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ARTICLE

Independence through leapfrogging: Energy transitions in Eswatini

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Abstract

The need to swiftly transition to clean energy and expand electricity access is pressing; however, the goals of SDG7 are unlikely to be met by 2030, with the UN specifically mentioning land-locked states as being off track. Through the conceptual lens of 'leapfrogging' fossil fuels, straight from traditional fuel sources to renewable energy, this paper discusses the relationship between electricity production and independence. It makes a conceptual contribution by introducing the term 'energy independence through leapfrogging', which is used to characterise the process of reducing dependency on another country – in the case of Eswatini, electricity is supplied by South Africa. Drawing from empirical research in Eswatini involving document analysis and in-depth interviews, this paper discusses the potential for the country to move from being primarily an importer of electricity to generating its own supply from renewable sources. With Eswatini's current electricity supply from South Africa at risk/expiring in 2025, this research argues that the country faces a moment of opportunity for Eswatini to build further generation capacity, with a recommended focus on solar energy. The paper identifies potential challenges/barriers to this energy transition, examining power generation, storage, maintenance and affordability as key areas for intervention. Drawing on previous theories of electricity access, the paper argues that 'access' to electricity requires consideration of the affordability and reliability of energy systems. Eswatini is an understudied geographical area, and this paper makes a contribution to the literature on energy transitions by examining the specific circumstances attending this transition and examining these with relevance for other land-locked nations in sub-Saharan Africa.

KEYWORDS

development geography, energy transitions, Eswatini, Global South, leapfrogging, renewables

1 | INTRODUCTION

Sustainable Development Goal (SDG) 7 calls for universal access to affordable, reliable and clean energy (UN, 2015). According to the UN (2022) progress review, the world is off track with reaching this goal, with landlocked Global South countries particularly lagging behind in terms of energy access (UN, 2022), implying that specific interventions are required to enable landlocked nations to achieve SDG7. 733 million people worldwide are without an official electricity connection, with three-quarters living in sub-Saharan Africa (UN, 2022). This paper examines electricity access in the Kingdom of Eswatini (formerly Swaziland), a small landlocked nation that is largely dependent on fossil fuel-based energy imports from South Africa. Eswatini derives 80% of its electricity supply from neighbouring South Africa and approximately 10% from Mozambique (Government of Eswatini, 2018), with which it also shares a border (see Figure 1). As the contract of supply between South Africa's national energy utility, ESKOM, and the Eswatini Electricity Company is due to expire in 2025, there is a moment of both crisis and opportunity in the national energy landscape, triggering a potential paradigm shift from the current pathway of supply (see Bailey & Wilson, 2009).

Eswatini is at a particular moment in history in which it is poised to both generate its own electricity and expand its coverage across the population, from a current strong position of 85% of households with access to the electricity grid (EEC, 2022). This moment is precipitating a transition from Eswatini being an importer of electricity to becoming a significant producer. As the country does not have to shift from the legacy of coal-fired power stations, it has distinct potential to move from more traditional sources of energy straight to renewable energy technology, thereby leapfrogging the use of fossil fuels (Murphy, 2001). The growing demand for fossil fuels in sub-Saharan Africa, along with financing for these projects, has been used to critique the implementation of leapfrogging (Alova et al., 2021), and in Ghana, Günel (2021) found that only a wealthy few were able to afford to leapfrog to distributed solar power. Nevertheless, the concept of leapfrogging has not only endured but has also been extended to a range of contexts. Some states may leapfrog centralised grid infrastructure altogether, straight to distributed energy systems (Levin & Thomas, 2016). Further, the concept has been applied to 'lifestyle leapfrogging' in which it is hoped that the growing consumer class in countries such as China and India will leapfrog Western-style hyper-consumption straight to sustainable lifestyles (Schroeder & Anatharaman, 2017).

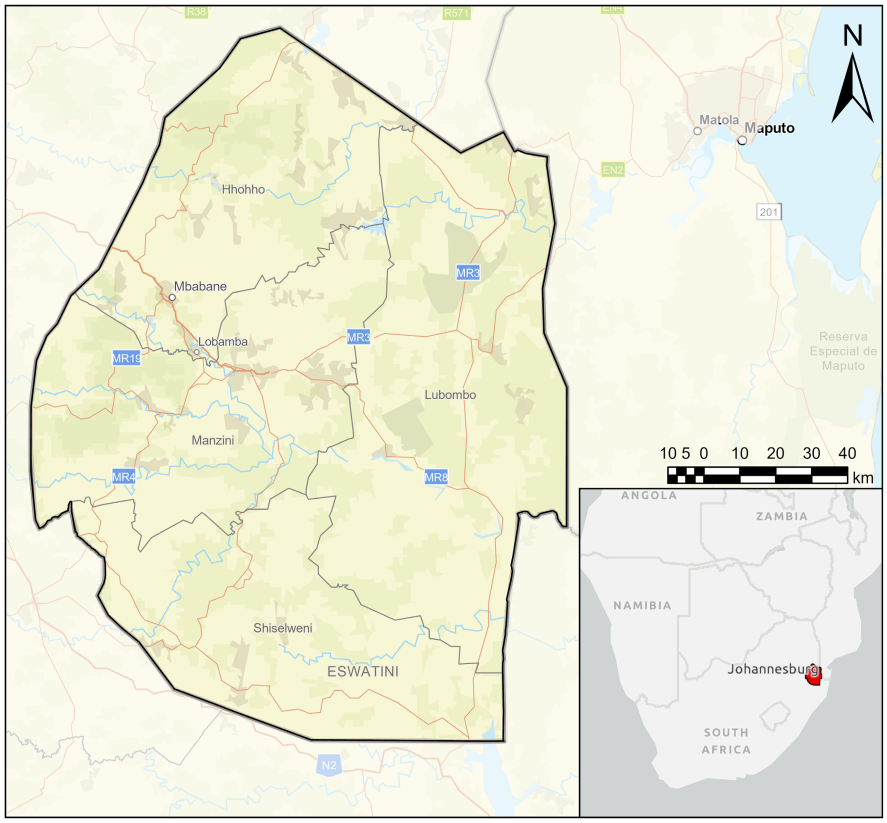

FIGURE 1 Map of Eswatini. *Source*: Esri, TomTom, Garmin, FAO, NOAA, USGS. Credit: Kate Newby.

In this paper, the metaphor of leapfrogging is extended to the concepts of energy independence and security. This paper contributes to the literature on energy transitions by examining the process in Eswatini and introducing the concept of 'energy independence through leapfrogging' to characterise this transition. Through a combination of documentary and qualitative interview analysis, this paper uses the case of Eswatini to examine the idea of leapfrogging to renewable energy technologies. It argues that Eswatini is undergoing a moment of crisis and opportunity, which is enabling a swift transition to renewable energy generation. Eswatini faces both internal and external pressures that are contributing to this crisis. As the internal demands for electricity increase, there are significant concerns about the affordability and reliability of supply from South Africa. These pressures have propelled a renewed focus on electricity generation for the country towards a renewable energy-dominated system. As Eswatini is working on the supply of electricity from renewable sources, it stands as a relevant case study for energy transitions and leapfrogging from traditional fuels to renewable electricity. It also offers insight into the possibilities for some nations to rapidly attain greater energy security while also developing energy systems that will support climate change mitigation. Though this research is based in a specific country context, findings can be applied to a range of countries across sub-Saharan Africa working towards generating electricity and transitioning to renewable energy, with particular relevance for land-locked states.

