable development through REL (Green, 2005). The cost of maintaining and operating solar PV is lower than that of SWT and

[1] https://www.usaid.gov/energy/mini-grids/technical-design/key-steps Accessed 11th April 2024

is cost-free in terms of fuel (Mahapatra & Dasappa, 2012). The abundance and high predictability favour solar PV technology, but in the case of small wind in Kenya, there is a general lack of infrastructure, maintenance services and poor access to financial services (Azimoh, 2016). However, as noted above, solar PV is not effective at night without batteries, and therefore, solar PV/diesel hybrid mini-grids could be more inefficient in many places compared to wind/diesel hybrid systems.

2.2. Small wind turbines in off-grid electrification

Small wind turbines could complement solar energy (as wind frequently occurs at night, when the sun is not shining); reducing dependency on diesel generators and increasing the availability and reliability of electricity supplies in poorly serviced areas. The attributes of SWT for example, the ease of manufacturing SWT compared to solar panels and the use of maintenance services for SWT to open new livelihood opportunities have not been comprehensively studied (Leary et al., 2018). The competition between SWT and solar PV is limited by the rapid decline in the latter's prices, especially compared with the variability of the wind resource and the high cost of maintaining SWT components (Leary et al., 2020).

That said, SWTs are largely unutilized in the development of mini-grids in developing countries, despite available studies indicating the potential complementarity with solar PV (Muchiri et al., 2023; Hansen and Xydis, 2020). SWTs present challenges relating to their design, placement, and transportation (Sumanik-leary, 2013). The placement of wind turbines, which have several moving parts, implies that they are exposed to the elements of the weather (lightning, corrosion strikes), and failure occurs. Additionally, the availability of data and limitation in knowledge and expertise are serious for SWT (Johannsen et al., 2020).

Despite these issues, when the Kenya MiniWind Project assessed the existing potential for adding wind to solar PV sites in Kenya using the Global Wind Atlas data (Technical University of Denmark, 2023)[2] they found that out of 155 mini-grid sites, 53 had wind speeds above 4m/s providing opportunities for the addition of SWT. This included 27 of Kenya's Off-grid Solar Access Projects (KOSAP) sites, 8 Rural Electrification Authority (REA) sites and 18 All Other sites (Nygaard et al., 2018). This proportion represents 34% of the existing mini-grid sites which could potentially host solar PV/wind hybrid mini-grids. Furthermore, they found that SWT (10-100 kW) can be connected to the main grid or mini-grids. For this to happen, net metering is a prerequisite, and power purchase agreements need to be less bureaucratic (Nygaard et al., 2018). In addition, new regulations that allow different power generators to distribute electricity gazetted in March 2024 (Energy and Petroleum Regulatory Authority, 2024) could eliminate the monopoly of power

[2] The Global Wind Atlas is an online resource that is updated in real-time

distribution by Kenya Power and Lighting (KPLC) and change the trend of investments in generation using small wind turbine technology.

2.3. Policies influencing choice of technology

Various policies have been used to address the unique challenges of electrifying remote areas in different countries. For example, the regulations on power distribution gazetted in March 2024 in Kenya and financial incentives to promote private sector investment (Omole et al., 2024). These have different effects depending on the country and region they apply to. The literature spells out requisite conditions for successful mini-grid development, including the presence of appropriate legal frameworks, cost-reflective tariffs, plans for expanding the grid, guidance on when the grid arrives, licensing and tariffs for off-grid generation, and plans for private sector engagement (Bhattacharyya & Palit, 2021).

Further, Leary et al., (2020) and Omole et al., (2024) suggest that the thriving of SWT in developing countries requires the following conditions: evaluation of the potential and availability of plans, specific site assessments, institutional support, particularly the community set-up necessary for maintenance, the quality of products; government endorsement; tax exemptions on imports and favourable feed-in tariffs.

2.4. Multiple Streams Framework

The Multiple Streams Framework (MSF) is based on the Multiple Streams Theory (MST) developed by Kingdon (1984) and Sabatier (2007). It explains the reasons for choosing one issue over another, periodic changes in their agenda, and what informs the selection of a few choices from a broader range of options (Adams & Asante, 2020). The MSF is usually used to identify the existence of policy windows which are created through the coupling of the problem stream, policy solution stream and the political streams of the MSF, and are often used to lobby for policy change by policy entrepreneurs.

Petridou (2014) defines the different elements of the MSF as follows: 1) the "problem stream" concerns the issues that policymakers would like addressed (Nowlin, 2011); 2) the policy stream constitutes the ideas and solutions to the policy problem generated by experts in the field as well as policymakers. MST posits that a policy change will likely occur when policy entrepreneurs take advantage of a favourable short-lived moment that presents itself as a policy window; 3) the politics stream refers to the national political environment; 4) policy entrepreneurs could be either within or outside government and will use own resources to front policy ideas that link solutions to problems. Furthermore, Petridou (2014) notes that a policy window is opened when the issues identified under the problem stream, solutions stream, and politics stream come together and create an opportunity for policy entrepreneurs to front an argument that is favourable to policy change, which constitutes the policy output.

Studies that use the MSF to analyze energy policies in developing countries include Zimmer et al. (2010) who examined the factors that shaped climate-related policies, focusing on RE policy and fossil fuel pricing policies. Hernández & Lucatello (2022) have investigated the integration of climate policy in Mexico including how policy entrepreneurs influenced the enactment of the energy transition law in 2015. Policy entrepreneurs influenced the national transition to clean electricity. Carvallo et al. (2016) used the MSF to explain how non-conventional renewable energy (NCRE) was included in two laws in Chile but did not find any evidence of a political window for the NCRE Law. The MSF framework has been used to explain the possibility of Africa capitalizing on its RE capacity (Adams & Asante, 2020) through the coupling of the three streams.

These studies use the MSF to explain various aspects of RE policy in developing countries, but they do not investigate individual countries in Sub-Saharan Africa. Further, none of these studies explores how the CoT for REL is determined. We filled this gap by analyzing how policies influence CoT and specifically why small wind is not a technology choice in REL in Kenya when compared to solar PV, despite being domiciled under the same policy framework and innovation system.

In this paper, we used the MSF slightly differently, and focused on identifying gaps that have prevented the opening of policy windows through the coupling of the problems, solutions and politics streams. This paper contributes to the discussion on the design of functional policies and practices on REL (Omole et al., 2024) as well as the use of the MSF to analyze REL policy in developing countries.

3. Methodology

3.1. Conceptual Framework

We focused the analysis on investigating how the two technologies (solar PV and SWT) have developed at disparate rates despite being exposed to the same policy framework and innovation system. We used the five structural components of the MSF to analyze the key actors, problems, solutions, and events that influence the policy process that leads to CoT for REL using off-grid RE options (Hansen et al., 2018).

The conceptual framework for the analysis is presented in Figure 1.

Figure 1 Conceptual Framework- Based on the MSF (Adams & Asante, 2020)

The overall question guiding the study was: "H*ow do policies influence the choice of technologies to use in addressing rural electrification problems in off-grid areas?"* (Wandera, 2024. pg. 32). The more specific question was: "*How have policies influenced the choice of technologies, notably the lack of wind-powered technology, in addressing electrification of rural and marginal areas in Kenya*?" (Wandera, 2024. pg. 32).

