EVOLVING COMPETITIVE MARKETS IN SAPP

Leveraging Competitive Wholesale Electricity Markets To Drive Renewable Generation Capacity in the Southern African Power Pool (SAPP)

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List of Acronyms

BM:	Balancing Market
CEC:	Copperbelt Energy Corporation
CERC:	Central Electricity Regulatory Commission
CRIE:	Central American Regulatory Commission on Electrical Interconnection
DAM:	Day-Ahead Market
DRC:	Democratic Republic of Congo
EAPP:	Eastern Africa Power Pool
EDM:	Electricidade de Mozambique
EEC:	Eswatini Electricity Company
ESCOM:	Electricity Supply Corporation of Malawi
ESKOM:	Electricity Supply Commission (South Africa)
EXCO:	Executive Committee
FPM-M:	Forward Physical Market (Monthly)
FPM-W:	Forward Physical Market (Weekly)
GDP:	Gross Domestic Product
GHI:	Global Horizontal Irradiance
HCB:	Hidroeléctrica de Cahora Bassa
HHI:	Herfindahl-Hirschman Index
IDM:	Intraday Market
IPP:	Independent Power Producer
ISO:	Independent System Operator
ITC:	Independent Transmission Company
LEC:	Lesotho Electricity Corporation
LHPC:	Lunsemfwa Hydro Power Company
MANCO:	Management Committee
MIF:	Market and Implementation Framework
MOTRACO:	Mozambique Transmission Company
MSB:	Modified Single Buyer Model
NAPP:	North African Power Pool
NPU:	National Power Utility
NTCSA:	National Transmission Company of South Africa
OASIS:	Open Access Same Time Information System
OU TSO:	Ownership Unbundled Transmission System Operator
PAU:	Project Advisory Unit
PEAC:	Pool Energetique De L'Afrique Centrale
PPA:	Power Purchase Agreement
REC:	Renewable Energy Credit
REFIT:	Renewable Energy Feed-in-Tariff
REIPPPP:	Renewable Energy Independent Power Producer Procurement Programme
RERA:	Regional Energy Regulators Association of Southern Africa
RNT:	Rede Nacional de Transporte de Electricidade
RTIFF:	Regional Transmission Infrastructure Financing Facility
RTO:	Regional Transmission Operator
SADC:	Southern African Development Community
SAPP:	Southern African Power Pool
SAPP-CC:	SAPP Coordination Center
SARERA:	Southern African Regional Energy Regulator Authority
SNEL:	Société Nationale d'Électricité
TANESCO:	Tanzania Electricity Supply Company Ltd

TSO:	Transmission System Operator
VRE:	Variable Renewable Energy
WAPP:	West African Power Pool
ZESA:	Zimbabwe Electricity Supply Authority
ZESCO:	ZESCO Limited

Executive Summary

The SADC region has significant natural resource potential to increase renewable energy generation, improve electricity reliability, and support economic development.

The establishment and growth of the Southern African Power Pool (SAPP) competitive electricity markets has been an important achievement, initially fostering cooperation, followed by a shift to competition, using these markets to contribute to the region's electricity needs. Despite the considerable progress, development and growth of the SAPP competitive markets since their inception in the early 2000s, further progress is needed given the existing level of unmet electricity demand and the still relatively low level of competitive regional market volumes. In particular, significant new investment in transmission and generation infrastructure is needed to meet the region's electrification goals. Most of the region's state-owned utilities and their governments, which have historically financed the development of the electricity system, are under economic stress and have limited capacity to provide the necessary capital for system expansion. In theory, private sector capital, in addition to public sector contributions, or appropriately structured public-private partnerships, could support the expansion of the interconnected electricity transmission grid and the development of new generation resources in the SADC region.

Our research indicates there are reasons to believe electricity infrastructure investors lack confidence in SAPP wholesale electricity markets, which increases risk perception and lowers the likelihood of capital deployment. We also found there are numerous barriers to new market entry, likely eroding project viability and developer interest.

Our research reached these conclusions after identifying, characterizing, and prioritizing barriers to well-functioning competitive markets and renewable energy deployment in the SAPP, as well as solution options within the SAPP's purview. These barriers and solutions were initially identified through a literature review and then refined and expanded through semi-structured interviews with a wide range of stakeholders in the SAPP region. The barriers were characterized by which key principle of perfectly competitive markets the barrier affects, as explained by economic theory. We then prioritized the development of solution options to address the barriers identified as most significant based on the ranking of the barriers by stakeholders through feedback forms. Finally, our findings were presented to stakeholders at a SAPP workshop in September 2024 for further refinement.