Eswatini, as a small predominantly rural and semi-urban country, can be seen as representing a bounded experimental zone. Schot and Geels (2008) advocate promoting niche areas for sustainable development, testing out technology in specific geographic areas that may become important for achieving collective and societal goals in the future. Geographically bounded areas of experimentation 'provide a situated and real-world evidence base for how a low-carbon world could be realised' (Karvonen, 2018, p. 201). In this way, the analysis of Eswatini at this particular moment in time has the potential to offer important insights into transition processes that are relevant for understanding how low-carbon worlds might be realised more broadly. Whilst there is a significant body of literature on energy in South Africa (Baker et al., 2014; Baker & Phillips, 2019; Caprotti et al., 2020), Eswatini is an understudied geographical area, and this paper contributes towards filling that gap, adding to the understanding of renewable energy transitions within countries that currently have limited internal electricity generation capacity.

The article begins by examining the wider literature on energy transitions and leapfrogging before moving on to look at the specific energy context in Eswatini. The case study of Eswatini is presented along with an overview of the methodology. This is followed by the core analysis and discussion of the findings.

2 | ENERGY TRANSITIONS

This section discusses the literature on energy transitions with specific reference to sub-Saharan Africa. Section 2.1 outlines the socio-technical aspects of transitioning to renewable energy, discusses the role that energy plays in improving people's lives and outlines the context of energy supply from South Africa to Eswatini. Section 2.2 discusses the concept of electricity access, moving beyond a physical connection to consider affordability and reliability. Section 2.3 discusses off-grid options, including mini-grids and solar home systems.

2.1 | Socio-technical transitions and leapfrogging to renewables

Leapfrogging contains an implicit promise of bringing modern energy to people quickly and with less environmental impact (Murphy, 2001). However, the idea of technological leaps has been critiqued in the literature for a number of reasons. For example, the absorption of new technology can take time, especially at the household level (Murphy, 2001). Electricity networks are socio-technical systems involving humans, social norms and values, economic conditions and political landscapes (Geels, 2002), meaning sustainable energy transitions need to consider both the socio-technical and the justice aspects (Sareen & Haarstad, 2018). The underlying political economy of transitions also requires attention, as in the South African case, state and corporate powers can block change in order to favour their political allies and largest donors (Baker et al., 2014). Energy transitions cannot be achieved without support from social, cultural, political, and economic institutions (Murphy, 2001), including the private sector.

Demand for energy is set to grow rapidly across sub-Saharan Africa during the current decade (International Energy Agency, 2023). The value of electricity for improving people's quality of life can hardly be overestimated. Behind the goal of connecting people to electricity lies the social goal of creating an impact by improving people's lives (Pedersen,

Wehrmeyer & Nygaard, 2020). Electricity is a crucial factor for a range of modern services such as lighting, information and communication technologies, and cooking (Ulsrud et al., 2015). Lighting has been shown to allow for increased productivity in the evenings, including studying, food preparation, washing, reading, socialising and entertainment (Bisaga & Parikh, 2018). Mobile phone charging can allow access to the internet and connectivity to a range of vital services, while using electricity for cooking greatly reduces the risks to health associated with using wood fuels (Caprotti et al., 2020).

Multiple studies show the wider significance of electricity access for improving a wide range of aspects of human wellbeing through supporting services. For example, in rural Tanzania, Mottram (2022) shows how electricity is used by households for lighting, phone charging, and entertainment appliances, with important implications for access to education and employment. In household interviews in Malawi, the main desire for electricity was to end darkness, followed by access to mobile phone charging and appliances such as radios and television (Samarakoon et al., 2021). In rural Rwanda, a key positive effect of electrification was an increase in labour productivity, leading to higher income (Adom & Nsabimana, 2022). Beyond domestic and personal uses, research also highlights the importance of electricity for businesses, with opportunities for extending opening hours using lighting as well as powering appliances such as fridges (Mottram, 2022). A wide-ranging body of existing research thus highlights the central significance of energy for improving quality of life.

The International Energy Agency predicts that energy demand in sub-Saharan Africa will grow by 80% by 2040, based on population growth and increased urbanisation (IEA, 2014, cited in Newell & Bulkeley, 2017). This may well be met by an increased use of fossil fuels unless incentives are put in place to promote renewables (ibid.). In some cases, including South Africa, the state seeks to manage change in a way that favours the incumbent fossil fuel providers (Newell & Bulkeley, 2017). South Africa is the largest source of greenhouse gas emissions in Africa (Baker et al., 2014). The economy relies heavily on energy-intensive resource extraction, with vested interests in keeping incumbent industries in place (ibid.).

Eswatini imports the majority of its electricity from South Africa, so is currently unable to contribute meaningfully towards the transition away from fossil fuels, as South African electricity is mostly generated from coal. South Africa has been slow to embrace energy alternatives and is more reactive to crises of energy supply and demand (Baker et al., 2014). Energy systems are embedded in space in terms of infrastructure, requiring engineers with the capability of maintaining the grid, which affects how energy transitions are implemented and presents challenges for different countries both in transitioning to new systems and creating new ones (Baptista, 2018). However, sub-Saharan Africa is seeing a significant increase in investment in energy projects that tackle energy poverty and the climate crisis, meaning there is also opportunity to develop these skills and create new infrastructure (Baptista, 2018). As the contract for supply from South Africa to Eswatini is up for renewal in 2025 and South Africa faces its own energy crisis, Eswatini is now facing a potential supply crisis. This particular circumstance makes it well-positioned to leapfrog fossil fuels and develop renewable energy plants to support its increasing energy needs.

Large, centrally controlled energy systems can be entangled in injustices, with distributed systems such as solar offering greater affordability compared to fossil fuels (Nordholm & Sareen, 2021). This is discussed further in Section 2.3. Landlocked countries and island states can also face higher costs due to the need to transport fossil fuels to them (Sokona et al., 2012). This provides a key opportunity for Eswatini to change the dynamics of its place within the Southern African Development Community (a regional economic entity). Eswatini is currently an importer of energy but seeks to generate its own and eventually export to the SADC (Eswatini Electricity Company (EEC), 2022). However, given that transitioning to renewables goes beyond the physical infrastructure to include geopolitics and national development (Nordholm & Sareen, 2021), these possibilities are also constrained by the actions and competing goals of others.