3.2. Case selection

Despite achieving 75% connectivity over the last twenty years (Volkert & Klagge, 2022; Kenya National Bureau of Statistics, 2023) and 93% RE in the national electrification mix in 2022 (Ministry of Energy and Petroleum, 2023), most rural homes in Kenya are yet to be connected (George et al., 2019). Where grid connection is available, most people can hardly afford to pay the price of electricity and/or power is not guaranteed 24 hours a day 7 days a week, requiring alternative power generation, especially for institutions like schools and hospitals.

According to World Bank data on tracking Sustainable Development Goal (SDG) 7, 25% of the rural population (12 million people) in Kenya lacked access to electricity in 2022 (IEA 2023). The Last Mile Connectivity Programme (LMCP) mostly focuses on serving customers within a radius of 600 metres from existing transformers. All households outside this radius are hence disadvantaged and cannot benefit from the LMCP. It is however noted that the Least Cost Power Development Plan (LCPDP) divides the country into segments according to whether they will be connected to the grid or not (Republic of Kenya, 2018).

Off-grid solutions have been identified as the optimal solutions for the 14% of the unelectrified population (Ministry of Energy Kenya, 2018). The Kenya National Electrification Strategy (KNES) identifies solar PV as the primary technology choice for off-grid electrification, mostly 100 to 500W (powers a microwave, electric heater, rice cooker etc.) for middle-income groups, and 20 to 80 W (powers 4 lights, computer, and phone charging etc.) for low-income households (Boamah, 2020). Solar PV is preferred because it is modular and the maintenance requirements are low (Johannsen et al., 2020) coupled with the trends of declining prices of solar PV (Leary et al., 2020). Kenya has devolved important energy functions (Zalengera et al., 2020), and separated the functions of the national and county governments in the Energy Act 2019 (Government of Kenya, 2019).

The Rural Electrification Master Plan (REMP, 2008) and the Energy Policy (2018) embrace multiple technology options for REL including small hydropower, small wind, solar PV, and biomass generation out of which small wind stands out as the next possible alternative after solar PV, based on the energy availability profiles of solar and wind (above 4.5m/s) in 24 hrs/day cycle (Johannsen et al., 2020). Solar PV is more popular in the development of mini-grids compared to small wind, despite the two technologies emerging under a more or less similar policy framework and innovation system. Some scholars indicate that the government has deliberately aimed to suppress the growth of solar PV in Kenya (Ockwell et al., 2017). Contrary views indicate that solar PV development has enjoyed preference at the expense of other renewables such as small wind (Johannsen et al., 2020; Wandera 2020), despite the established potential for hybrid mini-grids. This therefore informed the selection of the two technology cases for this study.

3.3. Data collection and analysis

Data was collected through a desk review of secondary qualitative data from academic databases and policy grey literature published between 1999 and 2023 based on the transformations that have transpired in the energy sector in Kenya over the last decade. These were identified from Web of Science and Scopus using combinations of the keywords “energy policy analysis”, “policy analysis frameworks”, “analyzing energy policy”, “off-grid electrification policy”, and “rural electrification policy”, “off-grid electrification”, “mini-grids” and “Kenya”. The search from these two sources produced eight (8) papers. However, on analysis of their abstracts, five (5) were excluded. Finding academic research papers that focus on Africa in Web of Science or Scopus is documented to be difficult (Asubiaro & Onaolapo, 2023). We therefore conducted the same literature search using Google Scholar, which generated 57 search results. Following a review of the titles and abstracts of these papers and removing duplications and citation references, the final number of papers reviewed was 48.

The literature search was augmented by directly accessing relevant policy documents from Kenyan government websites based on the in-depth knowledge of the Kenyan policy environment by the first author. The documents reviewed include the Rural Electrification master Plan (REMP) 2008, Rural Electrification and Renewable Energy Corporation (REREC) Strategic Plan (2018-2023), KNES 2018-2022, Ministry of Energy Strategic Plan (2018-2022), Draft Energy Policy for Kenya (2018), and the Energy Act 2019. Two (2) key informants in the energy sector provided additional information on county energy planning since limited published material was available on this. The data collection also draws from qualitative responses from a survey on SWT in Kenya (Wandera, 2020) and an international survey of manufacturers of SWT (Wandera et al., 2021), which provided primary data from Kenyan and international business companies.

Data were analyzed by identifying texts which relate to defining an existing policy problem, available policy solutions, the politics surrounding the implementation, the existence of policy entrepreneurs, the availability of a policy window and the anticipated policy output from the policy interventions. The aim was to establish whether the three streams met at all and whether this resulted in a policy window that could lead to SWT policy. This study draws on policy documents in the energy sector and could be enriched through interviews with key policy actors.

4. A Multiple Stream Framework (MSF) analysis of off-grid electrification in Kenya

This section discusses each of the three policy streams, namely policy problem; policy solutions; and political stream. Analysis of the policy problem included challenges and the indicators/triggers that make REL more salient and urgent, warranting policy attention in Kenya. For the policy solutions stream, the focus was on the available solutions for REL, including how targets are set, feasibility, regulation and selection of technologies as well as opportunities and constraints. For the political stream, we identified the key stakeholders, their interests and influence. We explored the availability of a policy that could facilitate the hybridization of SWT with solar PV.

4.1. Policy Problem stream

Kenya has a high dependency on biomass as a primary energy and low use of electricity (mostly in rural areas) which contradicts the high electricity access (Volkert & Klagge, 2022). Many people still live "under the grid" as opposed to being connected to it (Lee et al., 2016). This is attributed to several challenges as explained in section 4.1.1.

4.1.1. Challenges

Key challenges to REL include the distance from the national grid and the lack of funds to gain access to the grid (Boyes, 2019), the scattered nature of homes in rural areas, the high costs of REL projects, low affordability of upfront connection costs by the majority of consumers, vandalism of power infrastructure and the high operating costs attributed to the low density of the population (Ministry of Energy, 2018). The generation of revenue from electricity sales in rural areas is far less than the cost of connections (Maqelepo et al., 2022). Challenges in the devolved governance of electrification are pertinent, especially the limited capabilities of the county governments in executing energy projects (Volkert & Klagge, 2022). Frequent transformer breakdowns are occasioned by using substandard transformers and the effects of weather (rain) on power transmission lines (Njogu, 2021). Meeting the requirements of Article 43 of the Kenya Constitution in relation to health, sanitation, food and nutrition, safe and clean water, social security and education (Republic of Kenya, 2010) is not possible without access to electrification.

4.1.2. Indicators/triggers of urgency

Other development sectors have received more attention under devolution compared to the energy sector (Volkert & Klagge, 2022). The national grid is unevenly distributed and concentrated in heavily populated areas of the country, leaving the marginal counties in dire need of electricity services *(ibid)*. Off-grid projects have received less government and development partner support compared to grid-connected projects and were also hampered by uncompetitive feed-in tariffs (Newell & Phillips, 2016).

