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Regional cooperation for mitigating energy poverty in Sub-Saharan Africa: A context-based approach through the tripartite lenses of access, sufficiency, and mobility

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ABSTRACT

Persistent low electricity access continues to plague Sub-Saharan Africa (SSA) and has been made more obvious due to the precarious nature of adopted energisation schemes across the region. The absence of resilient electrification schemes within most countries in SSA portends grave danger for the region. Regional cooperation (like the integrated European Union (EU) electricity market) can guarantee stable, secure, and affordable electricity supply across regions when properly regulated. However, such a template as is obtainable in Europe may be impossible to replicate within SSA owing to the peculiar problems, local controversies and very wide variation in regional electrification statistics that exist within the region. This research work pertinently examines the power pools within SSA and argues that improved regional cooperation, especially in tackling the issue of energy poverty and achieving "universal energy access (SDG 7)", should be pursued on the platform of national energy sufficiency. This argument draws extensively from the geopolitics within the region by different actors and the impact of national interests on regional cooperation. While we do not seek to oppose regional cooperation in electricity trading, we emphasize the need for nations within the region to strive for some level of national energy security through carefully crafted policies and road maps that resonate with their local realities. Regional cooperation should strive to standardise electricity access benchmarks and facilitate technology transfer through existing or improved instruments rather than pushing for more integrated electricity networks.

1. Introduction

The importance of energy as a major driver of economic activity, and by implication a basic denominator of growth, is well explained in history [1]. Specifically, ongoing innovations in electricity dependent technologies for manufacturing and industrialization have placed electricity as a key enabler of economic activities. However, the realisation of the broad benefits of these technological advances have been limited in Sub-Saharan Africa (SSA) due to inadequate and insecure electricity supply infrastructure, as well as suboptimal management, regulation, and governance of the electric power sector in the region.

SSA, comprising 48 nations, presents startling statistics that indicate a need for urgency in addressing the energy poverty prevalent in the

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Abbreviations

AfCFTA	African Continental Free Trade Agreement
AfSEM	Africa-wide projects like the African Single Electricity Market
ATC&C	Aggregate Technical, Commercial, and Collection
AU	African Union
BESS	Battery Energy Storage System
CAPP	Central African Power Pool
CCGT	Combined Cycle Gas Turbine
CO_2	Carbon Dioxide
COMESA	Common Market for the Eastern and Southern Africa
DFIs	Development Finance Institutions
EAPP	East African Power Pool
ECCAS	Economic Community of Central African States
ECOWAS	Economic Community of West African States
ESP	Energy Security Plot
EU	European Union
GDP	Gross Domestic Product
GW	GigaWatt
HCI	Human Capital Index
HDI	Human Development Index
IPP	Independent Power Producers
kW	kiloWatt
kWh	kiloWatt-hour
LNG	Liquefied Natural Gas
MoU	Memorandum of Understanding
MW	MegaWatt
REIPPP	Renewable Energy Independent Power Producers Programme
RET	Renewable Energy Technology
RMIPPP	Risk Mitigation Independent Power Producers Programme
SADC	South African Development Community
SAPP	Southern African Power Pool
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa
T&D	Transmission and Distribution
UN	United Nations
WAPP	West African Power Pool

region. According to the World Bank, SSA with a population of over 1.3 billion persons has an electricity access rate of just 48%, with only 32% and 78% of its rural and urban populations, respectively, having access to electricity [2]. The percentage increase in access to electricity over the past two decades within SSA is less than 15% [2], with installed generating capacity per capita at just 0.088 kW [3,4]. To better understand how dismal SSA's statistics are, we contrast selected indices with that of the European Union (EU-27). As indicated by The World Bank database, EU-27 despite having just 40% of SSA's population generates over 780% and 760% more in GDP and CO_2 emissions per capita than SSA. What is more, EU-27 with 100% electricity access has 1140% more electricity per capita when compared with SSA. Excluding South Africa from the mix presents a more dismal status quo in the region.

Global attempts at recognising the importance of energy in precipitating economic growth and development has led the United Nations (UN) to, among other goals, promote sustainable development goal 7 (SDG 7) which aims at *"ensuring access to affordable, reliable, sustainable, and modern energy for all"*. This goal is all the more important for SSA, considering the established relationship between energy poverty and economic poverty [5]. The historically low electrification rate within the SSA region has prodded countries in the global north to promote schemes through which energisation projects can be financed within the region while achieving multiple objectives [6]. First, these projects are attempts by these developed countries to offset some of their emissions generated locally by offshoring mitigation strategies [7]. Secondly, these projects serve political interests, especially as products of aids and "handouts" from developed and economically prosperous countries to developing countries [8,9]. Thirdly, and not much talked about, is the business interests these projects serve, considering that a sizeable fraction of invested funds might end up being repatriated [10,11].

The idea of regional cooperation in electricity markets has proven useful in Europe and North America, especially as most countries in Europe and states across the USA have started diversifying their electricity generation sources from fossil fuels to renewable sources like wind, solar, and biomass. Considering the stochasticity and intermittency of wind and solar, and the limitations of battery storage, integrated electricity grids allow for power export and import, thus enabling countries and states to meet their electricity needs cheaply and reliably. The availability of an interconnected electricity grid notwithstanding, states in the USA and countries in Europe have generation capacities that can meet the majority of their electricity demand without imports. Additionally, these states and countries have transmission and distribution capacities to ensure that every household can be connected to some grid. By ensuring some level of national electricity sufficiency, countries across the EU can take advantage of the integrated electricity network to increase competition locally and improve service delivery to customers through liberalised markets. Furthermore, the availability of an integrated electricity network in Europe means that member states can confidently conduct experiments to ascertain the feasibility of low-carbon energy transitions and how energy security can be achieved in a low-carbon energy era [12–15].

2. Contextualising energy poverty and energy security in SSA

2.1. The scale and dimensions of SSA's energy poverty

Before examining energy poverty, it might be useful to establish what we mean by the term 'energy' in this research work. While we agree with Smil [16] that providing a comprehensive definition of energy is an arduous task, we concern ourselves majorly with electricity as a form of energy, and clearly delineate when other forms are considered.

It has become customary for the authors in this research work, as in their earlier works, to continuously reinforce the fact that energy poverty in the global south does present a divergent view from what is obtainable in the global north. To better simplify discussions around energy poverty, especially in the global south, we build on arguments by Monyei et al. [17–19] and Monyei and Akpeji [20] by advocating that energy poverty in the global south MUST now be viewed through the tripartite lenses of access, sufficiency, and mobility.

Fig. 1 presents the proposed tripartite lenses for assessing energy poverty in SSA and its current status. Electricity access – physical connection to an electricity grid – is estimated at 48% using 2018 values from the World Bank's database [2]. Excluding South Africa, electricity sufficiency – assumed to be annual electricity consumption per capita (kWh/capita/year) – is estimated at 153 kWh using 2014 values from the World Bank's database [2]. Lastly, we measure mobility as installed generation capacity growth rate for the region. Acknowledging the paucity of data, we assume 3% as current growth rate [21–23]. The assumed benchmark values (boundary) are 100% for electricity access, 600 kWh/capita/year for electricity sufficiency [24] and 10% average annual growth rate for electricity mobility [21–23].