2.2 | The relationship between electricity access and transitions

Central to energy transitions in sub-Saharan Africa and the concept of leapfrogging are debates about access. Electricity access is defined by the UN as the presence of a direct supply of electricity and consumption above a minimum threshold of 250 kilowatt-hours per year in rural settings and 500 kWh per year in urban settings (UN, in Munro & Schiffer, 2019). Access to electricity is one of the indicators of sustainable development due to the important role that electricity plays in modern society (Dlamini & Dlamini, 2021). However, 'access' is a contested term. The 733 million described by the International Energy Agency as 'without access' may in fact have a differential range of access, including phone charging pay points, small home solar systems, batteries, kerosene lamps, and diesel generators (Munro, 2020). Access can be seen

as a dynamic social process rather than a static developmental state (Munro & Bartlett, 2019). Two key mechanisms of access discussed in the literature are reliability and affordability.

Firstly, a large number of those counted as having access to electricity also have unreliable and poorly functioning power supplies (Angelou et al., 2013 in Ulsrud, 2020). There are millions of people in sub-Saharan Africa who are poorly served by the existing electricity grid, which frequently fails to support reliable access due to processes such as load-shedding (planned electricity supply interruptions when demand cannot be met) and technical issues, often related to old and poorly maintained infrastructure (Rateau & Choplin, 2022). Therefore, the statistics on infrastructural access may only give us a partial picture. This is reflected in SDG7, which recognises the importance of reliability of electricity supply as part of access, rather than just the initial connection taking place (Farquharson et al., 2018). Strategies to address issues with reliability can also be costly. In many cases across sub-Saharan Africa, blackouts mean that backup diesel generators are used (ibid.). The cost of these generators can be three times as high as standard electricity production and much more damaging to health and the environment, with emissions from the backup generators exceeding emissions from primary electricity production in some cases (ibid.). Enabling a transition to renewable energy generation in Eswatini may therefore offer greater reliability of supply compared to relying on South Africa's struggling electricity network.

Electricity in South Africa is provided by the state-owned ESKOM, which is now widely seen to be corrupt and inefficient (Baker & Phillips, 2019). Load-shedding first hit South Africa in 2008, and households and businesses have struggled ever since (Ateba et al., 2019). In addition to the widespread corruption and mismanagement of ESKOM (Donovan, 2023), one of the many challenges to provision is the large number of illegal connections to the grid, often from townships or illegal settlements. This costs an estimated $1.4 billion per year and increases the incidence of electrocutions as well as power outages (Baker & Phillips, 2019). In 2022, a national state of disaster was declared in South Africa in response to a doubling of blackouts from the previous year (Donovan, 2023). In order to keep up with rising demand, ESKOM needs to generate significantly more electricity capacity (Amusa et al., 2009), partly owing to limitations for large-scale electricity storage, which means supply and demand need to be fairly well matched (Ateba et al., 2019). Reliance on the now widely documented failing South African system is thus increasingly recognised as unsustainable for multiple reasons.

Secondly, once an electricity connection is established, affordability amongst the poor remains a critical issue. At the household level, having access to some energy is not always the same as having sufficient access to energy (Schiffer, 2020). The IEA (2017, in Schiffer, 2020, p. 74) suggests that 'initial access to sufficient electricity to power a basic bundle of energy services' includes 'at a minimum, several lightbulbs, task lighting (such as a flashlight), phone charging and a radio'. Schiffer (2020) research in the Gambia suggests that 'sufficient access' moves beyond this limited description above to include people's aspirations to 'watch television, use fans to keep cool during the rainy season, upgrade to household gadgets such as electric irons and kettles or run fridges for the purpose of small entrepreneurial enterprises' (Schiffer, 2020, pp. 75–76). This means that interpreting and characterising what counts as 'sufficient' is not straightforward and difficult to capture with measures that prioritise infrastructural access.

Self-rationing and self-disconnection also need to be understood as part of 'access' in infrastructural provision (Butler, 2022). In Tanzania, rural households routinely disconnect their power supply as they cannot afford the fixed monthly charges when their income is seasonal (Mottram, 2022). Eswatini does not offer a free allocation of electricity to its citizens, meaning that income poverty remains a barrier to electricity access. In South Africa, 47% of the population are described as 'energy poor' despite 87% being connected to the grid (Caprotti et al., 2020). The South African government does offer each citizen a 'free' allocation of electricity each month (Simpson, 2021). However, many households are still using mixed fuels such as paraffin, coal and wood. This increases the incidence of air pollution, respiratory illnesses and shack fires (Caprotti et al., 2020). Contrary to the suggestion that households move from these fuels to cleaner technologies as their income increases, research on energy stacking has demonstrated that households tend to stack fuels by using a mixture of firewood, charcoal and electricity (Munro & Bartlett, 2019) and that this should be considered as part of a definition of energy access (Bhatia & Angelou, 2015). There is, therefore, a distinction to be made between access to energy supply, access to energy services and the actual use of energy (ibid.).

The mechanism of affordability is critical to the discussion of energy poverty, as looking solely through the lens of energy infrastructure makes existing inequalities likely to persist (Nordholm & Sareen, 2021). This means that advancing the well-being of energy-poor populations requires more than access to energy services; it involves attending to the structural issues of justice that are entangled in energy systems (Samarakoon, 2020). However, despite the recognition in the literature that social aspects of energy transitions are critical, in practice, there is an underlying assumption that providing electrification across Africa is an unfinished modernist project (Munro, 2020). Currently, USAID is coordinating a continental electrification programme under the flagship 'Power Africa' (USAID, 2021). It focuses on expanding the network

of connections across Africa, including electricity generation, grid extension and off-grid solutions (USAID, 2021). This framing has been used to justify neoliberal reforms, such as the privatisation of energy utilities, in order to solve the problem of energy (Munro & Bartlett, 2019). Schiffer (2020) critiques rural electrification programmes for being dominated by techno-centric approaches and top-down decision-making, which fail to account for local conditions and social mechanisms such as those discussed here relating to affordability and access. Murphy (2001) argues that leapfrogging in East Africa is unlikely to be successful without support from a range of socio-economic factors. This paper contributes to this debate by critically analysing the socio-technical and political nature of a renewable energy transition and the concept of leapfrogging.

2.3 | Off-grid energy transitions

In light of the failures discussed above in providing suitable access to electricity in the Global South, the formal grid has been critiqued as a Western modernist ideal that has proven to be ill-suited to cities in the Global South (Essex & de Groot, 2019). Off-grid solutions are generally framed as a good opportunity to provide power to the large number of rural Africans who live in scattered homesteads rather than concentrated villages (Sokona et al., 2012). An off-grid solar market has grown rapidly across the Global South, comprising largely small solar home systems and lanterns (Munro & Samarakoon, 2022). According to Munro and Samarakoon (2022), these were typically framed as a solution to rural energy poverty, as the name 'off-grid' suggests, but are being increasingly used in urban settings. An estimated 130 million solar devices have been sold across sub-Saharan Africa between 2010 and 2019 (Samarakoon, 2020).