The bulk (99%) of off-grid electrification needs are met by small-scale, stand-alone solar PV, while plans indicate the use of solar and diesel-powered mini-grids (Moner-Girona et al., 2019). Vulnerable populations such as refugees and rural communities in off-grid areas have limited access to electricity services, and the bureaucracy associated with grid connections compels the rural communities to avoid grid connections (Leonard et al., 2021). Irregular supply affects businesses, damages equipment and lessens public trust in the grid systems, while the slow transition to electric cooking and electric mobility represents a missed opportunity to improve gender equity while reducing the emission of greenhouse gases.

The separation of functions between the national and county governments under the constitution has been a source of enduring geographical inequalities in electricity and infrastructure access between the rural and urban areas of Kenya (Sieff, 2020). The capacity of the counties to implement energy development is currently lacking (Moner-Girona et al., 2019). So far, 16 county energy plans have been developed under the Sustainable Energy Technical Assistance Programme, but the plans for the remaining 31 counties remain unclear (communication with project staff, February 2024).

4.2. Policy Solutions stream

Three possible solutions for electrifying rural remote areas exist in the form of grid extension, mini-grids and off-grid stand-alone systems (Come Zebra et al., 2021). Grid connections are not viable solutions for REL because of the high cost of grid extension in sparsely populated areas (Khon et al., 2023). Stand-alone solutions are mostly used in households/institutions, while mini-grids enable the connection of several households and other establishments, hence mini-grids are the most optimal solutions for REL *(ibid).* Solar home systems (SHS) support basic applications such as mobile charging and lighting and are not viable for productive use. There has been a gradual shift from diesel-based systems to replacement or hybridization with RE. The costs of RE are expected to decline beyond 2035 (Come Zebra et al., 2021).

The installed thermal generation capacity declined from 808 MW in 2018 to 682 MW in 2022 (Kenya National Bureau of Statistics, 2023) over five years, and there is more focus on mini-grids based on RE - mostly solar PV mini-grids (Byrne et al., 2018). Solar PV is suitable for many locations, while wind is variable and site-specific and hence requires wind measurements for one year or more before installing the system (Ministry of Energy, 2009).

Globally, diesel and solar mini-grids cost more than small hydro and wind mini-grids (IRENA, 2018), the latter being dependent on the availability of water and wind resources. The Levelised Cost of Energy (LCOE) for diesel mini-grids is generally higher than other generation sources and the fuel prices fluctuate a lot (Table 1). Hybridizing solar PV/diesel and solar PV/wind can potentially lower the costs of either diesel or solar PV based generation (Tezer et al., 2017) and improve reliability, while reducing the emission of greenhouse gases (Boyko et al., 2023). It is possible to connect them to the national grid (Samoita et al., 2020) in due time and this offers better economic viability than stand-alone systems within the same load profile.

LCOE range	USD/ kWh
Diesel	0.92 - 1.30
Solar PV	0.40 - 0.61
Hybrid solar PV/diesel	0.54 - 0.77

Table 1 Comparison of the levelized cost of energy for mini-grids[3] (Come Zebra et al., 2021)

4.2.1. Setting targets, and regulations

The REMP 2008 proposed a target of 16 wind turbines (20-200 kW). Solar power was identified as the least cost option in hybrid schemes, and recommendations on solar PV were more elaborate. The 5000MW+ plan (2013-2016) (Ministry of Energy and Petroleum, 2013) proposes data logging at 20 -50 metre heights as well as analysis of data for dissemination to potential investors. The Kenya Sustainable Energy for All Action Agenda identified clean energy mini-grids as a high-impact opportunity and proposed the development of a mini-grid policy, an implementation framework and local manufacture of SWT, plus the implementation of 10 projects for wind (Republic of Kenya, 2016).

A comprehensive regulatory framework for solar PV mini-grids is in place, but there is none for SWT. The KNES (2018) which guides the activities of REREC suggested integrated energy planning but opted for a single technology (solar PV). KNES (2018) has explicit targets for solar PV such as 1.96 million connections through stand-alone SHS, but none for other renewables including SWT. The REREC Strategic Plan (2018-2023) targets the installation of 50,000 SHS and 20 large wind systems for institutions, but no targets for SWT for mini-grids. The Medium Term Plan (MTP) IV also contains very specific targets for maintaining and installing solar PV systems (Republic of Kenya, 2024) and the installation of data loggers.

4.2.2. Opportunities and constraints

The investments in electrification depend on regulations such as pricing instruments as well as fiscal and financial incentives to attract private sector actors (Come Zebra et al., 2021). Awareness creation could also be conducted to promote social acceptance Ghimire & Kim (2018) and enhance the understanding of the potential impacts of hybrid mini-grids on healthcare, education, and the economy. Clear and transparent policies are lacking, as well as the integration of hybrid mini-grids into electrification plans, and guidance on the direction of development once the main grid arrives (Come Zebra et al., 2021).

[3] The costs of the systems vary with the technology, region or country in addition to the renewable energy local resource, capital, replacement, and O&M costs

4.3. Political stream

Kenya's electricity system is still very centralized at the national level, with the Ministry of Energy and Petroleum (MoEP), KPLC and REREC as the main actors. KPLC is the sole off-taker and distributor, while KenGen is the main generator. REREC has the key mandate for REL bestowed by the Energy Act 2019 to implement and manage the REL programme and to develop and update the REL master plans in consultation with County Governments (Government of Kenya, 2019). Other actors include the private sector, who play a key role in the provision of mini-grid and solar home system (SHS) services in peripheral areas and maintain stronger linkages with the national-level government compared to the counties. State actors' involvement in the electrification sector seems to be aligned more with expanding the central grid and "limiting the role of solar PV in the energy mix" (Newell & Phillips, 2016; Byrne et al., 2018). In Kenya, international development agencies greatly influence the development of energy projects (Lomax et al., 2021). They also work with local stakeholders to align their interests to national policy. International actors are important partners for private sector actors in Kenya, who are mostly used to implement donor-funded projects.

4.3.1. Stakeholder interests, preferences, and power

According to some sources (Ogeya et al., 2021), the dominance of KPLC in the distribution of electricity signifies resistance to change which constrains the space that the private sector could occupy in innovating distribution models. Opening up to private sector poses a threat of interference with financial revenues associated with KPLC, which could also undermine the obligations to power producers, some of which run for extended periods extending beyond 20 years (Rothfuß & Boamah, 2020). Centralized electrification has been used as a cash cow for the state, and deviation has negative effects on the financial situation of the distributor as well as the fulfilment of state obligations *(ibid)*. KPLC cites the superiority of the grid and the use of grid connectivity to implement social interventions such as the lifeline tariffs (payments designed to ensure that residential customers receive a basic supply of electricity at a price affordable by the poor and the elderly) (Schannauer, 1979).

The Energy Act 2019 lacks detail on the roles and responsibilities of the two levels of government and the potential to misinterpret overlapping functions is high (Sieff, 2020). For example, it is not clear which government holds the upper hand with respect to providing land and rights of way for energy infrastructure when a project is conceived for implementation in any county *(ibid)*. The electricity regulatory function is the preserve of the national government, and this minimizes the opportunities for county governments to take part in REL using off-grid electricity because of bureaucracy and limited autonomy (Sieff, 2020).

4.3.2. Stakeholder influence and negotiation

The communication channels between the national and county governments seem to be limited, and counties feel left out of decision-making and implementation (Volkert & Klagge, 2022). The KNES is coordinated by national-level actors and only passively mentions the involvement of county electrification offices, whose structure and staffing are not defined (KNES 2018:23 & 26).