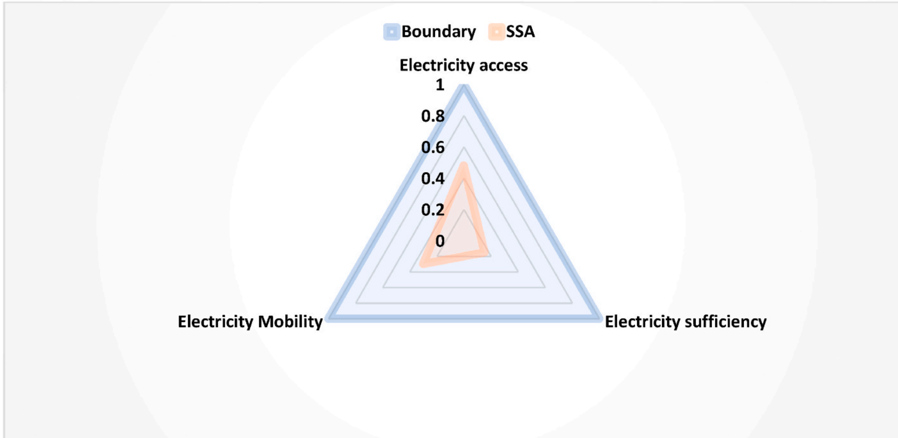

Fig. 1. Tripartite lens for examining energy poverty in SSA.

2.2. *Drawbacks to achieving SDG 7 in SSA*

The apparent vagueness in the formulation of SDG 7, variations in its interpretation, and the absence of tangible plans for regular upgrade of power system capacity and electricity delivery (especially at the community level) limits its effectiveness in fast tracking electrification in SSA and the global south as a whole [20,25]. Additionally, the variation in national priorities and the wide disparity in the spending power of member countries within the region makes it more difficult for countries within SSA to agree on tangible benchmarks and minimum standards for electricity access and electricity sufficiency.

Across SSA, the concept of energy security, though known, is hardly felt. Constrained by limited electricity generation capacity, ageing transmission and distribution (T&D) networks, low collection rates, low metering rate, high T&D losses and high aggregate technical, commercial, and collection (ATC&C) losses, utilities across SSA struggle to remain operational with most remaining nationalised with huge deficits and debts [26,27].

Values for electricity access (SSA) and electricity sufficiency (SSA) are sourced from the World Bank database while other values are assumed from information in literature [21–24].

The implications of these include power rationing, frequent blackouts and inability of utilities to regularly upgrade facilities and services [28,29]. Consequently, Countries within SSA have been exploring options from transnational electricity trading to regional/bloc electricity trading to meet local energy needs, foster regional cooperation, and facilitate regional economic growth [21,30].

3. Regional electricity trading within SSA

Electricity trading among SSA countries existed as far back as 1950 before the formation of regional power pools [31]. Then, most of the trades were bilateral, and still are. Observations of the successes of competitive electricity markets in the global north made power pooling an attractive option for boosting electricity supply adequacy and security in the four major SSA subregions – East, West, Central, and South. The first functional power pool in the region was the Southern African Power Pool (SAPP), which was formed in 1995 [31]. Subsequently, the West African Power Pool (WAPP), East African Power Pool (EAPP), and Central African Power Pool (CAPP) were formed. These power pools are constituted majorly by state-owned utilities within the region. In the subsequent sections, we discuss the set-up of each power pool, the electricity situation of its member countries, energy trading, the balance of power within each pool, and renewable energy developments. An Energy Security Plot (ESP) was developed for each power pool to describe the energy profile of its member countries relative to one another. Each country's size and location on the ESP of its power pool was determined using its electricity access, dependency (expressed as a fraction of total electricity consumption that is imported), and annual electricity consumption per capita normalized using a benchmark of 600 kWh [24].

3.1. *Southern African Power Pool (SAPP)*

3.1.1. *Broad socioeconomic status*

SAPP was formed in 1995 by an intergovernmental memorandum of understanding (MoU) between the member governments of the South African Development Community (SADC) (excluding Mauritius) to foster regional economic integration and the expansion of electricity access across the SADC region and other African regions [31]. The participating utilities in SAPP span 12 countries within the SADC region —Angola, Botswana, Democratic Republic of Congo (DRC), Eswatini, Lesotho, Malawi, Mozambique, Namibia, South Africa, Tanzania, Zambia, and Zimbabwe — and serve a population of about 317 million people, with an average population growth rate of 3% per annum [32–34]. On average, the pool has a GDP per capita of about US$3000, a human development index (HDI) of 0.56, and electricity access rate of 47%. While these statistics are significantly higher than those of other SSA regions, they obscure the wide disparity in development that exists within the pool. The GDP per capita of the member countries in the pool ranges between US$390 (Malawi) and US$8300 (Botswana), HDI ranges between 0.45 (Mozambique) and 0.73 (Malawi), while electricity access ranges between 18.02% (Malawi) and 91.23% (South Africa). Apart from Eswatini, the DRC, Malawi, and Mozambique which have HDIs below 0.5 and fall under the low human development category, the countries can be classified under the medium human development category.

3.1.2. *Electricity sector overview*

As of 2019, SAPP had an installed generating capacity of 71.3 GW (0.2 kW per capita) and an operating peak capacity of about 59 GW [35] — the highest across all SSA power pools. Coal (especially in South Africa), hydropower (especially in Angola, DRC, Zambia), and gas power plants dominate the current electricity generation mix, accounting for about 60%, 21%, and 8% of the total installed generating capacity, respectively. The combined installed capacity of wind and solar power plants across the pool is less than 7% of the total generating capacity. Thus, the electricity generation in the pool is significantly fossil-fuel based and also subject to the seasonal volatilities of hydro-power generation. SAPP's current electricity demand is about 280 TWh (828 kWh per capita) – over 480% of WAPP's which has a population that is about 1.3 times larger – and is projected to reach

461.2 TWh (65% increase) by 2025 [35]. South Africa's national utility, Eskom, accounts for approximately 51% of installed generation capacity.

SAPP has plans to commission about 23.085 GW (26.8% net increase, considering planned decommissioning) between 2019 and 2023 [35]. South Africa, independent power producers (IPPs), as well as solar and wind power plants are expected to account for 40%, 14.5%, and 12% of planned capacity additions between 2019 and 2023, respectively. The participation of IPPs in generation capacity expansion in the region indicates a gradual influx of private sector investments in the power pool, most of which have been through public-private partnerships in the form of power purchase agreements (PPAs) in which the incumbent state-owned utility is the off-taker. While the plans to commission additional generation capacity is laudable, history casts uncertainties on SAPP's ability to meet or exceed its projections on planned capacity additions. About 33.9 GW of capacity additions were projected for the period 2004–2018, but only 26.1 GW (77%) was achieved [35].

3.1.3. Electricity trading

Of all the four SSA power pools, SAPP has the most developed organizational structure including, in top-down order, the SADC directorate of infrastructure, an executive committee, a management committee, sub committees - environmental, markets, coordination centre board, operating, planning - and a coordination centre to facilitate electricity trading.