The proliferation of these small, home solar systems is typically characterised as positive, but is framed differently by some analysts. For example, Samarakoon et al. (2021) argue that while they offer respite to the energy poor, they do not represent a sustainable long-term solution due to the reproduction of energy injustices. One key challenge that has been highlighted concerns the consequences of this rise in home solar systems for responsibilities related to electricity provisioning. Samarakoon (2020) notes how it can lead to a shift from the state being responsible for providing electricity to individual vulnerable people being responsible for their own electricity provision. Off-grid solar markets have shifted electricity from being a public good to being a private good, thus generating further injustices (ibid.). Munro and Samarakoon (2022) identify off-grid urban and unreliable grid urban populations as key target markets for companies selling home solar products. These citizens are framed as 'consumers' (ibid.). In this way, small home solar systems can be characterised as solving the technical challenges, but they do not solve the social and justice issues. This has led many to conclude that these two challenges, the technical and the social, should be considered together.

In the urban setting of Cape Town, solar mini-grids were installed in an informal urban settlement that was unlikely to receive a formal grid connection due to its positioning on wetlands (Bobbins et al., 2022). However, whilst some of the residents can choose to pay for an electricity supply, this arrangement does not give them access to the free basic allocation of electricity offered by the South African state (Cantoni, Caprotti & de Groot, 2022), once again demonstrating that a technical solution needs to interact with social and political conditions to enact justice. South Africa recognises the rights of informal settlement dwellers to access free basic electricity, but realising this goal is challenging. In the settlement of Enkanini, Stellanbosch, the social enterprise 'iShack' has been able to bridge this provision gap (Conway et al., 2019). Small home solar kits have been provided via grant funding to residents in the Enkanini informal settlement, and through links with the municipal government, the free basic allowance can now be accessed (ibid.). However, Conway et al. (2019) are clear that there is no capital cost recovery in this programme, and investment was only possible with grant funding.

Centralised electrification was previously the norm for nations seeking improved electricity access (Levin & Thomas, 2016). As the costs of distributed technologies such as rooftop solar, wind turbines and energy storage have reduced, the economic circumstances are changing (ibid.). In this context, as well as leapfrogging fossil fuels, nations have the possibility of leapfrogging the stage of centralised grid infrastructure, straight to distributed systems (ibid.). However, in light of the discussion here, the social and justice aspects of these need to be carefully considered. This paper is largely concerned with Eswatini's capacity to move from limited power generation to significant generation from renewables, thus leapfrogging fossil fuels. This paper introduces the term 'independence through energy leapfrogging' as a way to describe the political process of energy transition for Eswatini and the possibilities for disentangling from South Africa's energy network through a national renewable energy system.

3 | THE ENERGY CONTEXT IN ESWATINI

Eswatini is a relevant case study as a land-locked nation with the potential to leapfrog fossil fuels to renewables, as it negotiates the process of generating its own electricity. The government of Eswatini has set the ambitious target of providing electricity to all households in the country by 2030 and generating renewable energy for 50% of that provision (UNDP and Government of Swaziland, 2018). Progress has been rapid, moving from 65% of households in 2018 connected to an electricity supply (UNDP and Government of Swaziland, 2018) to 85% of the population by the end of 2022 (EEC, 2022). Dlamini and Dlamini (2021) found that the urban corridor of the Manzini-Mbabane city areas had the highest levels of electricity usage, with usage declining with distance towards rural areas. The UNDP is investing $25.9 million between 2018 and 2024 to bring about electrification through generating renewable energy in Eswatini (UNDP and Government of Swaziland, 2018). Solar is seen to be the optimal solution for renewable energy compared to wind and hydroelectric power (Mashwama & Shongwe, 2020). New solar power plants are being installed in Eswatini, including a 10-MW plant opened in 2021 (Nxumalo, 2022) and a planned 100 MW in the next few years. Home solar power usage is very low, with an estimated 0.19% of households using home solar systems (Dlamini & Dlamini, 2021).

The UNDP and Government of Swaziland (2018) argues that the majority of people live within 1 km of the existing grid network, so extending the grid should be the main strategy in pursuing electrification. Between 2012 and 2017, an average of 41,000 people were connected to the grid annually in Eswatini. This was made possible by funding from Taiwan, China and the EU (UNDP, 2021). Nonetheless, the challenges of the 'last mile' are present in Eswatini, where there is a centralised grid infrastructure, but some rural communities are not yet connected, and there is a high cost to connecting them (see Tomei, 2019). In their 2020 report, the UN concludes that it may also be necessary to fund off-grid systems in areas where grid extension is not expected in the foreseeable future due to high capital costs. This would include mini-grids and solar home systems (UNDP, 2021).

At present, the majority of Eswatini's electricity supply is imported from South Africa (ADB, 2020), of which 90% comes from coal-fired power plants (Baker & Phillips, 2019). Eswatini has four hydroelectric power plants (Eswatini Electricity Company, 2022), but with frequently occurring droughts, these have proven less effective at electricity generation (Government of Eswatini, 2018). Another key challenge is that only large commercial customers are paying the true cost of their electricity supply. 70% of sales, which are from domestic, small business and agriculture, pay significantly less than the price paid by the Eswatini Electricity Company (EEC) to South Africa's energy company, ESKOM. The Government of Eswatini is keen to generate its own supply of electricity to combat a variety of problems, including adequacy of supply, blackouts, costs and price votality and sustainability (Government of Eswatini, 2018). Thus, Eswatini's current plans can be characterised as aligned with notions of leapfrogging, bypassing fossil fuels to provide national grid power from renewable energy sources.

4 | METHODOLOGY

This study employed a qualitative approach, combining document analysis with expert interviews and household interviews to investigate how the process of energy transition towards generating electricity from renewables was unfolding in Eswatini, along with the challenges for clean energy access.

4.1 | Document analysis

Ten documents from national and international actors relating to energy policy in Eswatini were analysed prior to the interviews taking place. Policy papers from the UNDP and the International Renewable Energy Agency (IRENA), along with the Government of Eswatini's policies, were analysed to get an overview of the general direction of both national and international policy. A list of these is presented in Table 1. Discourse analysis was used to investigate the narrative currently used and why (Waitt, 2021). This involves a close reading of the texts with a focus on questions of why, by whom and for whom the document was produced, as well as the content. This background assisted with formulating research questions and shaping the interview topics. The interviews also sought insight into further relevant documents for analysis, such as a strategy document from the national utility, the Eswatini Electricity Company, which were subsequently analysed for content and themes.

TABLE 1 Energy policy documents relating to Eswatini.

Code	Date	Title	Agency
D01	2020	World Bank country diagnostic: Eswatini	World Bank
D02	2014	Swaziland Renewables Energy Assessment	IRENA
D03	2018	National Energy Policy 2018	Government of Eswatini
D04	2020	African Development Bank Country Strategy Paper 2020–24	ADB
D05	2010	National Social Development Policy 2010	Government of Eswatini
D06	2018	Programme Framework for Renewable Energy in Swaziland (PARES)	UNDP
D07	2020	Country Programme Document for Eswatini (2021–2025)	UNDP
D08	2020	Energy and the poor Unpacking the investment case for clean energy	UNDP and UNCDF
D09	2021	UN Eswatini Country Results Report 2020	UN
D10	2022	EEC Integrated Annual Report 2022	Eswatini Electricity Company

TABLE 2 A list of interview participants in phase one.