The influence of KPLC seems to be well established at the county level, but that of REREC is only evident in some counties, where they provide matching funds for projects. KPLC and REREC collaborate with members of parliament (MP) concerning the prioritization of projects, which tends to be political.

International influence at both county and national levels is driven by the international treaties to which Kenya is a signatory such as the Sustainable Development Goals and the Paris Agreement (Volkert & Klagge, 2022), since these have a clear bearing on national energy policy as well as the county energy plans. The interaction of the international community with counties varies with individual counties, mostly based on previous relationships (Sieff, 2020).

4.4. Policy entrepreneurs

The solar PV sector in Kenya has seen many policy entrepreneurs (Byrne et al., 2018), it started with a donor push (GIZ and the World Bank), then the government through the Sessional Paper No. 4 of 2004, creating possibilities for market-led development of solar PV, and then the private sector such as PowerPoint, facilitated by policies and regulations. These actors tick some of the boxes relating to attributes of policy entrepreneurs such as investing resources and time as well as influencing the policy direction (Arnold, 2021) for solar PV development. However, they may not fit the description of activists or lobbyists, but they have influenced the trends of the development of solar PV.

For SWT, the REMP (2008) and Energy Policy (2018) recognized wind as a potential option for REL and recommended continued collection of data and intensification of wind measuring programmes in compliance with international standards at 50m (Ministry of Energy, 2009). It was difficult to identify in the literature agencies that have played the role of policy entrepreneurs for SWT. The Kenya MiniWind Project (2018) generated useful knowledge on SWT, and the Innovation for Renewable Electrification in Kenya project (2015-2020), generated numerous research products that argue for Kenya to make use of the potential for SWT (Lema et al., 2022; Hansen et al., 2021; Johannsen, 2019; Wandera, 2021). Their contribution was more to the knowledge base to influence policy. Peer-reviewed literature that was used in this study, the local manufacturers of SWT, and tertiary institutions of learning which have engaged in SWT research have likewise contributed to building the knowledge base. However, none has acted as policy entrepreneurs who are described as "advocates who are willing to invest their resources—time, energy, reputation, money—to promote a [policy] position in return for anticipated future gain in the form of material, purposive, or solitary benefits" (Kingdon, 1984). We therefore refer to them as quasi-policy entrepreneurs in this study.

4.5. Policy window

A **policy window** opens when the coupling of the problem, solutions and politics streams happens, allowing policy entrepreneurs to lobby for policy change. This study identifies some alignment between the policy problem and the policy solutions concerning concurrence in the definition and framing of the problem of REL in Kenya and the urgency (section 4). The policy solution also aligns to the REL problem concerning mini-grids as the primary option for REL. However, there is limited alignment in the politics stream for technology choice since the focus at the national level is on solar PV and limited policy action on SWT. The political stream is not well aligned to the policy problem and policy solution because of various factors including government focus on grid electrification, poor communication between national agencies and counties, limited capacity to handle energy development at the county level as well as overlapping functions. Quasi-policy entrepreneurs for SWT in REL have invested more in knowledge generation than lobbying or activism.

We did not identify any policy window that could lead to the policy output of "enhanced use of SWT in REL using solar PV/wind hybrids". Instead, gaps were identified in the policy solutions stream including the unavailability of appropriate data and synthesis to inform policy development; limited feasibility studies for solar PV/SWT hybrid mini-grids and limited capacity of county governments to deliver on the REL function as elaborated subsequently as summarised in Figure 2.

4.5.1. Synthesis of SWT data into policy recommendations

The development of the Solar and Wind Energy Resource Atlas (SWERA) with support from the Danish Technical University, Denmark, was a major step in developing solar PV resources in the country. The REMP (2008) recommended continued and intensified wind measuring programmes in compliance with international standards at 50m. MoEP subsequently initiated the installation of data loggers in 2010, and this is still ongoing as evidenced in the MTP IV (2023) which targets the installation of 80 data loggers. As observed by Wandera (2020), this data collection has gone on for over a decade now, and the update of the wind atlas is still a target in MTP IV (2023-2027), but there is limited activity towards actualization. The REMP (2008) stipulates that the analysis of 12 months of data would be sufficient to conduct the pre-feasibility assessment. It could be inferred that capabilities for analysing this data are limited or if they exist, they have not been used. This represents a gap in the policy solutions stream that could be leveraged to advance SWT policy.

4.5.2. Feasibility studies for hybridization of solar PV mini-grids

Studies on the complementarity between solar PV and small wind exist (Muchiri et al., 2023; Hansen & Xydis, 2020; Johannsen et al., 2020; Samoita et al., 2020) but remain unutilised. Nygaard et al., (2018) estimated that about 34% of the existing mini-grid sites which could potentially host solar PV/wind hybrid mini-grids are yet to be exploited for unclear reasons. The gap in this respect relates to conducting site-specific feasibility in potential sites and using these to attract the private sector.

4.5.3. Capacity strengthening of counties for rural electrification

County governments are well positioned to oversee REL programmes using renewable hybrid electrification because of their close contact with the communities, presence on the ground and therefore monitoring capabilities, and their ability to better advise on environmental and social impacts of mini-grids, particularly issues that relate to land. However, the efforts to develop county capacity to fulfil this function are limited and plans to enhance this capacity are unclear but desirable, especially given the lack of focus on SWT in the REREC strategic plan.

Figure 2: Analysis using the MSF (Authors' own, modified based on Adams & Asante, 2020)

Generally, the policies that apply to solar PV also mention wind and do not discriminate between the two technologies, for example, the REMP (2008), the Draft Energy Policy (2018), the Energy Act 2019 and the Draft Mini-grid Regulations 2021. The KNES (2018) is a key document in REL, but it is more explicit on solar PV strategies and targets than SWT. The availability of Solar PV Regulations and the Regulatory Impact Assessment (2019) signifies the advancements in the solar PV sector compared to SWT, whose market remains stagnated. Mainstreaming solutions for off-grid electrification in planning could incentivize stakeholders to develop customized solutions for enhancing access.

Recommendations to develop an efficient database management system for the installed wind masts across the country and an umbrella Wind Energy Policy document have not been implemented (WindForce, 2013). The conditions required for the growth of SWT markets as described in Section 2.3 are not yet present in Kenya. Factors such as the identification of solar PV as the least cost option, reduction in the price of PV, and the ease of implementation among other factors have favoured solar PV.

There are overlaps between the national and county governments functions in the Energy Act, a sign of poor definition of stakeholder roles. Misinterpretation is bound to arise and reduce effectiveness. In reality, the capability of the counties to undertake this function may be limited (Sieff, 2020). KPLC's resistance towards off-grid systems limits social justice for communities in rural areas that need electricity (Ogeya et al., 2021). REREC has weak relations with some county governments, while the county officials have limited trust in MPs. These factors could constrain the ability of counties to utilize the available renewable resources for their benefit.