Competitive market obstacles (Section 3.1) were primarily characterized in terms of supplier market concentration, creating barriers to market entry, limited market buyers, and lack of available data. Stakeholders identified the top three obstacles to well-functioning competitive markets as: 1) Insufficient transmission infrastructure for interconnection and/or regional movement of electricity, 2) Dominance of the single-buyer market, and 3) Lack of or weak nation-state regulatory frameworks to support regional SAPP activities.

Renewable energy project development obstacles (Section 3.2) were almost exclusively characterized as creating barriers to market entry. Stakeholders prioritized the top three obstacles as: 1) Lack of viable commercial arrangements for variable renewable energy (VRE) balancing, 2) Lack of functional and consistent nation-level regulations, and 3) Higher project costs related to reliance on imported renewable energy equipment.

With respect to potential solution options within SAPP's purview (Section 4.2), stakeholders prioritized: 1) Development of new cost allocation and other finance methods to facilitate new transmission expansion, 2) Training to educate new or potential new market entrants on SAPP processes, and 3) Modeling and analysis of regional SAPP participation benefits disaggregated to the nation-state level.

The research team presents potential implementation strategy options from a global solutions inventory developed during this research (in Section 4.1 and Appendix B), based on stakeholder prioritization of obstacles. This led to strategy options focusing on reducing barriers to market entry and improving investor confidence in markets through reforms in three key areas described further below.

Strategy Option: Transition SAPP to a regional transmission operator (RTO) for operation and planning of cross-border transmission facilities and market administration.

- A SAPP RTO would independently operate cross-border transmission facilities (i.e., interconnectors), while ownership and maintenance of these facilities would remain unchanged.
- Open access transmission and enabling transmission tariffs with rate unbundling would be required for all cross-border facilities, as well as establishment of a public system to disclose and procure available transmission capacity.
- A SAPP RTO would conduct SAPP region-wide transmission expansion planning for cross-border capability (enabling intraregional transmission expansion would remain unchanged), facilitate competitive procurement of transmission infrastructure through an open bidding process with cost-reflective tariffs, consistent cost allocation mechanisms for cost recovery, and availability incentives.
- A SAPP RTO would administer competitive markets that incorporate congestion into locational energy prices, facilitate new trading and off-take arrangements that allow consumers and IPPs to transact directly (without restrictions), and ensure critical markets (e.g., balancing) are functional.

Strategy Option: Transition operation of SAPP member transmission systems to Independent System Operators (ISOs).

- State-owned, vertically integrated utility transmission systems to be operated independently by ISOs. Ownership unbundling of these assets could also be explored but is not a necessary enabler.
- Transition transmission tariffs to facilitate open-access requirements to the system with cost-reflective unbundled rates for customer service and an open, real-time, dynamic platform for viewing and procuring available transmission capacity. These requirements would apply to national transmission systems, as opposed to the cross-border facilities addressed in the previous set of strategies.
- Integrate open and transparent regional transmission planning with national planning that includes opportunities for competitive procurement of transmission solutions and consistent and viable methods of cost allocation and recovery methodologies.

Strategy Option: Establish a regional regulatory authority and enhance data transparency.

- Establish a region-wide regulatory authority for the SADC region to oversee cross-border transactions and facilities, and to ensure alignment with enabling in-country transmission facilities for wheeling. This regional regulator would aim to harmonize regulations across the region, develop and implement the necessary rules and standards for well-functioning markets, and encourage member states to take certain actions within their respective jurisdictions.
- Establish an independent market monitoring body with responsibility for detecting anti-competitive behavior and with sufficient authority to take action to mitigate such behavior or to refer such behavior to a regional (and/or national) regulator. Since a market operator should not be a market monitor, this could be implemented in a separate entity as an enhanced form of the existing market monitoring role of the Southern African Power Pool Coordination Center (SAPP-CC).
- Develop enhanced data-sharing and market transparency requirements to enable better decision making for buyers, sellers, and other market participants, and to facilitate market monitoring.

Implementing these reforms is expected to be challenging, but not insurmountable, given the domestic political, legal, and jurisdictional complexities of the SADC region.

It should be noted that the political, legal, and jurisdictional complexities associated with implementation of these strategy options have not been addressed in detail in this research. However, the strategy options presented are generally consistent with the Regional Energy Regulators Association of Southern Africa (RERA) 2015 Market and Implementation Framework (MIF) and 2016 MIF Implementation Plan (approved by SADC energy ministers in 2016), as well the solutions of the Regional Association of Energy Regulators of Eastern and Southern Africa (RAERESA), SADC, and many others. These documents detail the implementation considerations that may be required to advance significant reforms and are included for reference and further consideration in this research. We further recognize that the strategy options identified in this research represent a shift towards an improved market architecture for the region to enable increased competitive regional trade and renewable energy deployment.