Code	Name	Description
P01	Industry01	Solar Energy Company – International (M)
P02	NGO01	Environmental NGO member (F)
P03	NGO02	Environmental NGO member (F)
P04	Utility01	Energy utility – managerial (M)
P05	Utility02	Energy utility – managerial (M)
P06	Academic01	Academic Researcher (M)
P07	Academic02	Academic Researcher (M)
P08	Consultant01	Climate consultant (M)
P09	NGO03	Consultant associated with UN (F)

4.2 | Interviews

Field research was conducted in Eswatini in 2022 and 2023. The first phase of the research involved a series of in-person, semi-structured interviews with those in expert positions across Eswatini, plus one online interview with a participant based outside of Eswatini, in order to understand the national energy landscape (see Table 2). Participants were asked a series of questions on affordability and access to electricity, extension of the grid network, mini-grids and processes of extending access to the remaining 15% of the population. Six interviews were conducted with nine participants, with each interview lasting approximately 45–60 min. The interviews were conducted in English, which the participants were all fully conversant in, but which may have inhibited expression compared to speaking in Siswati, the primary language in Eswatini. My ethnicity and gender as an English female researcher with the means to travel are likely to have played a role both in the access I was able to obtain and in how interview participants responded to me.

Interviews were transcribed and thematically coded using NVivo and analysed following established qualitative thematic analysis techniques outlined by Saldana (2016). In this process, themes were not pre-set and were allowed to emerge throughout the coding process. These were then gradually refined through an iterative process, moving between different data sources and literature, until a set of key themes emerged. This paper focuses on one of the core themes related to the process of energy transition and trajectories or narratives that reflect or relate to ideas of leapfrogging.

5 | LEAPFROGGING TO CLEAN ENERGY INDEPENDENCE?

5.1 | Crisis and energy transition in Eswatini

Eswatini is entering a period of crisis in the provision of electricity as it renegotiates its supply contract with South Africa. As coal-fired power from South Africa is an increasingly challenging option, the prospect of leapfrogging to renewable

energy appears to be a desirable approach to both accessing clean energy and securing greater energy independence. In 2018, 50 years on from achieving independence from British rule, the Kingdom of Eswatini was renamed from Swaziland as it had been known under colonial times. Moving from a position of energy insecurity in its relationship to dependence on South Africa, the ongoing process of transition in Eswatini can be characterised as 'independence through energy leapfrogging'. Whilst Eswatini has benefitted from South Africa's electricity sector, other land-locked nations have struggled to generate sufficient electricity for their populations. Malawi supplies electricity to just 11% of its population, using primarily hydroelectric power (Samarakoon, 2020), and Uganda supplies 42% of its population, whilst also facing regular power outages due to ageing infrastructure, theft and vandalism (Wabukala et al., 2022).

The supply contract between ESKOM in South Africa and the EEC is due to expire in 2025. Whilst a new agreement is likely to be secured, concerns over pricing and the ongoing supply have initiated a transitional moment in Eswatini. The years leading up to the end of the contract have highlighted the challenge of energy insecurity, with concerns that South Africa will not supply electricity to Eswatini post-2025. All participants expressed concern about the extent to which Eswatini has been reliant upon South Africa, with one participant describing this reliance as 'ridiculous':

> ...we have strong indigenous knowledge, fertile land, good climate. There's no reason why we should be stuck in this situation, but we are. And I think it just suits whoever it's suiting, to be importing so much food and energy.
>
> (P08)

This quote highlights a sense of frustration with the situation of dependency on South Africa and surrounding nations. There is also an implication of either corruption or mismanagement in governance. There is a desire to capitalise on the natural assets of the country.

The two most prominent concerns about why South Africa would not continue to supply electricity post-2025 were rising costs and the lack of sufficient supply. First, participants frequently spoke about the rising cost of supply post-2025, with the belief that the 'price will be much, much higher', with the wholesale price 'ten times' what had previously been paid (P01). Secondly, South Africa has not been able to generate adequate capacity for its own needs and has suffered years of severe load-shedding (Ateba et al., 2019). The effects of load-shedding on the South African economy are severe and appear frequently in the national news, resulting in the common idea that South Africa may choose to 'put national interests first' (P01) as 'they're really suffering with power cuts' (P09).

These two concerns about cost and availability preventing a supply post-2025 were echoed by other participants. This has generated a sense of impending energy crisis for Eswatini, as these dual threats to the existing systems of provisioning create deep uncertainty and concern about what the future may hold. Such moments of crisis have been highlighted in academic literature as creating opportunities for change and transition in energy systems (Baker et al., 2014). This is reflected in the Eswatini case, as in a bid to become more energy secure, the country is now moving to focus on generating its own power. The ways in which a country gains energy security have a major impact on their economy and on international relations (Bridge et al., 2013). As a result of these concerns, participants often discussed renewable energy as a way for Eswatini to provide its own supply without being reliant on South Africa. One participant stated that, 'the government is pushing really hard' on generating renewable energy within Eswatini (P06). The strong push that has come from the need to re-negotiate the contract with ESKOM has heightened the political and economic need to find a solution.

According to the *Times of Eswatini*, it is expected that a deal will be struck between the Eswatini Electricity Company and ESKOM for a supply post-2025 (Maziya, 2022). The details, including price and regularity of supply, will emerge over time. However, this moment of crisis has prompted action on a range of renewable energy solutions. The potential for ongoing crises of both cost and reliability of supply from South Africa is likely to keep electricity generation high on the national agenda. The EEC states that supply contracts are a short-term solution and that longer term, power plants must be created within Eswatini (Maziya, 2022). As a representative described, 'We have just launched our 2022 to 2027 strategy, and key in that strategy is that we want to increase internal generation capacity, so that we reduce the dependence on imported electricity, which is mainly imported from South Africa' (P04). This suggests that the national electricity utility is focused on power generation as a response to the challenges of dependency on imports. The power generation projects outlined so far have all been with renewable energy, a combination of solar, hydro and biomass.