5. Discussion, conclusion and policy implications

The key question for this paper was: "*How do policies influence the choice of technologies used in addressing rural electrification problems in off-grid areas?" (Wandera, 2024. Pg. 172).* The findings indicate that policies have an overall influence in addressing REL challenges faced by developing economies. Regarding the CoT, policies guide the assessment of energy resources for electrification, determining the cost and sustainability. Policies are necessary for evaluating the potential and developing implementation plans, in addition to soliciting institutional support and signifying government endorsement of technologies. They define the institutional framework for deploying specific technologies, for example, the designation of the REREC as the REL agency in the Energy Policy (2018) and the Energy Act (2019). Policies also influence the CoT through planning, defining activities and setting targets at the institutional, national and county levels. Policies are the backbone for developing regulations and setting tariffs. Global policies also influence the trends in developing countries, for example, the championing of solar PV at the global level influences actions in developing countries.

The more specific question was: "*How have policies influenced the choice of technologies, notably the lack of wind-powered technology, in addressing the electrification of rural and marginal areas in Kenya?" (Wandera, 2024. pg. 172).*

The problem stream is complete as far as defining the REL problem is concerned. Gaps in the policy solution stream include limited data, limited feasibility studies and weak capacity in counties to implement REL. Gaps in the political stream include weak communication between national-level institutions (KPLC and REREC) and county-level institutions. There is also limited recognition of SWT as an important policy solution for REL. We therefore argue that the windows of opportunity for developing the SWT market for Kenya have existed for some time without being used. This constitutes a missed opportunity to enable energy access which remains a problem, despite the high proportion of renewables in the grid. The availability of explicit targets for solar PV appear to have a profound influence on the successful roll-out of solar PV, and yet the absence of targets for SWT, had a counter effect.

The limited attention to data collection and synthesis to inform policy development is also a missed opportunity for SWT market growth. Capacity development for defining SWT policy to attract private sector investment is necessary. Feasibility studies could aid the setting of targets, and development of the requisite policy on SWT, which is still lacking to date.

There is potential to drive REL through the devolution framework, but this requires developing county capacity for energy planning and REL using renewables in hybrid mini-grids. In addition, the national government needs to take deliberate steps to address the capacity gap in counties and to facilitate them to implement the functions bestowed upon them under the Energy Act (2019) which could be better implemented as decentralized rather than the current centralized approach to electrification. We recommend research on how the county governments can be capacitated to undertake REL using hybrid mini-grids, supported by the national government.

The agencies identified in the SWT sector do not qualify to be called policy entrepreneurs as defined by Kingdon (1984), but we refer to them as quasi-policy entrepreneurs. Their contribution to the wind sector has been more in terms of knowledge rather than lobbying for the inclusion of wind. We therefore conclude that SWT has never had policy entrepreneurs who could argue and lobby, as well as invest their resources, in influencing SWT policy development. This study focused on policy-related factors that have not favoured SWT as a REL technology choice. We recommend further research on non-policy-related factors that affect the CoT, such as sustainability and reliability of the technology.

The results of this study are consistent with those of Wandera et al. (2021), especially the low capabilities in conducting feasibility studies and selection of project sites; limited availability of skilled manpower for diffusing SWT technology; the need to emphasize the development of local technical capacity including their involvement in project development, implementation, operation, and maintenance. This study also validates the findings of a "weak technological innovation system for SWT in Kenya" (Wandera, 2020) constrained by the "functions of knowledge development, guidance of the search, resource mobilization, and market formation" *(ibid).*

This paper recommends that MoEP takes the capacity gaps as a point of departure in addressing existing gaps in SWT policy for REL. Further, greater awareness of the gaps that prevent the coupling of the three policy streams of the MSF during the policymaking process could enhance REL. The key drivers would be the need for a more robust electrification system in Kenya's marginal areas, drawing on both solar and wind; as well as developing the SWT value chain as a complementary tool in the electrification process and the creation of job opportunities.

The insights generated in this paper contribute to the discussion on missed opportunities arising from insufficient attention to specific aspects of technology deployment, for example, the provision of incentives, weaknesses in preconditions for the growth of a technology market and availability of necessary capabilities (Lema & Rabellotti, 2023). The discussion brings out the complexity associated with making choices of technology for REL. Missed opportunities are attributed to weaknesses in pre-conditions and insufficient response to turn opportunity into reality, but this can be corrected through the policymaking process.

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The authors declare that they have no known competing financial interests or personal relationships that could influence the contents of this paper.

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REFERENCES

Adams, S., & Asante, W. (2020). Politics of Renewable Energy in Africa: Nature, Prospects, and Challenges. *Innovation in Global Green Technologies 2020*, 1–15. https://doi.org/10.5772/intechopen.89019

Arnold, G. (2021). Does Entrepreneurship Work? Understanding What Policy Entrepreneurs Do and Whether It Matters. *Policy Studies Journal*, *49*(4), 968–991. https://doi.org/10.1111/psj.12388

Asubiaro, T. V., & Onaolapo, S. (2023). A comparative study of the coverage of African journals in Web of Science, Scopus, and CrossRef. *Journal of the Association for Information Science and Technology*, *74*(7), 745–758. https://doi.org/10.1002/asi.24758

Babayomi, O. O., Olubayo, B., Denwigwe, I. H., Somefun, T. E., Adedoja, O. S., Somefun, C. T., Olukayode, K., & Attah, A. (2023). A review of renewable off-grid mini-grids in Sub-Saharan Africa. *Frontiers in Energy Research*, *10*(January), 1–30. https://doi.org/10.3389/fenrg.2022.1089025

Boamah, F. (2020). Desirable or debatable? Putting Africa's decentralised solar energy futures in context. *Energy Research and Social Science*, *62*(June 2019). https://doi.org/10.1016/j.erss.2019.101390

Boyes, D. (2019). *The Problem with Problematising Rural Electrification*. http://lup.lub.lu.se/student-papers/record/8977907

Boyko, E., Byk, F., Ilyushin, P., Myshkina, L., & Suslov, K. (2023). Methods to improve reliability and operational flexibility by integrating hybrid community mini-grids into power systems. *Energy Reports*, *9*(February), 481–494. https://doi.org/10.1016/j.egyr.2023.06.038

Byrne, R., Mbeva, K., & Ockwell, D. (2018). A political economy of niche-building: Neoliberal-developmental encounters in photovoltaic electrification in Kenya. *Energy Research and Social Science*, *44*, 6–16. https://doi.org/10.1016/j.erss.2018.03.028

Carvallo, J. P., Kelleher, C., & Carter, B. (2016). *Policy Process and Institutional Change For Renewable Energy in Developing Economies : The Case of Chile INTERNATIONAL*. *February*. https://doi.org/10.13140/RG.2.1.3657.7045

Clarke, S. (2018). *Electricity Generation Using Small Wind Turbines for Home or Farm Use*. 1–16. http://www.omafra.gov.on.ca/english/engineer/facts/18-005.pdf

Come Zebra, E. I., van der Windt, H. J., Nhumaio, G., & Faaij, A. P. C. (2021). A review of hybrid renewable energy systems in mini-grids for off-grid electrification in developing countries. *Renewable and Sustainable Energy Reviews*, *144*(July 2020). https://doi.org/10.1016/j.rser.2021.111036

Corfee-Morlot, J. P. J. O. A. (2018). Financing Climate Futures Achieving clean energy access in sub-Saharan Africa. *Journal Paper Citation (0)*.