For several decades preceding the formation of SAPP, South Africa's apartheid regime leveraged its energy surplus to enter into bilateral energy trade contracts with its neighbours, including Angola, Mozambique, and Zimbabwe [30]. The apartheid regime used this as a strategy to extend its control over SADC's energy sector and exert regional dominance. Nations which were locked in long-term bilateral contracts found it difficult to achieve energy independence from South Africa expeditiously. Even after the formation of the SAPP in 1995, bilateral contracts still dominated the electricity trades within the pool. To achieve a more flexible, efficient, and transparent electricity market that could equitably serve member countries, a short-term competitive energy market was established in April 2001 and became fully competitive in 2004 [35]. This is the only competitive electricity market in SSA. The current portfolios in SAPP's short-term energy market and their establishment dates include day ahead (2009), post-day ahead (2013), intraday (2016), month ahead (2016), forward physical (2016), and balancing (2018) markets. The day ahead market (DAM) is the most active of all portfolios. Between April 2018–March 2019, 2054.2 GWh of electricity valued at US$107 million was traded across all SAPP's competitive electricity market portfolios. The contribution of the SAPP's competitive electricity market to total trades has been growing since its inception. As of 2019, it accounted for 32% of total trades, against 68% for bilateral trades [35].

The presence of a competitive market notwithstanding, South Africa dominates electricity trades within the SAPP, accounting for 65% of net exports and about 85% of SAPP's electrical energy demand. Overall, the low national energy security in over 70% of the member countries of the pool has made them mainly net importers or limited their participation in the pool. The ESP for the pool (Fig. 2) indicates how the member countries fare in terms of electricity consumption, electricity access, and electricity import dependency. Namibia, with only average electricity access, was the highest net importer, accounting for 51% of net imports. This is due to Namibia's low baseload generation. Low net import and exports by countries like Botswana, Tanzania, Zimbabwe, Malawi, and Lesotho, Eswatini indicate low demand or capacity, or minimal participation in the pool.

Constraints posed by transmission inadequacy meant that only 11% and 46% of sell and buy offers were matched in the 2018/2019 financial year [35]. There are now nine planned and ongoing interconnector projects to improve *trans*-border electricity trades, including the Zambia-Tanzania-Kenya interconnector project intended to connect the SAPP with EAPP. However, as the pool expands, future regulations will need to focus on promoting trades in the competitive electricity market and curbing regional energy hegemony.

3.1.4. Energy road map including renewable energy options

Although SAPP's current electricity generation mix is dominated by fossil fuel and hydropower, there have been some progress in the integration of non-hydro RES. Wind and solar accounted for 26% of total commissioned generation capacity in 2018, and their expected contribution to the pool's committed generation capacity between 2019 and 2023 is about 12%. While the declining costs of renewables and climate change mitigation are promoted as major incentives for a rapid uptake of renewables in SAPP [36], other factors including, inter alia, national energy policies, structure of the national electric power system, as well as market and investment conditions, influence the national uptake of RE technologies.

Currently, South Africa is the major country in the SAPP making significant progress towards the integration of wind and solar into the pool's electricity generation mix. It has the fastest developing and largest renewable energy market in the SADC region and Africa. The onslaughts of load shedding in South Africa between 2007 and 2008 and the significant impacts on its emerging industrial economy led to the establishment of its renewable energy independent power producers programme (REIPPP) in 2011 to expeditiously procure new generation capacity. So far, South Africa has successfully procured 6401 MW of RE power projects through four competitive bid windows; about 4000 MW of these are now operational [37]. The total investment value of procured projects is over ZAR210bn (~US$14bn at US$1 - ZAR15) [38].

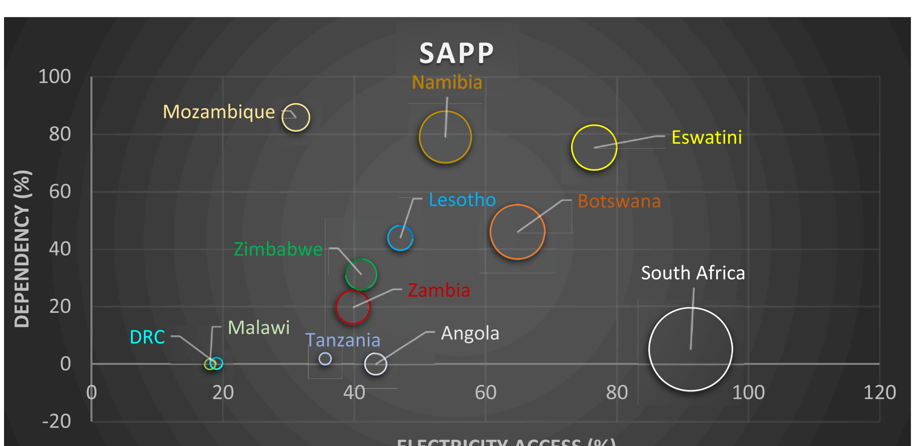

Fig. 2. Electricity Security Plot (ESP) for the SAPP member countries (Bubble size indicates normalized annual electricity consumption per capita).

South Africa's REIPPP bid window 4 yielded energy prices as low as US $0.07 per kWh – among the lowest in global renewable energy auctions [39]. Also, five of the eight projects that were successful in its recent ad hoc risk mitigation independent power producers' program (RMIPPP) for dispatchable power to curb the country's resurgent load shedding due to capacity shortages were hybrid projects that blended renewable energy technologies, fossil fuel sources (Diesel/Liquefied Petroleum Gas), and battery energy storage system (BESS) [40]. According to South Africa's gazetted 2019 integrated resource plan [41], wind and solar are expected to account for 26 500 MW of additional capacity, 21.04% of installed generating capacity, and 12.6% of annual energy generation. Although fossil fuels still feature significantly in South Africa's electricity generation mix up till 2030, the renewables to fossil capacity addition ratio (5:1) in Ref. [41] indicates that South Africa is making appreciable progress towards a low-carbon energy transition.

Excluding South Africa, the integration of renewable energy sources in the other countries in the SAPP is only at the nascent stage. Solar power has the fastest growth in capacity additions especially because of the ubiquity of the resource and shorter project development times. Between 2010 and 2019, the combined solar power additions by these countries increased from 17.6 MW to 380.9 MW, while wind only increased from 0.2 to 5.2 MW. Namibia accounted for 36.1%% and 100% of these solar and wind capacity additions. Namibia's progress is attributable to its National Renewable Energy Policy (NREP) [42] and Net Metering Rules (NMR) [43]. Notably, its annual rate of solar generating capacity spiked following the introduction of its NMR in 2016. Malawi — with the lowest electricity access rate in the pool — has also seen significant solar capacity additions, adding 22 MW between 2010 and 2019. Despite the Covid-19 pandemic in 2020, its 46 MW Nkhotakota solar PV project reached financial close [39].

Mozambique, with an electricity generation mix that is over 90% renewable (predominantly hydro and biomass) presents an interesting case on the 'trilemma' of energy transition, national sufficiency, and regional cooperation. As seen from the SAPP's ESP, the nation is energy poor. Also, its high hydropower dependency means that it is vulnerable to drought. Recent discoveries of about 180 trillion cubic feet of natural gas reserves concentrated in its Rouvuma basin is shifting the nation's attention towards the development of its gas resources to improve national energy security [44]. It is expected that liquefied natural gas (LNG) will increase Mozambique's influence in the regional energy balance in Southern Africa and advance its economy by improving energy availability, fostering infrastructure development and industrialization, creating jobs, and increasing tax revenue. The materialization of these prospects requires the evolution of energy policies that establish adequate balance between national energy security, regional cooperation, and 'clean energy' development. As seen with Mozambique's Cahora Bassa hydro plant, where most of its output is wheeled to South Africa, if the influence of a dominant and erstwhile regional hegemon like South Africa on the utilization of regional energy resources is not checked, the 'energy proceeds' from LNG projects in Mozambique might end up benefitting the South African economy than it does Mozambique's.