Figure 2 illustrates the combined pressures on Eswatini from both internal and external factors. Concerns over the supply of electricity from South Africa's ESKOM create external pressures. The likelihood of significantly increased costs, combined with the ongoing challenge of South Africa failing to meet its own electricity needs, creates acute pressure on the *supply* side. At the same time, the increasing power *demand* and needs of the country are a result of both general

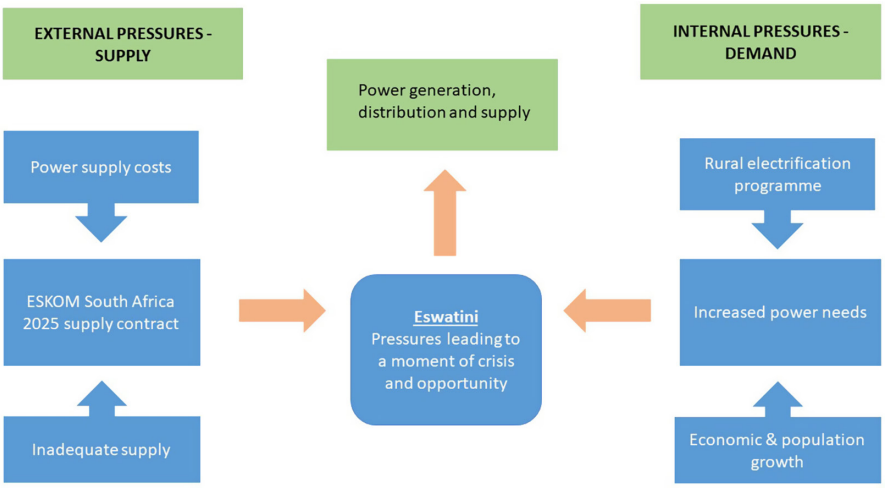

FIGURE 2 Supply and demand pressures on Eswatini.

economic and population growth, as well as the extension of electricity provision to the whole population over the coming years.

Therefore, a context has emerged in which leapfrogging appears pertinent for Eswatini both in terms of moving directly to renewable energy systems in the absence of its own power generation infrastructure and advancing energy independence. However, there are challenges with this model in relation to power generation, storage, maintenance and affordability, which are outlined below.

5.2 | Challenges for leapfrogging: creating power generation and storage

Recognising the moment of transition for Eswatini, there is potential for the country to leapfrog the use of fossil fuels directly to the generation of renewable energy. The Eswatini Electricity Company (EEC) has traditionally generated a small amount of electricity from hydropower. They currently have an installed capacity of 60 megawatts, which operates during peak times when there is sufficient rain. Despite the ongoing issue of droughts associated with climatic change, the EEC is building another hydropower plant at the Maguga dam, along the Komati river. In 2021–22, the EEC reported a significant increase in rainfall, which increased the internal generation capacity from hydro compared to previous years, and February 2023 saw heavy flooding in Eswatini (ReliefWeb, 2023). The climate vulnerability of Eswatini may make this pattern of droughts and floods recur, with impacts on the amount of hydropower that can be generated.

In September 2021, the EEC opened a newly constructed 10 MW solar PV plant, located in Qomintaba, about 40 km from the border town of Lavumisa. This was the first utility-scale solar photovoltaic plant in Eswatini, occupying around 35 hectares of land (Nxumalo, 2022). The sugar industry is also now exporting to the national grid (Government of Eswatini, 2018) using bagasse cogeneration, in which waste products from the sugar industry are used to generate electricity (IRENA, 2014). The hydropower and this solar park at Lavumisa are owned by the EEC. Additional solar capacity is being acquired by the Regulatory Authority, ESERA, from Independent Power Producers (ITWeb, 2021), with the aim of procuring a further 40 MW of biomass and 40 MW of solar power. The EEC currently has the capacity to generate a maximum of 60 MW from hydro and 10 MW from solar. To put this in context, the current need is 240 MW at peak times and the aim is to generate 570 MW by 2031 (EEC, 2022).

A key element in the plans for electricity generation and storage comes from industry. As part of a 40-year deal with Eswatini, a private company plans to site a large battery storage facility near the central town of Matsapha. This storage facility will draw from the main grid overnight and in periods of low usage and enable energy to be sold back to ESKOM at peak times. A participant from the international company described his company's plans to instal 100 MW of power through solar energy. This is approximately 40% of Eswatini's current need. However, the current plan is to export this energy to South Africa. In addition to this generation from solar, the batteries will charge up from the grid overnight, using ESKOM's coal-powered energy, and sell it back to ESKOM at peak times. This, of course, does not meet goals for renewable energy, but it may alleviate the challenges related to the lack of electricity in South Africa. It is unclear whether

this will truly benefit Eswatini in terms of electricity supply, but the related jobs and goodwill projects appear to be of significant benefit.

Battery storage is likely to be an important solution in residential settings too. For homes not yet connected to the grid, there is a need for household-level battery storage alongside individual solar power. In the case of having a home solar system, 'the needs for the household increase in the night when for example, when the children come back from school they need to study' (P04). Installing a battery allows the solar power to be stored for use at peak times. This should be considered when relying on household-level off-grid solutions as well as mini-grids. Most of the interview participants were broadly positive about action at the national level to address grid extension to rural areas, stating, 'Eswatini has done quite well that way' (P09) and 'the rate of electrification is quite high' (P06). Eswatini has achieved an electrification rate of approximately 85% of the population, which is significantly higher than many countries in southern Africa. However, it was acknowledged that the remaining 15% of the population yet to receive electricity are the hardest to reach, and therefore progress in electrification may be slowing.

In addition to household electricity usage, the importance of a reliable electricity supply for industry cannot be overstated. For industrial processes, the challenge posed by interruptions to the power supply can be severe. One participant described the situation of the power fluctuating regularly, '...the ...factory that I was talking to the other day, they were telling me even a one minute shut down entails like a 10 or 15 min production line restart. And this can happen multiple times a day when you have a poor quality electricity network, which obviously costs them a lot. But, a battery would solve all of those problems' (P01). Some of the key factories in Eswatini have recently installed rooftop solar panels in order to generate and manage their own electricity supply. The batteries being offered by this international energy company would allow for an uninterrupted flow of electricity, thus mitigating the problem. Therefore, a combination of solar power and battery storage could provide an optimum solution to both household and commercial electricity needs. Whilst the Eswatini Electricity Company is focused on power generation, it seems that industry may lead the way in battery storage capacity. However, as some companies in Eswatini are going off-grid to supply their own energy needs, there is also a move towards distributed power systems. Thus, leapfrogging needs to consider the key challenges for renewable energy provisioning and what is supported in this process, as well as the differential challenges in rural and urban areas.

5.3 | Challenges for leapfrogging: maintenance and affordability

In addition to the challenges identified above, the challenges of maintaining renewable energy systems and the overall affordability of electricity were identified during data collection. Two of the participants working in the INGO/Consultancy sector raised the issue of ensuring that there are adequate skills within the population of Eswatini to produce and maintain solar panels. One described that it would be unsustainable to rely on South Africa for repairs. They mentioned that there is a huge unemployment issue in Eswatini, which particularly affects the youth. The World Bank (2023a) estimates the unemployment rate of young people at 49.8% in 2022. Offering them skills training could lead to small businesses being created. The dependency on imports has prevented Eswatini from raising up sufficient skills within the energy sector. There is great potential to generate skilled jobs in the sector without the associated loss of jobs in the fossil fuel sector – at least within Eswatini. This could mean an investment in both knowledge capital and human capital around renewable energy.