As part of this research, we do not consider the state of readiness of individual SAPP member states for potential reforms, as this was beyond the scope of this research and is generally captured in the implementation resources of RERA, SAPP, RAERESA, and SADC (amongst others). It is recognized that the transition towards the envisioned market architectures based on the presented strategy options is likely to be incremental and will require political will as well as regulatory framework changes. This may require some market participants to lead while others follow as is currently the case for selected countries in the SADC region.

The SADC region could continue with the status quo of slow and constrained electricity system growth and low use of competitive wholesale markets in the SAPP. On the other hand, the introduction of broad-based reforms could pave the way for new market entry and infrastructure growth. Implementing these transformational reforms will inherently reduce the control of incumbent national utilities over the existing electricity system, which is as a prerequisite for developing a more independent and competitive electricity sector. If reforms are pursued, it may be critical to not just understand the benefits of more independent and competitive regional electricity markets, but also to explore how national utilities in their current form that are potentially negatively impacted by these reforms can successfully adapt and redefine their roles as the sector evolves.

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1 Introduction

Despite exhibiting the lowest energy use per capita, with 75% of the population lacking access to electricity, Africa holds immense energy demand potential. In 2022, 600 million people, or 43% of the continent's population, did not have access to electricity, with 98% of those in sub-Saharan Africa [1]. With 60% of the world's technical solar resource potential, 11% of its hydropower potential, and 3-5% of its wind potential [2], [3], [4], the African continent holds a potentially transformative path towards renewable energy supply to meet growing continental and international energy demand. This significant renewable energy potential offers the opportunity to harness clean energy at competitive costs, fostering energy security and promoting economic development across the region. According to various projections, renewable energy sources could account for 50-80% of new electrical generation capacity additions by 2030, predominantly driven by solar, wind, hydropower, and geothermal [1] [2] [5]. The transition towards increased renewable energy use is a pivotal aspect of Africa's energy trajectory, with projections indicating that renewables are expected to dominate new electrical generation capacity additions by 2030 [1], [5], [6]. This shift not only aligns with global sustainability goals but also addresses Africa's escalating energy demands while reducing carbon emissions.

Increasing electricity supply is crucial for improving energy access for the continent's growing population and fostering economic development. Reliable and sufficient electricity is fundamental to supporting industrial activities, enhancing educational and health care services and improving the overall quality of life for the more than 1.5 billion people living on the continent in 2024. Currently, many Southern African nations suffer from unreliable electricity supply, with frequent outages disrupting businesses, reducing productivity and increasing operational costs, leading to significant losses [7]. In South Africa, for example, load shedding led to a reduction in GDP growth by as much as 2% in 2023, with projected economic growth expected to be just 0.3% for the year. Additionally, sectors such as industry, commerce, and agriculture have lost between 11-14% of productive business hours due to outages [8].

The Southern African Power Pool (SAPP) as a regional wholesale electricity market in Southern Africa was established in 1995 initially to promote regional co-operation and sharing of resources. Following this, the SAPP has evolved to become a competitive regional electricity market with several trading mechanisms for competitive regional electricity trade. The SAPP stands at the forefront of the continent's energy transition as the most advanced regional electricity market, with an opportunity to leverage its advanced infrastructure and expanding centralized markets to enable cost-effective competitive energy trading among its members. While there remains significant untapped potential for further integration of renewable energy into the region's resource mix, harnessing this potential could yield considerable benefits, including cost reductions, increased inter-regional trade, enhanced management of renewable resources, progress in decarbonization efforts, and increased grid reliability. However, significant challenges persist in meeting the continent's energy needs. For instance, SAPP's actual matched and traded demand on the competitive market ranges between 150 MW - 300 MW, while an additional 800 MW typically remains unmatched and unserved. Bilateral volumes account for approximately 10,000 MW, with served regional demand reaching around 60,000 MW and an estimated unserved demand of 10,000 MW. Addressing these challenges through the effective use of competitive wholesale electricity markets and integration of renewable energy could help mitigate electrical energy shortages and improve energy security across the region.

This report is structured as follows:

- **Section 1** (this section): Provides the motivation and context for the study.
- **Section 2**: Provides an overview of SAPP market arrangements.
- **Section 3**: Presents obstacles to competitive markets and renewable energy deployment in the region.
- **Section 4**: Details potential solution options to increase renewable energy capacity and improve the functioning of SAPP competitive markets.
- **Section 5**: Provides strategy options that connect identified barriers to solution options for a potential set of SAPP reforms.
- **Section 6**: Concludes the report.