3.2. West African Power Pool (WAPP)

3.2.1. Broad socioeconomic status

WAPP was established in December 1999, as a cooperation of the electricity companies in West Africa under the regional economic community, Economic Community of West African States (ECOWAS), which among other successes has facilitated the institution of free movement of goods and persons within member countries. Spanning 15 countries within the region, the WAPP serves a population of over 400 million people [45,46]. The member electricity companies include utilities from Benin, Burkina Faso, Cape Verde, Cote D'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo.

With the exception of Cape Verde, whose GDP per capita is $3 604, the GDP per capita of the WAPP member countries is generally below $3 000, with values as low as $554 in Niger and $528 in Sierra Leone. Niger also ranks lowest in the region in terms of Human Development Index (HDI) with a value of 0.394, while Cape Verde and Ghana rank highest with values of 0.665 and 0.611, respectively. Excluding Ghana and Cape Verde, which are classified as medium human development countries, the rest of countries in the region are classified under the low human development category. However, the general trend of HDI in WAPP's member countries has been upward. For example, Nigeria's HDI value increased by 15.9% between 2005 and 2019 [34]. Also, relative to other power pools in Africa, WAPP has the highest average electricity access rate of about 50%.

3.2.2. Electricity sector overview

WAPP has an installed capacity of 23 000 MW, but only 13 400 MW of this is operational. The pool's annual energy consumption is 58 TWh (just about 25% of South Africa's annual electricity consumption) and a peak load of 10 200 MW. The ratio of power exchanged to power generated in 2019 was 8.8 [47]. Power generation within the pool is mostly from gas and hydropower plants — powered through multiple dams such as the Akosombo Dam and the Kainji Dam. The current hydro-dependency of the pool's power generation is about 28% [45]. Such hydro dependency means that drought and draining have historically affected the reliability of electricity supply in member countries.

There has been a drive to improve existing generation through additional private investment in power plant infrastructure. These private investments have focused on solar, wind, and combined cycle gas turbine (CCGT) power in countries such as Togo, Gambia, Cote D'Ivoire, Ghana and Nigeria [39]. These investments seek to leverage the regions copious resources in solar, gas, and wind. For example, Nigeria has the ninth largest natural gas reserves in the world with current production capabilities of over 45 billion m^3, some of which has been used to fuel domestic and regional energy demand. The privately sponsored power generation projects which used to be traditionally funded by foreign/non-African Development Finance Institutions (DFIs), are now increasingly funded by local DFIs and through various public-private partnership mechanisms. These investments have reduced the deficit in electricity access in the region although this still remains a challenge. For example, from around 30% electricity access rate in 1993, Ghana has increased its electricity access rate to about 82.39% in 2019. While countries like Cape Verde have electricity access rate of 93.59%, seven of the fifteen WAPP member countries have electricity access rates below 50% as at 2019, with Niger having an access rate of 12.3% [34].

3.2.3. Electricity trading

The WAPP was developed to mitigate electricity gaps within the ECOWAS region by providing opportunities for exchange of power. Till date, power exchanges have remained through bilateral contracts. A contractual framework through which some of the more resource constrained countries in the pool can sign contracts with the less constrained countries to meet their demand was established and has been quite successful. Furthermore, to foster the operation of the pool and guarantee efficient power exchanges, there have been successes in technological capacity building, ensuring support for resource constrained countries, creating collective bargaining opportunities for fundraising and access to loans, and standardization of technical and business practices in the region [47]. Despite these successes, there are several challenges which have inhibited the growth of the pool. For example, generation and networks inadequacy have caused low national energy security in over 80% of the member countries and inhibited the growth of the pool. Overall, the ESP for the WAPP (Fig. 3) indicates that most WAPP member countries are characterized by low electricity access and low annual electricity consumption per capita – very well below the benchmark of 600 kWh adopted in this research paper. Also, about 30% of the member countries are significantly dependent on energy

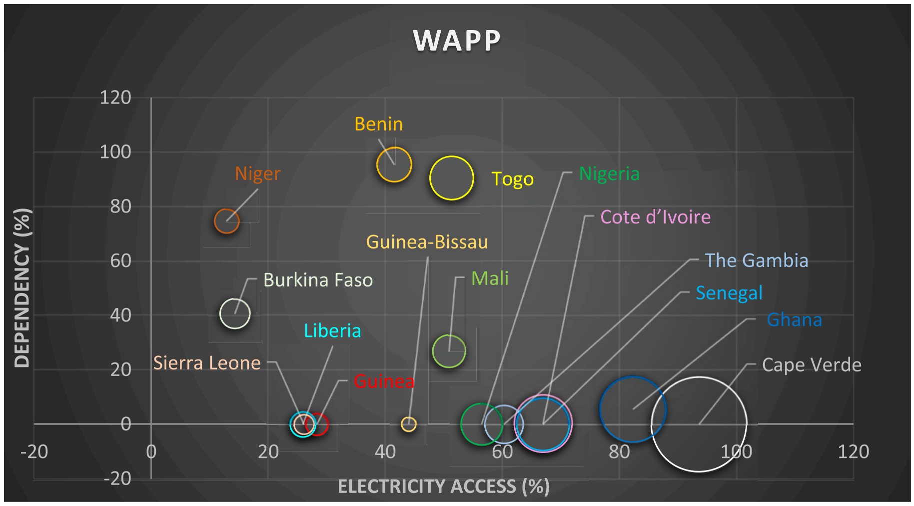

Fig. 3. Electricity Security Plot (ESP) for the WAPP member countries. (Bubble size indicates normalized annual electricity consumption per capita).

imports through the pool.

In terms of the political economy within the pool, the balance of power is heavily skewed towards Nigeria, which has the largest population, GDP, and is endowed with abundant natural resources. Also, Nigeria is the major financier of the bloc's activities [48]. These factors make Nigeria command great influence within the bloc. However, the ESP for the WAPP (Fig. 3) indicates that several countries with lesser political and economic prowess than Nigeria, namely, Cote d'Ivoire, The Gambia, Senegal, Ghana, and Cape Verde are more electricity sufficient than Nigeria, given their relatively higher electricity access rates and normalized electricity consumption per capita. This could be attributed to the significantly larger population of Nigeria.

Future regulations to aid power trading within WAPP will need to address penalty for violations of supply agreements, especially considering the political power imbalance between the countries and the potential for politics to lead to significant supply disruptions. Certain security of supply issues have already been in play. For example, Nigeria's reduction of its gas supply to Ghana to 40% of the contractually agreed capacity partially caused the Dumsor crisis in Ghana in 2012 [49]. Current interconnections also do not have adequate redundancy should power supply from one exporter be interrupted. Long-term development of the pool will need to focus on expanding the development of sources across countries and creating redundancies to prevent supply disruptions or *energy bullying*.[1]

3.2.4. *Energy road map including renewable energy options*

Considering the triple challenge of access, sufficiency and mobility, various energy road maps have been developed and are being pursued by the WAPP member countries. At the regional level, the pool has defined a goal of 10% renewable energy as source of power exchanged through the pool by 2025 [47]. Domestically, in different member countries, several utility-scale independent power projects sponsored by DFIs are under development. In 2020, many of these projects were impacted financially due to COVID-19, however certain countries are still very much in line with their defined energy road map. Togo is one of such country which has had recent success in pursuing its energy sector road map, despite COVID-19. The country's goal is to achieve energy independence by 2030 through as many renewable-based independent power projects as possible. To this end, in 2020, two of such projects with capacity of 115 MW were launched, while other projects totalling 100 MW are under development [39]. To contextualize these capacity additions, consider that the currently installed grid capacity in the country is 235 MW. Financing for these projects have come from institutions such as the International Finance Corporation (IFC), the West African Development Bank (WADB), and several commercial banks [39]. These successes mean that Togo is well on its way to achieving its sufficiency needs as well as its environmental target by 2030. Not all the countries in the pool can emulate Togo's path due to different population sizes, energy needs and resources, however the success of Togo provides a useful benchmark for comparing the road map milestones of other countries in the region going forward.