Energy and Petroleum Regulatory Authority. (2024). *The Kenya Electricity Grid Code Part 2: Kenya National Grid Distribution Code*. *March*.

García Hernández, A. L., & Lucatello, S. (2022). Climate policy integration: taking advantage of policy windows? An analysis of the energy and environment sectors in Mexico (1997–2018). *Journal of Environmental Policy and Planning*, *24*(1), 56–67. https://doi.org/10.1080/1523908X.2021.1940893

George, A., Boxiong, S., Arowo, M., Ndolo, P., Chepsaigutt-Chebet, & Shimmon, J. (2019). Review of solar energy development in Kenya: Opportunities and challenges. *Renewable Energy Focus*, *29*(00), 123–140. https://doi.org/10.1016/j.ref.2019.03.007

Government of Kenya. (2019). The Energy Act No. 1 of 2019. *Kenya Gazette Supplement Acts, 2019*, *29*(29).

Green, D. (2005). *The Politics of Environmental Technology Choice for Rural Electrification in Northern Thailand Author (s): Donna Green Published by : Ashoka Trust for Research in Ecology and the Environment and Wolters Stable URL : https://www.jstor.org/stable/26396579*. *3*(2), 265–279.

Hansen, J. M., & Xydis, G. A. (2020). Rural electrification in Kenya: a useful case for remote areas in sub-Saharan Africa. *Energy Efficiency*, *13*(2), 257–272. https://doi.org/10.1007/s12053-018-9756-z

Hansen, U.E., Gregersen, C., Lema, R., Samoita, D., & Wandera, F. (2018). Technological shape and size: A disaggregated perspective on sectoral innovation systems in renewable electrification pathways. *Energy Research and Social Science*, *42*. https://doi.org/10.1016/j.erss.2018.02.012

Hansen, Ulrich Elmer, Gregersen, C., Wandera, F. H., Kotschenreuther, N., & Hanlin, R. (2021). Centralised and decentralised deployment models. *Building Innovation Capabilities for Sustainable Industrialisation*, 71–87. https://doi.org/10.4324/9781003054665-4

IEA (2023), SDG7: Data and Projections, IEA, Paris https://www.iea.org/reports/sdg7-data-and-projections, Licence: CC BY 4.0

IRENA. (2018). *Policies and Regulations for Renewable Energy Mini-Grids*. https://irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_mini-grid_policies_2018.pdf

Johannsen, R M. (2019). *Hybrid PV and wind mini-grids in Kenya: Barriers and potential for diffusion*. 1–59. https://www.irekproject.net/wp-content/uploads/Hybrid_PV_wind_mini-grids_working_paper_05032019.pdf

Johannsen, Rasmus Magni, Østergaard, P. A., & Hanlin, R. (2020). Hybrid photovoltaic and wind mini-grids in Kenya: Techno-economic assessment and barriers to diffusion. *Energy for Sustainable Development*, *54*(2020), 111–126. https://doi.org/10.1016/j.esd.2019.11.002

Kenya National Bureau of Statistics. (2023). *Economic Survey 2023*. https://www.knbs.or.ke/download/economic-survey-2023/

Khon, K., Chhlonh, C., Vai, V., Alvarez-Herault, M. C., Raison, B., & Bun, L. (2023). Comprehensive Low Voltage Microgrid Planning Methodology for Rural Electrification. *Sustainability (Switzerland)*, *15*(3). https://doi.org/10.3390/su15032841

Kinally, C., Antonanzas-Torres, F., Podd, F., & Gallego-Schmid, A. (2022). Off-grid solar waste in sub-Saharan Africa: Market dynamics, barriers to sustainability, and circular economy solutions. *Energy for Sustainable Development*, *70*, 415–429. https://doi.org/10.1016/j.esd.2022.08.014

Kingdon, J. (1984). *Agendas, alternatives, and public policies, 2* (pp. 1–19).

Lahimer, A. A., Alghoul, M. A., Yousif, F., Razykov, T. M., Amin, N., & Sopian, K. (2013). Research and development aspects on decentralized electrification options for rural household. *Renewable and Sustainable Energy Reviews*, *24*, 314–324. https://doi.org/10.1016/j.rser.2013.03.057

Leary, J., Czyrnek-Delêtre, M., Alsop, A., Eales, A., Marandin, L., Org, M., Craig, M., Ortiz, W., Casillas, C., Persson, J., Dienst, C., Brown, E., While, A., Cloke, J., & Latoufis, K. (2020). Finding the niche: A review of market assessment methodologies for rural electrification with small scale wind power. *Renewable and Sustainable Energy Reviews*, *133*(March). https://doi.org/10.1016/j.rser.2020.110240

Leary, J., To, L. S., Alsop, A., Latoufis, K., van Dam, E., Rivas, J., Troullaki, K., Pleitavino, G., Schaube, P., & Odongo, F. W. (2018). *Is there still a role for small wind in rural electrification programmes? LCEDN Briefing Paper 2*, 1–17. www.lcedn.com

Lee, K., Miguel, E., & Wolfram, C. (2020). Experimental evidence on the economics of rural electrification. In *Journal of Political Economy* (Vol. 128, Issue 4). https://doi.org/10.1086/705417

Lee, K., Miguel, E., & Wolfram, C. (2016). Appliance ownership and aspirations among electric grid and home solar households in rural Kenya. *American Economic Review*, *106*(5). https://doi.org/10.1257/aer.p20161097

Lema, R., Andersen, M. H., Hanlin, R., & Nzila, C. (2022). *Building Innovation Capabilities for Sustainable Industrialisation: Renewable Electrification in Developing Economies* (R. H. and C. N. Rasmus Lema, Margrethe Holm Andersen (ed.); First). Routledge.

Lema, R., & Rabellotti, R. (2023). Green Windows of Opportunity in the Global South. *UNCTAD Background Paper, March*. https://unctad.org/system/files/non-official-document/tir2023_background2_en.pdf

Leonard, A., Wheeler, S., & Mcculloch, M. (2021). *Rapid Electrification in Kenya: Progress, challenges, and practical geospatial solutions*. *2018*, 0–4.

Lomax, J., Osborne, M., Aminga, V., Mirumachi, N., & Johnson, O. (2021). Casual pathways in the political economy of climate adaptation: Winners and losers in Turkana, Kenya solar mini-grid projects. *Energy Research and Social Science*, *82*, 102296. https://doi.org/10.1016/j.erss.2021.102296

Mackey, T. K. (2019). Opening the policy window to mobilize action against corruption in the health sector: Comment on “We need to talk about corruption in health systems.” *International Journal of Health Policy and Management*, *8*(11), 668–671. https://doi.org/10.15171/ijhpm.2019.65

Mahapatra, S., & Dasappa, S. (2012). Rural electrification: Optimising the choice between decentralised renewable energy sources and grid extension. *Energy for Sustainable Development*, *16*(2), 146–154. https://doi.org/10.1016/j.esd.2012.01.006

Maqelepo, L., Williams, N., & Taneja, J. (2022). Rural electrification subsidy estimation: a spatial model development and case study. *Environmental Research: Infrastructure and Sustainability*, *2*(4), 045009. https://doi.org/10.1088/2634-4505/ac9711

Ministry of Energy. (2009). *REM_FinRep_Vol1*.