2 Overview of the Southern African Power Pool (SAPP)

The SAPP, the most advanced power pool in Africa,[1] was formed in 1995 and currently includes 12 countries in the Southern African region with 22 market participants (as of July 2024). SAPP members are illustrated in Table 1. SAPP members fall within three main categories: 1) national power utilities, 2) operating members, and 3) market participants. National power utilities dominate SAPP membership, while other membership categories including operating members and market participants have had a smaller role thus far. Operating members and market participants can include Independent Power Producers[2] (IPPs) and Independent Transmission Companies[3] (ITCs).

The region shifted from initial co-operation and regional electricity resource-sharing when established in 1995 to a more competitive set of wholesale electricity markets over time. These competitive markets have taken the form of monthly forward physical market (FPM-M), weekly forward physical market (FPM-W), a day-ahead market (DAM), intra-day market (IDM) and balancing market (BM) [9], [10]. The interconnectors between national power systems of the Southern African region and their transfer capability (in 2024) are shown in Figure 1, along with each regions' peak demand (for 2023) and their dominant electricity resource. This illustrates the relative sizes of each national power system, existing resource diversity in the region and how most SAPP members are operational members (operating synchronously) whilst some are currently non-operating members (not yet interconnected – Angola, Malawi, Tanzania, Madagascar) [11].

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[1] Other power pools in Africa currently include the Eastern Africa Power Pool (EAPP), the Pool Energetique De L'Afrique Centrale (PEAC) (i.e., Central African Power Pool [CAPP]), the West African Power Pool (WAPP), and Comité Maghrébin de l'Electricité (COMELEC) (i.e., the North African Power Pool [NAPP]).
[2] An IPP is a "corporation, person, agency, authority, or other legal entity or instrumentality that owns or operates facilities for the generation of electricity for use primarily by the public, and that is not an electric utility."
[3] An ITC is an entity that owns and operates transmission infrastructure, independently from electricity generation and distribution companies. ITCs are responsible for the reliable transmission of electricity from generation facilities to distribution networks and large consumers.

Table 1. List of SAPP Members and Country

SAPP Member Name	Member Type	Country
National Power Utilities		
Botswana Power Corporation (BPC)	NPU	Botswana
Electricidade de Mozambique (EDM)	NPU	Mozambique
Eswatini Electricity Company (EEC)	NPU	Swaziland
Electricity Supply Corporation of Malawi (ESCOM)	NPU	Malawi
National Transmission Company of South Africa (NTCSA)	NPU	South Africa
Lesotho Electricity Corporation (LEC)	NPU	Lesotho
NamPower	NPU	Namibia
Rede Nacional de Transporte de Electricidade (RNT)	NPU	Angola
Société Nationale d'Électricité (SNEL)	NPU	DR Congo
Tanzania Electricity Supply Company Ltd (TANESCO)	NPU	Tanzania
ZESCO Limited (ZESCO)	NPU	Zambia
Zimbabwe Electricity Supply Authority (ZESA)	NPU	Zimbabwe
Operating Members		
Copperbelt Energy Corporation (CEC)	ITC	Zambia
Hidroeléctrica de Cahora Bassa (HCB)	IPP	Mozambique
Lunsemfwa Hydro Power Company (LHPC)	IPP	Zambia
Mozambique Transmission Company (MOTRACO)	ITC	Mozambique
Ndola Energy Corporation (Ndola)	IPP	Zambia
Market Participants		
GreenCo Power Services Ltd	IPP	Zambia
Enterprise Power DRC	IPP	DR Congo
Maamba Collieries Limited	IPP	Zambia
Nyangani Renewable Energy	IPP	Zimbabwe
Solarcentury Trading	IPP	Namibia

NPU – National Power Utility; IPP – Independent Power Producer; ITC – Independent transmission Company