3.3. *Eastern African power pool (EAPP)*

3.3.1. *Broad socioeconomic status*

The Eastern African Power Pool (EAPP) was established in 2005 via an Inter-Governmental Memorandum of Understanding (MoU) [50]. The initial members included seven Eastern Africa countries: Burundi, the Democratic Republic of Congo (DRC), Egypt, Ethiopia, Kenya, Rwanda and Sudan with Tanzania, Libya, Uganda and Djibouti joining the EAPP over the course of 2010–2012 [50]. The formation and subsequent evolution of the EAPP is to foster the interconnection of power systems by the heads of states of the Common Market for the Eastern and Southern Africa (COMESA) regional power block [50,51]. According to Deloitte [52], the EAPP, currently in its preliminary stage, envisages the evolution of a fully integrated and operational power market by 2035.

With respect to economic productivity, Egypt ranks the highest followed by Ethiopia and Kenya, with 2020 GDP measured (in current US$) as $303 billion, $95.9 billion, and $95.5 billion respectively. The last three bottom performers with respect to GDP are Sudan, ($30.5 billion), Rwanda ($10.35 billion) and Burundi ($3 billion). Population across the block is estimated at over 520 million with Ethiopia (112 million), Egypt (100 million) and DRC (86.8 million) accounting for over 55% of the block's population. Human Capital Index (HCI) across the region averages 0.4 with HCI of 0.5 for Egypt and Kenya. Electrification rate across the block shows widening disparity and varies from a low of 11% for Burundi to 100% for Egypt.

3.3.2. *Electricity sector overview*

With the EAPP's population in excess of 520 million and average electricity access at just over 50%, the region suffers from serious electricity access deficit. Most of the electricity consumed within the region is produced from hydropower, oil, and natural gas [51]. The pool's installed generating capacity is about 71 GW, with Egypt and

[1] Here we modify the definition provided in Ref. [17] to describe the potential for a (monopoly) party in the power pool to significantly influence (or constrain) the pool's supply capacity in meeting the energy demands of other dependent parties.

Libya accounting for about 64.4% and 14.4% of this capacity, respectively. Excluding Egypt and Libya, the other twelve member countries suffer from gross generation inadequacy. The pool records some surplus generation capacity, but this is expected to grow significantly in the next few years, especially with several committed generation capacity expansion projects in Ethiopia, Tanzania, and Kenya. This indicates a need for the expansion of transmission capacity to optimize the generation capacity utilization factor across the pool. Currently, the average annual electricity consumption per capita is about 631 kWh, and ranges between 32 kWh (Burundi) and 4042 kWh (Libya). Again, this is indicative of the disparity in the electricity situation of the member countries in the EAPP power pool.

3.3.3. Electricity trading

As acknowledged by Remy and Chattopadhyay [51], cross-border electricity trade in the EAPP is quite low. Table 1 presents the existing and committed interconnections across the region. The major existing interconnections for electricity trading are Egypt - Sudan (300 MW), Ethiopia - Sudan (200 MW), Egypt - Libya (180 MW), and Rwanda - Uganda (255 MW) amongst others. Planned interconnections as of 2020 include Ethiopia - Kenya (200 MW), Ethiopia - Djibouti (140 MW), and Tanzania - Kenya (1600 MW). Differing from WAPP and SAPP, the ESP for the EAPP (Fig. 4) indicates lower dependence on electricity imports to meet local consumption.

In examining the balance of power within the EAPP region, it becomes difficult to assign a major contender due to the shifting geopolitical contestations within the region in recent times. The construction and current operations of the Grand Ethiopian Renaissance Dam (GERD) is fuelling spats between Sudan, Egypt, and Ethiopia. While Ethiopia argues on the need to generate sufficient electricity that is cheap, can meet its growing electricity demand, and earn income through electricity exports, Egypt is more concerned with the potential for the dam's operations to adversely affect its water supply considering that it depends on the Nile River for 90% of its fresh water supply [53–55].

3.3.4. Energy road map including renewable energy options

Within the EAPP, member countries are adopting varied policies that will grow and diversify their energy mix while ensuring resilience and sufficiency can be guaranteed. In Ethiopia for instance, the government recently initiated a 1000 MW geothermal project in the areas of Tulu Moye and Corbetti. Additionally, Enel Green Power is also intending to build a 100 MW solar park in Ethiopia, which is valued at US$120 million [56]. The renewable energy outlook for Egypt follows the Integrated Sustainable Energy Strategy, ISES 2035 and involves stepping up the use of renewables and improving energy efficiency in its power sector. According to Ref. [57], the government has set targets for renewables to make up 42% of the country's electricity mix by 2035, based on rapid solar and wind deployment. In Kenya, the Kenyan National Electrification Strategy (KNES) was launched to provide a road map towards achieving universal access to electricity for all Kenyans by 2022. Universal access to electricity is a key requirement for meeting Kenya's development goals under Vision 2030 of becoming a newly industrialised and middle-income country [58].

3.4. Central Africa power pool (CAPP)

3.4.1. Broad socioeconomic status

CAPP was established in 2003 and saddled with the task of encouraging and developing electricity trade among the member states of Economic Community of Central African States (ECCAS) through the improvement and interconnection of electricity infrastructures of the participating countries [59]. CAPP consists of 10 member states with 11 public, semi-public, and private electricity utility companies which serve 180 million people. CAPP is guided by the MOU signed by the power ministers of the participating member states and the MOU signed by the representatives of all the participating utilities (inter-governmental and Inter utility MOUs) [60]. CAPP is currently the least developed power pool in SSA.

On average, the GDP per capita and HDI for the CAPP member states between 2010 and 2019 was $3524 and 0.51, respectively [61]. Although some countries in the central African region have been plagued with several internal conflicts in recent times, they have still managed an average GDP growth of 2.6% between 2010 and 2019. This is projected to grow by 3.5% by 2020 [62]. Equatorial Guinea has the highest GDP per capita, and is closely followed by Gabon and Angola. The HDI between 2010 and 2019 places Gabon ahead of Congo, Equatorial Guinea, and São Tomé and Príncipe, which follow in descending order. The average national electricity access rates across the pool's member states is less than 42% [63]. Out of the ten countries in the CAPP, only five countries have a national average electrification rate

Table 1
EAPP existing and committed interconnections.[a].