Ministry of Energy. (2018). Republic of Kenya National Energy Policy. *National Energy Policy*, 16–103.

Ministry of Energy and Petroleum. (2013). *5000+ MW by 2016: Power to Transform*. https://doi.org/10.1093/oso/9780192869395.003.0010

Ministry of Energy and Petroleum. (2023). *Strategic Plan 2023-2027*. *2443*, 2443.

Ministry of Energy Kenya. (2018). *Kenya National Electrification Strategy: Key Highlights 2018*.

Moner-Girona, M., Bódis, K., Morrissey, J., Kougias, I., Hankins, M., Huld, T., & Szabó, S. (2019). Decentralized rural electrification in Kenya: Speeding up universal energy access. *Energy for Sustainable Development*, *52*, 128–146. https://doi.org/10.1016/j.esd.2019.07.009

Muchiri, K., Kamau, J. N., Wekesa, D. W., Saoke, C. O., Mutuku, J. N., & Gathua, J. K. (2023). Wind and solar resource complementarity and its viability in wind/PV hybrid energy systems in Machakos, Kenya. *Scientific African*, *20*. https://doi.org/10.1016/j.sciaf.2023.e01599

Newell, P., & Phillips, J. (2016). Neoliberal energy transitions in the South: Kenyan experiences. *Geoforum*, *74*, 39–48. https://doi.org/10.1016/j.geoforum.2016.05.009

Njogu, H. W. (2021). Effects of floods on infrastructure users in Kenya. *Journal of Flood Risk Management*, *14*(4), 1–10. https://doi.org/10.1111/jfr3.12746

Nowlin, M. C. (2011). Theories of the Policy Process: State of the Research and Emerging Trends. *Policy Studies Journal*, *39*(SUPPL. 1), 41–60. https://doi.org/10.1111/j.1541-0072.2010.00389_4.x

Nygaard, I., Gichungi, H., Larsen, T. H., Pedersen, M. B., Cronin, T., Davis, N., Chitechi, E., Kago, E., & Højgaard, J. W. (2018). *Market for the integration of smaller wind turbines in mini-grids in Kenya.* (Issue October).

Ockwell, D., Newell, P., & Geall, S. (2017). *STEPS the Political Economy of State-Led Energy Transformation Kenya and China*.

Ogeya, M. C., Osano, P., Kingiri, A., & Okemwa, J. M. (2021). Challenges and opportunities for the expansion of renewable electrification in Kenya. *Building Innovation Capabilities for Sustainable Industrialisation*, *2030*, 46–70. https://doi.org/10.4324/9781003054665-3

Omole, F. O., Olajiga, O. K., & Olatunde, T. M. (2024). *CHALLENGES AND SUCCESSES IN RURAL ELECTRIFICATION : A REVIEW OF GLOBAL POLICIES AND CASE STUDIES*. *5*(3), 1031–1046. https://doi.org/10.51594/estj/v5i3.956

Petridou, E. (2014). Theories of the policy process: Contemporary scholarship and future directions. *Policy Studies Journal*, *42*(S1), 12–32. https://doi.org/10.1111/psj.12054

Rahman, M. M. (2014). *Accomplishing rural electrification for over a billion people: Approaches towards sustainable solutions* (Vol. 53).

Rahman, M. M., Paatero, J. V., & Lahdelma, R. (2013). Evaluation of choices for sustainable rural electrification in developing countries: A multicriteria approach. *Energy Policy*, *59*, 589–599. https://doi.org/10.1016/j.enpol.2013.04.017

Republic of Kenya. (2010). Constitution of Kenya. *National Council for Law Reporting*, *February*, 191. http://www.parliament.go.ke/sites/default/files/2017-05/The_Constitution_of_Kenya_2010.pdf

Republic of Kenya. (2016). *Sustainable Energy for All Action Agenda*.

Republic of Kenya. (2018). Updated Least Cost Power Development Plan Study Period 2017-2037. In *Least Cost Power Development Plan 2017-3027* (Issue June). http://gak.co.ke/wp-content/uploads/2019/02/Updated-Least-Cost-Power-Development-Plan-2017-2022-min.pdf

Republic of Kenya. (2024). *Fourth Medium Term Plan 2023-2027*.

Ridde, V. (2009). Policy implementation in an African state: An extension of Kingdon's multiple-streams approach. *Public Administration*, *87*(4), 938–954. https://doi.org/10.1111/j.1467-9299.2009.01792.x

Rothfuß, E., & Boamah, F. (2020). Politics and (Self)-organisation of electricity system transitions in a global north-south perspective. *Politics and Governance*, *8*(3), 162–172. https://doi.org/10.17645/pag.v8i3.3636

Sabatier, P. A. (1991). Toward Better Theories of the Policy Process. *Political Science and Politics*, *24*(2), 147–156.

Samoita, D., Nzila, C., Østergaard, P. A., & Remmen, A. (2020). Barriers and solutions for increasing the integration of solar photovoltaic in Kenya's electricity mix. *Energies*, *13*(20). https://doi.org/10.3390/en13205502

Schannauer, A. C. (1979). *Lifeline Electric Rates : Are They Unreasonably Discriminatory Lifeline Electric Rates : Are They Unreasonably Discriminatory ? 83*(3), 1978–1979.

Sieff, R. (2020). *Decentralised energy governance in the global south: the case of Kenya since the implementation of devolution*. Loughborough University.

Sumanik-leary, J. (2013). *Small wind turbines for decentralised rural electrification : case studies in Peru, Nicaragua and Scotland*. *November*.

Technical University of Denmark. (2023). Global Wind Atlas - Mean Wind Speed at 100m over Turkey. *Global Wind Atlas*, 100. https://globalwindatlas.info

Tezer, T., Yaman, R., & Yaman, G. (2017). Evaluation of approaches used for optimization of stand-alone hybrid renewable energy systems. *Renewable and Sustainable Energy Reviews*, *73*(December 2016), 840–853. https://doi.org/10.1016/j.rser.2017.01.118

Torres-Madroñero, J. L., Alvarez-Montoya, J., Restrepo-Montoya, D., Tamayo-Avendaño, J. M., Nieto-Londoño, C., & Sierra-Pérez, J. (2020). Technological and operational aspects that limit small wind turbines' performance. *Energies*, *13*(22), 1–39. https://doi.org/10.3390/en13226123

Van Treuren, K. W. (2016). Small horizontal axis wind turbines: Current status and future challenges. *Proceedings of the ASME Turbo Expo*, *9*, 1–12. https://doi.org/10.1115/GT2016-57701

Volkert, M., & Klagge, B. (2022). Electrification and devolution in Kenya: Opportunities and challenges. *Energy for Sustainable Development*, *71*, 541–553. https://doi.org/10.1016/j.esd.2022.10.022

Wandera, F. H, Andersen, M. H., & Lema, R. (2021). Learning from global suppliers: The Diffusion of Small Wind in Low- and Middle-Income Countries. *International Journal of Technological Learning, Innovation and Development*, *13*(1), 24–49.