This concern for a lack of skills also raised wider issues of governmental priorities. If a strategy for training in solar panel manufacture, installation or maintenance were successful, this could both enhance employment opportunities and national energy dependence and independence through energy leapfrogging. One participant in particular was sceptical about how much this transition to renewables would benefit Eswatini: '...the problem is, we don't have the local skill set to realise any energy solution ourselves. ... everything needs somebody else from outside' (P08). This is framed in terms of Eswatini's sense of dependence on external countries – especially South Africa – for the supply of goods, services and economic prosperity. Additionally, this participant mentioned a lack of trust in the government. This has been a key issue in recent years, leading to anti-monarchy protests in 2021 (The Guardian, 2021). In some quarters, King Mswati III is seen as abusing his power for financial and political gain (Economist Intelligence, 2019).

> It is, it's just another case, of... a lot of that money is just gonna leave the country. It's importing skills. We're not even importing skills, we're just borrowing them to make these things happen and then they'll go... A lot of this is built on a foundation of a lack of trust of our authorities in the investment choices that they make in terms of who they're partnering with, and whenever anything lucrative is involved it just becomes even more

> dodgy and shady. If it's to do anything with minerals and mining then we just have a track record of fallen projects. But also, we do need the external help we don't have the resources here to do that, the expertise.
>
> (P08)

The frustration at the lack of adequate governance is clear: there is a desire for both external assistance and mistrust in the motives of those who might offer that assistance. There is an opportunity here for Eswatini to initiate a renewable energy sector, increasing employment options and utilising the resources of its primary university. However, favourable policy conditions and choices will need to be implemented in order to capitalise on these opportunities. The UNDP in particular is looking at strategies for training citizens in the maintenance of solar panels, in partnership with the University of Eswatini. They are establishing an energy academy at the University to train youth and women in renewable energy skills and entrepreneurship, with the idea that they could work as maintenance engineers.

Moving beyond the generation of grid electricity from renewables, the key aspect of the affordability of electricity remains a barrier to access. The average monthly income in Eswatini was $304 US dollars in 2021, with an overall unemployment rate of almost 25% in 2022 (World Data, 2023). Whilst estimates of those living in income poverty in Eswatini vary, the World Bank (2023b) puts 32% of the population under the international poverty line in 2022, with 55% of the population under the lower-middle-income country poverty line. Whilst South Africa has a free basic allowance of electricity for its citizens (Simpson, 2021), Eswatini does not. Leapfrogging alone will not address all of the issues related to energy access.

> But, the biggest problem in Eswatini is now the pricing. Physical accessibility, yes, it's there, but now the pricing. A lot of people cannot afford to use that electrical power for electricity intensive applications like cooking, heating and so on and so forth. So, a lot of emaSwati [Swati people], probably in excess of three quarters of the entire population, are still using firewood, particularly for cooking and heating purposes. ... Hence, the push by government to move towards the renewable energy sources and encouraging people to move towards that....
>
> (P06)

This quote demonstrates the challenges of cost with access to electricity. Even those who have a grid connection are unable to use it and continue to rely on traditional fuels such as firewood. Drawing on Munro and Schiffer's (2019) approach, access to a physical grid connection does not equal access to electricity. This is exemplified by the situation found in health clinics across Eswatini. All of them have a grid connection and are therefore considered to have access to electricity under current statistical measures. However, a large number of them are cut off from the supply because the Ministry of Health does not pay its electricity bills regularly. This was their situation at the beginning of the COVID-19 pandemic in 2020. None of the clinics in the country had hot water available for patients attending them, and very few even had hot water for doctors and nurses.

To tackle this need, Frazium Solar, a solar energy company, leveraged grant funding and undertook a project to install solar water heaters at all 90+ clinics across Eswatini. These solar water heaters provided hot water to patients attending the clinics. As part of the project, access to a clean water supply was also needed in some of the areas. On a return visit to the clinic, the energy company found that nurses and health workers were making use of the hot water as most of them lived on site. Local people were also using the taps as a clean water supply.

The cost of electricity can lead people to seek out off-grid solutions. In Eswatini, this can be a successful strategy. But it requires a significant investment in infrastructure as well as the need for ongoing maintenance. Mini-grids were rarely mentioned by interview participants until raised as a question by the interviewer. Participants had a variety of opinions on them, but the underlying message seemed to be that grid extension and electricity generation were the primary focus. One participant stated that

> ... a mini-grid would definitely solve the problem. There, there would be enough solar ... [but] the people that live in these communities are very poor and they wouldn't be able to afford very much at all... technically it could be done very simply and very easily, but practically it would be very difficult.
>
> (P01)

This section has demonstrated that the maintenance of renewable energy technology hardware and the affordability of electricity are crucial elements of any transition.

5.4 | Evolving geopolitical relations: the southern African context

Relationships between the countries in southern Africa and the rest of the world play a key role in the generation and supply of electricity for the region. While the analysis so far has focused primarily on the context within Eswatini and its most direct relationship with South Africa, the importance of wider international relations also merits discussion. The Eswatini Electricity Company is looking to countries within the region, such as Namibia and Mozambique, for additional supply. China and Taiwan also have key roles in the energy landscapes of southern Africa. This final analytical section focuses on these wider relations and their implications for the possibility of leapfrogging.

There was consensus amongst interviewees that there will still be a significant need for imported electricity for at least the next decade and likely beyond. Participants indicated that they are continuing to look at the regional market as a source of supply. The Southern African Power Pool (SAPP) is an organisation with 12 member countries, including Eswatini and South Africa, aiming to coordinate and supply the regional market. The point was made by several participants that it may be cheaper to import electricity than to generate it internally, signalling the importance of cost in decision-making about future energy supply. However, one participant framed this as not needing to be a binary between Eswatini being either an importer or a generator of electricity. Even reducing the dependency on imports to a much lower level would allow for greater energy security. This participant described the process of 'weaning off' the import of electricity (P08).

The policy environment in each country within the region is different. The participant from the solar power industry described his experiences in identifying a host country for his solar and battery storage projects and dealing with other countries as: 'corrupt governments, just people trying to make money for themselves' and 'doing something in South Africa, we tried that...never again! I mean, just thought no, this is not the place to do business' (P01). They looked for a 'periphery country' to avoid this perceived corruption in South Africa but still close enough to sell electricity to it. The companies' choice of Eswatini was based on both proximity to South Africa and an enabling business environment, along with a perceived lack of corruption. The company had tried first with Lesotho before succeeding with Eswatini in a €100 million deal (Meza, 2021). 'Lesotho was really, really keen to go and we would have solved a lot of their problems. And it's... an absolute tragedy that they didn't proceed with that project, but ... we ran afoul of two things: political infighting in Lesotho, because we were partnered with one major faction but they ended up having their power eroded by a rival faction. But that rival faction was, and still is, bankrolled by the Chinese, so we were up against Western versus Eastern influence in Africa!'. This quote highlights the nature of political contestation in parts of southern Africa and the role of wider international actors, such as China, in energy development in the region. Though China's presence can be welcomed by some governments in sub-Saharan Africa, there is a recognised danger of this relationship taking on a neo-colonial pattern (Jauch, 2018). Chinese investment in African countries around the supply of raw materials is comparable to past colonial investments (Carmody & Owusu, 2007). Eswatini is the only remaining country in Africa to maintain diplomatic relations with Taiwan, an alliance that has endured for half a century (Madowo, 2019).