	Burundi	DRC	Egypt	Ethiopia	Kenya	Rwanda	Sudan	Tanzania	Libya	Uganda	Djibouti	Ruzizi HPP	Rusomo HPP	Eritrea	SAPP
Burundi												30	\250		
DRC												30			
Egypt							300		180						
Ethiopia					\200		200				180 \140			\100	
Kenya				\200				\1600		145 \155					
Rwanda										255		30	\250		
Sudan			300	200											
Tanzania					\1600					\400			\250		\590
Libya			180												
Uganda					145 \155	255		\400							
Djibouti				180 \140											
Ruzizi HPP	30	30				30									
Rusomo HPP	\250					\250		\250							
Eritrea				\100											
SAPP								\590							

Source: Adapted from Ref. [51].

[a] Single box values represent existing interconnection capacity; \x represents committed interconnection capacity; y\x represents existing (y) and committed interconnection capacity (x). All values are in MW.

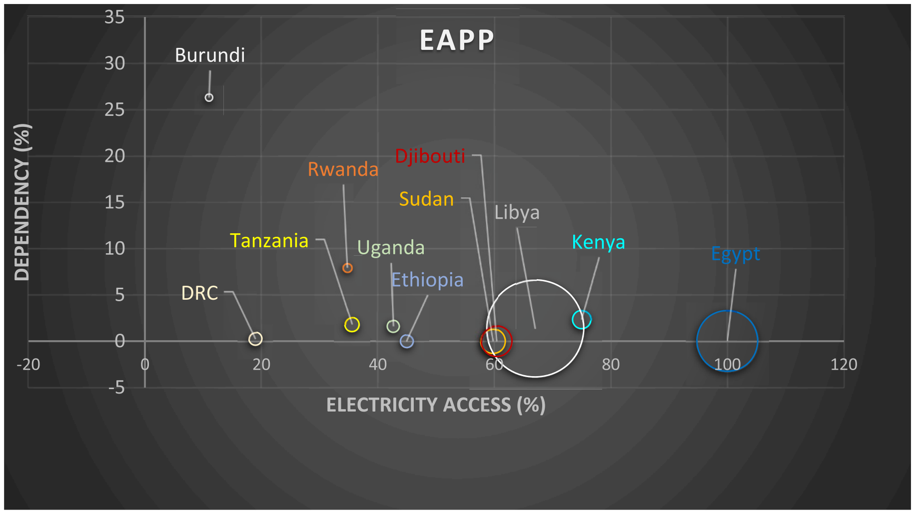

Fig. 4. Electricity Security Plot (ESP) for the EAPP member countries (Bubble size indicates normalized annual electricity consumption per capita).

above 50%, while countries like Chad, DRC, and Burundi have less than 15% (Fig. 5).

3.4.2. Electricity sector overview

The total installed generating capacity in the CAPP is about 7000 MW, with hydro power accounting for more than 80% due to the vast hydro resource available in Central Africa [64]. The dominance of hydropower is expected to continue especially with the proposed Grand Inga electricity project which is expected to produce 40 000 MW of electricity [65]. The continued reliance on hydropower means that the region will have to depend on seasonal changes in precipitation and the ensuing fluctuations in water flow which may be affected by climate change.

In 2018, CAPP's total electricity generation was 36.6 TWh (excluding self-generation); Angola, Cameroon and the DRC contributed 81% of this figure. There is a wide gap in the electricity generation per capita among member states, with 1601.1 kWh and 19.5 kWh recorded for Gabon and Chad, respectively in 2018. The pattern is similar for consumption per capita. The non-homogenous feature of the energy generation per capita among the CAPP member states is a strong suggestion of the unbalanced nature of the pool and the infrastructural inadequacies of each member state in meeting its energy needs [21,59]. Also, T&D losses are high, with four members (Cameroon, São Tomé and Príncipe, Republic of Congo and the Central African Republic) of the CAPP averaging a total loss of 41%. The high T&D losses in Cameroon, for instance, are due to ageing and under-maintained infrastructure [66].

3.4.3. Electricity trading

Electricity trading in the pool exists mainly in the form of bilateral and tri-lateral agreements, e.g., those between DRC and Congo (60 MW), Rwanda, DRC and Burundi (45 MW), DRC and Zambia to SAPP (150 MW) [67,68]. Presently, minimal power trading occurs among member states annually. For instance, in 2018, only a total of 414 GWh of electricity was exported from the power pool (Republic of Congo – 22 GWh, DRC – 392 GWh), while a total of 608 GWh of electricity was imported (Burundi – 121 GWh, Cameroon – 66 GWh, Republic of Congo – 18 GWh, and Gabon – 403 GWh) [63]. The low import dependency observed for 80% of the pool's members in its ESP (Fig. 5) indicates electricity trading in the CAPP is typically low. This is because of generation inadequacy, low interconnection among its member states, as well as inadequate and poorly designed transmission infrastructure. For instance, Cameroon presently operates three independent transmission corridors (Southern Interconnected Grid, Northern Interconnected Grid and Eastern Isolated Grid) totally isolated from each other, thereby making the exchange of excess power between the grids impossible [66]. This national deficiency in Cameroon and other member states is a catalyst to the CAPP's low interconnection and power exchange.

The lack of robust regional policies and regulations for electricity trading, absence of conflict resolution apparatus (for resolving disputes that may ensure electricity trading), challenges of electricity theft, vandalism and non-cost reflective tariffs, as well as difficulty in attracting investments are some of the major bottlenecks encountered in the pool [68].

3.4.4. Energy road map including renewable energy options

In order to be self-sufficient and contribute to the regional pool, various members of the CAPP have drawn out strategic national road maps and agendas. For instance, the Angolan government proposed an investment of $18 billion between 2013 and 2017 [69]. The 2013–2017 action plan was targeted at increasing its generation capacity. It further established a national development plan (2018–2025) that would see its electricity sector independent of the oil market's prevailing uncertainties [69]. With respect to the expansion of renewable energy projects, the Angolan government established a national strategy for renewable energies that would ensure the development of up to 800 MW of renewable energy projects [69]. Angola's northern part is home to renewable power over more than 1 GW [70]. The southern part of the country relies on costly diesel-powered power generators sustained through government subsidies. The Angolan government, through external funding from the African Development Bank (AfDB), approved the construction of transmission lines to connect the isolated North and South Angolan transmission grids [70]. Apart from cutting down diesel consumption by approximately 46.8 billion litres to reduce emissions by 80 megatons, the project is the right way in attaining self-sufficiency in the Angolan power sector. It is also expected that about $130 million would be saved annually in diesel subsidies [70]. This cost could be redirected at developing the power sector over a period of time.