Wandera, Faith H. (2021). Understanding the diffusion of small wind turbines in Kenya. In *Building Innovation Capabilities for Sustainable Industrialisation* (pp. 88–110). https://doi.org/10.4324/9781003054665-5

Wandera, Faith Hamala. (2020). The innovation system for diffusion of small wind in Kenya: Strong, weak or absent? A technological innovation system analysis. *AJSTID*. https://doi.org/https://doi.org/10.1080/20421338.2020.1771979

Yusuf, J. E. (Wie), Neill, K., John, B. S., Ash, I. K., & Mahar, K. (2016). The sea is rising… but not onto the policy agenda: A multiple streams approach to understanding sea level rise policies. *Environment and Planning C: Government and Policy*, *34*(2), 228–243. https://doi.org/10.1177/0263774X15614457

Zalengera, C., To, L. S., Sieff, R., Mohr, A., Eales, A., Cloke, J., Buckland, H., Brown, E., Blanchard, R., & 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

Zimmer, A., Jakob, M., & Steckel, J. (2010). *– An explorative case study on the drivers of climate policy*. *1995*, 1–37.

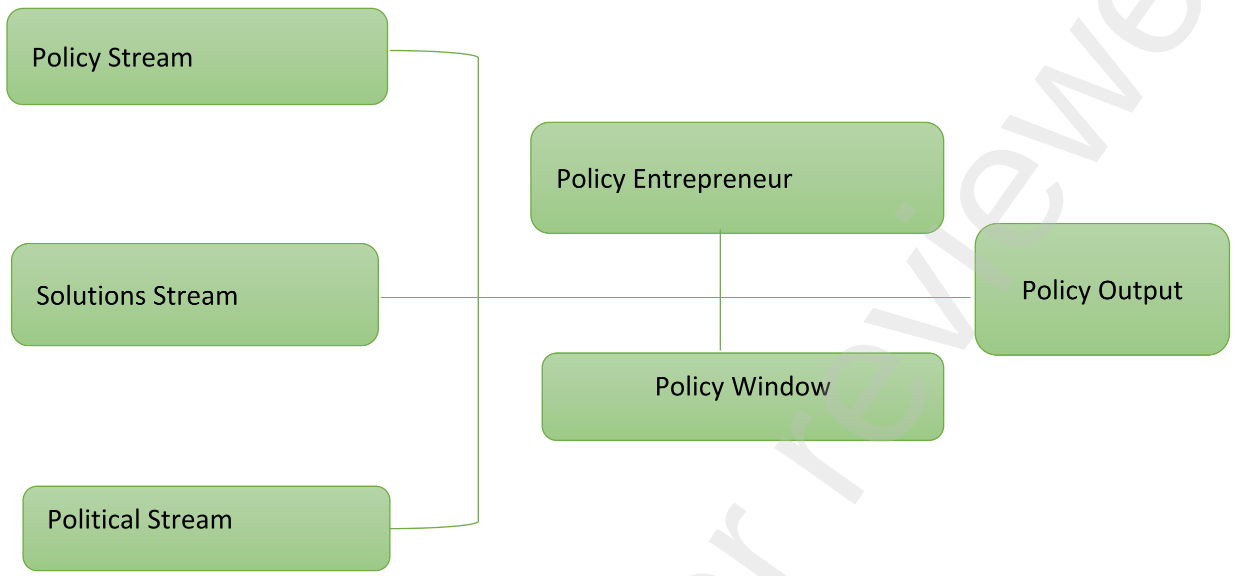

Figure 1 Conceptual Framework- Based on the MSF (Adams & Asante, 2020)

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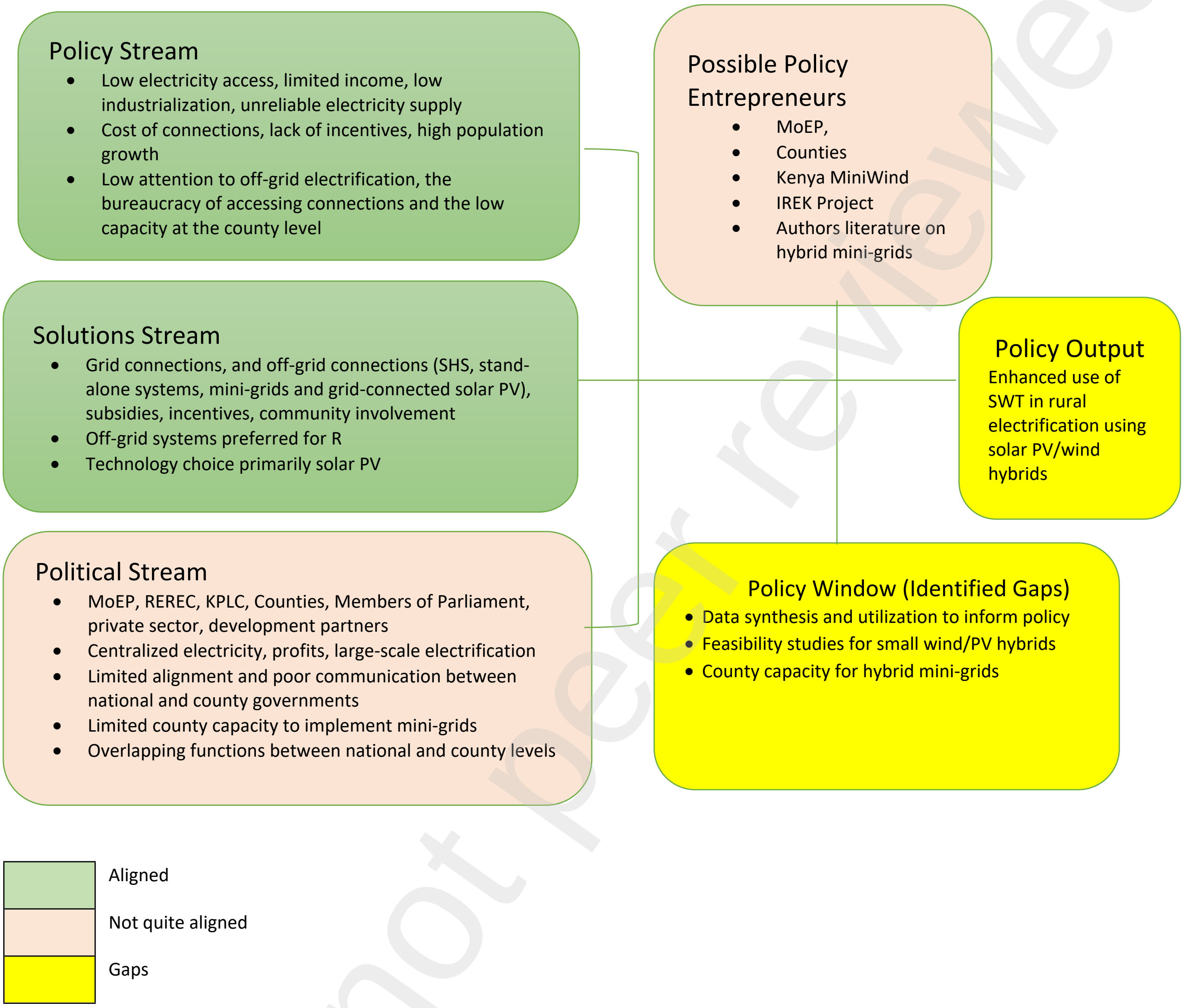

Figure 2: Analysis using the MSF (Authors' own, modified based on Adams & Asante, 2020)