These relations between different nations can play important roles in the narratives and ideas that come to dominate and shape what ultimately happens in energy transitions for Eswatini. Another key example of this concerns the debates around the best routes to energy access for Eswatini and discourses that sit at odds with the pursuit of renewables. One participant discussed diverse narratives relating to the development of energy systems in the country:

> Every time I follow it, it's a different narrative. We're – they're going to build gas infrastructure and it will be 100% natural gas. Then you hear no mention of that, and Indonesia says they are going to build a coal power plant. Then the Finns are coming in to do biofuels with all of our wood etc, and the EU will do so much, then we export it for the EU's wood pellet needs and I·m like, really?...
>
> ...And then you dealing with a whole narrative of like, 'don't tell us what to do, we·ll go our own development route'. If we've got this natural resource, we're entitled to use it to our advantage – then all the other global south countries like Indonesia saying we'll help you, because we also have that resource, and don't let the UK or whatever tell you what not to do that they've done themselves.
>
> (P08)

This quote highlights the tensions in Eswatini at this moment of transition. Contrasting with a straightforward narrative of leapfrogging to a renewable-fuelled energy future, there are competing interests at work that support differing

options available for energy provision. From a justice perspective, Eswatini may consider itself well within its rights to use fossil fuels, as differential responsibility can consider both historical emissions and population size when evaluating emissions (Hickel, 2020), potentially entitling Eswatini to use a certain amount of fossil fuels for development. The official narrative remains that Eswatini is pursuing renewables at scale; however, there are ongoing rumours of a fossil-fuelled power plant to be constructed. The changing political landscape within each state and across the southern African region has important impacts on policy decisions. Industry is already demonstrating impatience with the pace of change, and international investors see the possibility for economic gain. The relationships between import and export, plus the danger of exploitation by other nations, mean that the simplicity of leapfrogging may be illusory. Embracing complexity, this paper argues that we can learn from the case study of Eswatini as nations attempt to leapfrog to energy independence. Geopolitics within the region and across the world play a role in the energy landscape of Eswatini, potentially influencing decision-making.

6 | CONCLUSIONS

Eswatini is an understudied geographic area, especially in relation to energy, and this paper contributes to the literature by examining the transition to renewable energy underway in Eswatini. Eswatini is currently dependent on coal-based electricity from South Africa, and elite actors in Eswatini's energy network display legitimate concerns over the supply of electricity to their country post-2025, when the contract with South Africa is due to expire. Through this moment of crisis, the paper discusses how the country is taking this opportunity to develop its energy system and is investing in renewable technologies. Along with international support and the private sector, the national institutions are building new solar and hydropower plants as well as utilising biomass from the sugar industry. Beyond simply a transition to renewable energy to ensure a low-carbon future, this transition would potentially enable Eswatini to leapfrog to a future of energy independence. Considering the UN's statement that landlocked states are lagging behind in achieving the goals of SDG 7, the potential of Eswatini and the case study presented here demonstrate the multiple overlapping socio-political benefits for nations that are able to leapfrog fossil fuels to renewables. This highlights the possibilities for Eswatini to achieve 'independence through energy leapfrogging', gaining political and economic freedoms through generating its own power.

The UNDP and government of Eswatini have set ambitious targets for both grid extension and renewable energy generation, with plans to expand electrification to the entire population by 2030 and to generate 50% of electricity from renewable sources by that date (UNDP and Government of Swaziland, 2018). Solar has been identified as the optimal solution for renewable energy (Mashwama & Shongwe, 2020), which can be especially useful with the challenges of the 'last mile'.

This paper draws on an analysis of policy documents as well as in-person qualitative interviews with experts in Eswatini. Four key themes are drawn out in the discussion. Firstly, the crisis in energy supply is described, with the specific concerns of the rising costs of buying electricity and the potential lack of supply with South Africa's load-shedding. The rising demand then adds to the mounting pressure in the national energy landscape. This paper argues that the crises of supply and demand are creating a moment of opportunity for which the installation of renewable energy generation capacity can be a solution.

Secondly, there are challenges with leapfrogging straight from traditional fuel sources to renewable energy: the challenges of creating generation capacity as well as the need for battery storage. Hydropower continues to be pursued, but Eswatini experiences ongoing challenges with both droughts and flooding. Solar energy requires battery storage to ensure a smooth flow of power, and plans are being made to add storage capacity to the grid. Individual factories are adding their own solar power and battery storage to avoid the costly shut-downs caused by power outages.

Thirdly, the need for maintenance of infrastructure and affordability of electricity at the household level are significant factors in the transition to renewable energy. The maintenance of technology such as solar panels may require further dependence on South Africa. Participants emphasised the opportunities available to upskill young people in Eswatini, with the potential for job creation where it is specifically needed. This adds to the narrative of Eswatini achieving greater independence. Affordability remains a crucial issue for electricity access across the world. In Eswatini, around three-quarters of the population still rely on firewood for many energy needs. Thus, despite a high rate of electrification, many people do not access electricity due to its cost. This supports the findings elsewhere (e.g. Butler, 2022; Munro, 2020; Munro & Schiffer, 2019; Samarakoon, 2020) that physical access to an electricity connection does not equal access to electricity.

Lastly, the geopolitical context was discussed, focusing specifically on the southern African region as well as involvement in Eswatini's affairs by Taiwan and China. The Eswatini Electricity Company continues to work with the regional market in southern Africa, looking for supply from Namibia and Mozambique. Eswatini, as the last remaining country to have diplomatic relations with Taiwan, influences finance and decision-making, with China playing a significant role in neighbouring countries. The possibility of a bilateral agreement on fossil fuel financing remains in national discourse. Geopolitical relations is an area that would benefit from further research and analysis.

Specific policy recommendations arising from this research are that solar energy and battery storage should be pursued at scale, utilising both national resources and investment from businesses. Skills training and job creation in the sectors of solar panel construction and maintenance should be prioritised, which could be linked to how private investment is directed within the country, to ensure that capacity building supports local skills development. Climate vulnerability should be taken into consideration when planning infrastructural projects, including hydropower stations. The consideration of electricity pricing for the population needs some attention. Grant funding might need to be leveraged in order to increase the accessibility of electricity to a wider population, in addition to current plans to extend the grid infrastructure. The concept that Eswatini can leapfrog fossil fuels straight to renewable energy generation can also be considered as a significant policy recommendation.

This paper demonstrates the complexity of a socio-technical transition towards renewable energy and contributes to debates surrounding the viability of the concept of leapfrogging in energy transition literature. Through the example of Eswatini, the multiple and overlapping benefits of independence through energy leapfrogging are clear, and the value of the leapfrogging narrative as a powerful way to characterise the possible trajectories for countries like it is revealed. However, what is also clear is that such transitions will likely require a commitment to recognising and overcoming substantial challenges beyond the technical, with an increased focus on the various economic, social and political issues involved.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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