Since embarking on various power sector reforms, Angola's electricity sector has seen significant improvements with respect to sustainability, operations, installed capacity and efficiency. To be more specific, more than 2400 MW has been added to the total installed capacity with renewable energy (majorly hydro), contributing up to 1700 MW of the total installed capacity during the same period of the action plan implementation [71]. Also, there has been a slight increase in the electricity access figures. The national access increased by 1.5%; while urban access decreased slightly by 0.5%, rural access increased by 2.5% [71]. Although Angola is striving towards self-sufficiency, its electricity

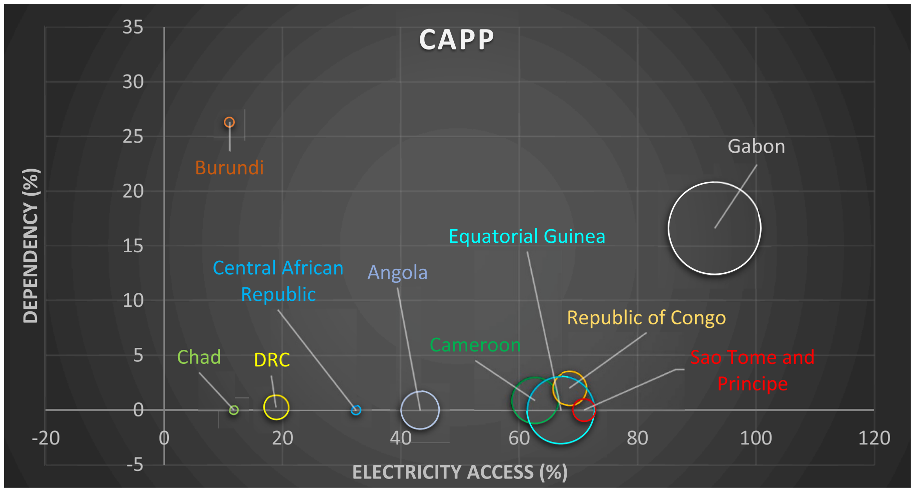

Fig. 5. Electricity Security Plot (ESP) for the CAPP member countries (Bubble size indicates normalized annual electricity consumption per capita).

sector's present situation has not allowed for electricity trading with the member states of the CAPP. Like the efforts put in place by Angola, member states would have to make a realistic resolution to invest in electricity infrastructure to minimize concerns of self-sufficiency.

4. Contextualising regional cooperation for mitigating energy poverty in SSA

There are theoretical underpinnings to some of the assumptions surrounding energy integration which stemmed from the colonial experience of most African states. They are neofunctionalism and intergovernmentalism. These two broad theories direct several regionalist discourses including that of the EU and earlier attempts by the African Union (AU). They are predicated on the grand functionalist theory which stipulates that a state, as a functioning rational actor, is able to maintain power and its self-interest. Neofunctionalism as propounded by Haas [72], envisions the emergence of supranationalism among nation states with national actors coalescing together towards mutually beneficial ends that will guarantee better political and market gains. Intergovernmentalism, proposed by Stanley Hoffman, is an alternative theory of regionalism which seeks the retention of national sovereignty alongside supranational relations without ceding total power to regional institutions [73]. At the core of both theories are regional integration and regional cooperation. The post-world war II and post-cold soviet states experiment influenced serious discussions on the subject of regional integration and regional cooperation.

Regional integration and regional cooperation are concepts which are often used interchangeably but with different meanings. While the former seeks a re-centring of national political centres to broader institutionalised platforms of states with shared geographical boundaries, racial, and cultural identities towards mutual political and economic ends, the latter allows for the maintenance of national identities while working together as a comity of nations to address common foes and challenges. Although regional cooperation is preferred, it is regional integration that guides more European international relations; the same has been extended to former colonies. Far from the wish of a post-independent "United States of Africa" as championed by Kwame Nkrumah of Ghana for a soviet-style agglomeration of African states, this regional integration was contested by pro-western Nigerian government under Abubakar Tafawa Balewa who stuck to a cooperation model [74].

The authors agree that regional cooperation has played significant roles within SSA, especially in boosting trade, facilitating mobility of persons and combating insurgencies. There is even more renewed hope that the African Continental Free Trade Agreement (AfCFTA) would catalyse more intra-Africa trade and lead to increased shared prosperity within the region. Furthermore, the authors are confident that in the long run, Africa-wide projects like the African Single Electricity Market (AfSEM) [75,76], The Strategy for the Development of a Harmonised Regulatory Framework for the Electricity Market in Africa [77,78], and The Africa Energy Transition Programme [79] will offer significant frameworks for increasing local exploitation of generation capacities and boosting electricity generation capacity across SSA, especially through increased investments. However, countries within SSA must learn from history to avert a repeat of incidents during the gulf oil crisis of the 1970s and the sustained domineering influence of Russia especially with regards to gas supplies to Europe. Accordingly, in the context of mitigating energy poverty and achieving energy security in SSA, regional cooperation should be pursued in a way that allows countries or states within SSA to gradually develop sufficient capacity for regional interdependence in energy flows while maintaining national sovereignty over national energy resources.

To provide a better perspective on our arguments and recommendations on how countries within SSA can leverage regional cooperation towards mitigating energy poverty and achieving the SDG 7 target of "universal access by 2030", we summarise our policy recommendations into two groups. Within the first group, we provide a policy pathway that countries must adhere to within their national borders to be better prepared to take advantage of regional electricity cooperation and trading. Within the second group, we propose key focus areas that must guide regional cooperation within countries in the region. Additionally, we present a technology/innovation knowledge map (Fig. 6) that shows how global north and global south relationships can be better exploited for improved outcomes.

4.1. National pathway for mitigating energy poverty

The ESPs for the WAPP, SAPP, EAPP and CAPP regions (Figs. 2–5) indicate some level of increased electricity access among several countries. However, when fully contrasted with normalized annual electricity consumption per capita, some inconsistencies are observable: some countries like Nigeria, The Gambia, Djibouti, Sudan, Kenya, Sao Tome, Republic of Congo, report over 55% electricty access, yet have significantly lower annual electricty consumption per capita than others like Togo, Angola, Zambia, and Zimbabwe who report lower electricity access. The reason for the low annual electricity consumption per capita in the former group of countries could be low national electricity sufficiency or lower demand. The authors' personal experiences suggest that the former reason is more plausible: as several countries within SSA start to extend grid connections to households, should generation, transmission and distribution capacities not increase at par, electricity

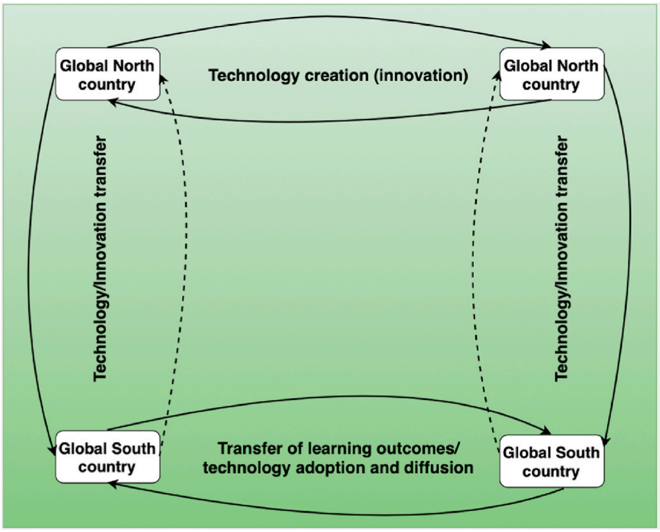

Fig. 6. Technology/Innovation relationship map.

availability would worsen.

Given that energy poverty is first a national problem, countries within SSA are primarily responsible for setting the pace for regional energy poverty mitigation through actionable policies that provide clear road maps to mitigating energy poverty within their borders. To be better prepared to benefit from regional electricity cooperation, we suggest that individual SSA countries:

- Develop an electrification master plan and a blended electrification approach with emphasis on distributed generation and productive use of electricity. Such an electrification plan should (ideally) be a single working document that details electricty access targets, current and future demand projects, mode of universal electrification (grid connection or off-grid), projected energy resource and ownership mix for generation, and network expansion schemes. This single document once developed, must translate into a well-designed, coordinated and implemented competitive procurement programs for electricity generation.
- Aim to achieve 100% electricity grid access for households. We do not make this bold demand carelessly, especially considering the difficulty in terrains within the region and the associated costs. However, we opine that it will be beneficial for countries within SSA to have the majority of households served through some form of electricity grids that centralise electricity generation at decentralised levels. The benefits of such decentralised-centralised systems are immense. First, such systems can be upgraded centrally and cheaply, with the extra costs passed down to customers through surcharges. Second, such systems, especially when they are capable of meeting the complete electricity needs of connected households can help reduce emissions significantly [5], considering that households can utilise electricity for cooking and heating needs without defaulting to easily accessible options like coal, firewood and biomass. Third, such systems are at a scale that makes its possible for them to be easily hybridised with renewables like solar and wind.
- Implement regulatory reforms to improve the influx of investments in new power projects. In countries with vertically integrated public utilities, such reform should include the unbundling of the vertically integrated utility to improve the operational efficiency of the generation, transmission, and distribution functional zones of the electricity sector; reduction of the barriers to entry posed to independent power producers, and a **gradual increase** in the share of renewable energy technologies (RETs) in the generation mix through transparent and efficient procurement and integration programs. We emphasize that **gradual increase** as opposed to rapid uptakes of RETs is more beneficial for SSA countries due to the intermittencies associated with the outputs of RETs, weak electricity grids, and the need for an optimal generation technology mix that does not undermine the progress of industrialization.
- Improve the sustainability of deployed projects through increased metering of all connected customers. SSA utilities face the daunting task of rates collection. Low rates collection raises concerns on the operational sustainability and viability of utilities and deployed projects. Additionally, the absence of metering capabilities engenders the appearance of 'rogue operators'[2] as is obtainable in Nigeria, where estimated billing has been adopted in meeting utility revenue requirements.
- Carefully assess the conditions guiding access to aids for electrification projects from various agencies to determine their alignment with national electrification objectives, and harmonise conflicting objectives. Due caution must be taken to avoid aids or grants that include conditions that undermine national sovereignty or hinders technology development/transfer and human resource development within the recipient nation. Overseas Development Assistance must seek to ensure that actual technology transfer takes place (Fig. 6). Furthermore, transparent monitoring of electrification aids is required to ensure that the funds are not diverted for other purposes.

4.2. Regional pathway for mitigating energy poverty

Cooperation at the regional level must transcend just electricity trading to a more unified structure that sets out the region's position with regards to relevant electricity statistics. Within such structure, cooperation must seek to achieve uniformity in the national policies and goals of member countries by leveraging broader instruments and policies to guide national policy formulation. To this end, regional cooperation must:

- Aim to achieve uniformity in benchmarking critical statistics like sufficiency, mobility, and emissions. Considering the opaque nature of the UN SDG 7, regional structures within SSA need to agree on what should constitute minimum benchmarks for sufficiency (kWh/individual/year), mobility (kWh/individual/year for individuals or kW/year for installed generation capacity), and emissions (tCO_2/individual/year) for member countries. This is necessary to guard against countries within the region adopting varied metrics, thus hampering progress towards the 2030 goal.
- Catalyse competition within the region by liberalising the electricity markets and facilitating increased participation of external players in electricity generation and transnational trading. Flexible regional agreements as opposed to bilateral contracts — usually with strong political underpinnings — are required for regional electricity market efficiency and system balancing during times of peak demand across regional power pools. Also, viable regional electricity markets that ensure the mutual benefit of all participants require the implementation of regulations against unfair state aids that can unduly favour certain national generation companies to the detriment of others.
- Ensure a balance between the financial and development objectives of power pool participation. For instance, Mozambique's peak demand is just about 41% of its operating capacity while it has an electricity access rate of only 31.1% [2], yet it exports over 50% of its generation through the SAPP, mainly to SA's Eskom [35]. This indicates that skewed focus on power wheeling to regional power pools solely for the financial benefits of participating generators might

[2] While we do not intend to cast aspersions on electricity distribution companies in Nigeria (DISCOs), we highlight their perverse practices of utilising estimated billing as a means of cost recovery (especially as it constitutes a significant portion of their revenue generation strategy).

detract from local electricity access and development gains for some countries.

5. Conclusion

The limitations of geography occasioned by artificial boundaries drawn by colonial powers have rendered most modern African states unviable energy-wise. This dictates the need for a more cooperative approach across the constituent SSA states in order to address their energy challenges. Some of the countries are landlocked, while the major rivers are non-navigable and unsuitable for energy production. The few energy infrastructures across most African states were created by foreign colonial powers without anticipation for future developments; the succeeding governments have not been able to overcome the vestiges of their colonial pasts. For effective regional cooperation towards achieving UN SDG 7, measures must go above and beyond some vague “universal access to energy” to address the real culprit – energy poverty through the tripartite lenses of access, sufficiency, and mobility. Furthermore, regional cooperation for addressing energy poverty must be predicated on national independence and leverage on the transfer of learning outcomes among countries with similar socioeconomic indices (see Fig. 6). Regional bodies must thus work in tandem with member countries in evolving policies at both the national and regional levels to chart a sustainable pathway towards achieving significant impact.

Additionally, on the issue of national energy sufficiency, it is important for countries within the region to pursue regional cooperation on the basis of improved energy security. The ESPs presented in this paper and inferences from selected instances in Europe and the gulf region indicate that a country that is over-reliant on an external country for meeting a significant portion of its energy need has a high risk of energy insecurity. The ongoing coronavirus pandemic and the associated politicking involving equitable distribution of vaccines and the liberalisation of vaccine production rights strongly indicate that increased self-sufficiency is necessary to avoid external influences over national sovereignty. Countries in the SSA region need to ensure a balance between improving local network capacity and efficiency, and leveraging the integrated electricity network to achieve some level of self sufficiency, as well as improve network reliability and service delivery through competition. Acknowledging the inherent disparities in national priorities amongst SSA countries within each power pool, participating countries will have to be realistic about their current deficit and maximising their comparative advantage in electricity generation.

Since energy poverty is necessarily a national problem, regional cooperation must transcend electricity trading to interventions for mitigating electricity poverty in each country within the region. Importantly, national sovereignity must be at the foundation of all interventions. The regional pathway to mitigating energy poverty proposed in this paper is a more unified structure which allows an effective sharing of excess electricity from the individual countries within the region. Lastly, the narratives of the bandwagon who call for a so-called just transition or low-carbon transitions have been avoided in this paper [80–84]. While the world can benefit from a diversified energy mix that is more renewables focused, SSA and by extension the global south will benefit more, FIRST, from having electricity that is stable, cheap, and can continue to meet her energy needs in the long-term. Considering the many paradoxes being experienced in low-carbon energy transitions across the world, especially in the global north [85], it would be best for the global south to pursue the proliferation of a sufficient electricity generation base with improved transmission and distribution networks before joining the global decarbonisation drive. While some critics suggest that this proposition is short-sighted, the local realities and the very low contribution of the global south (especially SSA) to global emissions (on a per capita basis) is sufficient enough reasons for the region to be supported in exploring “whatever available and viable means possible” to meet its huge unmet energy needs and plug projected deficits.

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Author contributions

Conceptualization (CGM, KOA, OO), methodology (all authors), writing – review and editing, all authors.

Declaration of competing interest

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