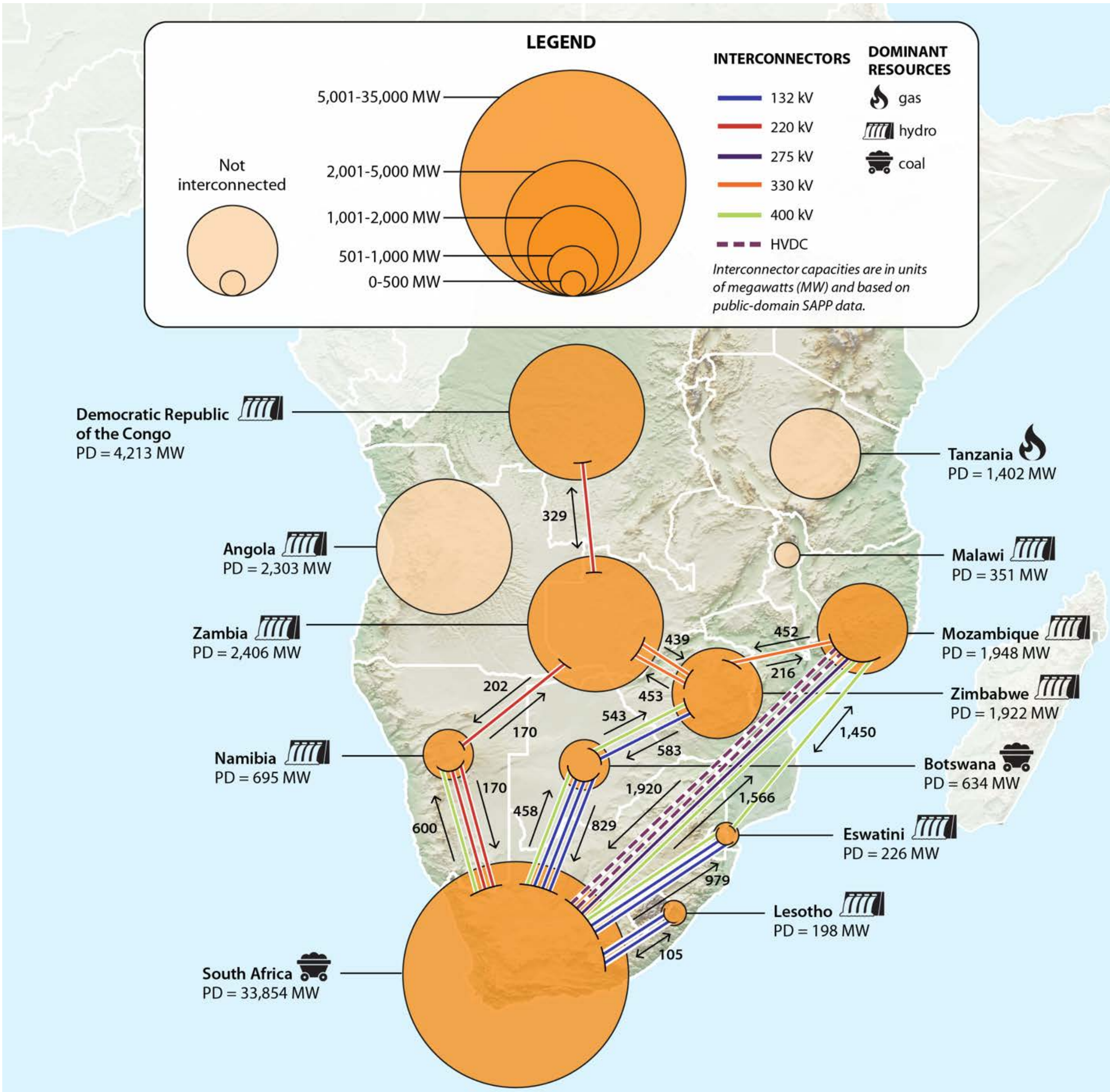

Figure 1. SAPP transmission interconnectors (2024)

Based on SAPP public domain data presented in [11]

As shown in Table 2, the large majority of demand in the SAPP region is located in South Africa (≅34 GW), followed by DRC (4.2 GW), Zambia (2.5 GW), Angola (2.3 GW), Mozambique (1.9 GW) and Zimbabwe (1.9 GW) [12]. ESKOM (South Africa) also has the largest supply of installed and operating capacity, but with lower plant performance exhibited by substantial electricity deficits (almost 9 GW), with other countries in similar deficit conditions (DRC, Eswatini, Lesotho and Zambia amongst others). In 2021, the SAPP region's generation mix was 59% coal-based electricity, 24% hydroelectricity, 4% distillate fuels, 4% solar PV, 3% nuclear, 3% wind, 2% gas, and ~1% other sources [12]. Electricity supply excesses are noted for 2023 in Angola and Mozambique. As a further illustration of chronic shortfalls of electricity in the region, South Africa has experienced increasing levels of electricity shortages since 2009 and culminating in outages for 78% of the hours in 2023 (≅ 6800 hours) and an estimated 16.6 TWh of unserved energy (7.3% of total system demand, based on data from [13]).

Table 2. SAPP Demand and Supply Data (August 2023)

Country	Installed Capacity (MW)	Operating Capacity (MW)	Peak Demand (MW)	Peak Demand Plus Reserves (MW)
Angola	6,020	4,947	2,303	2,803
Botswana	892	630	634	701
DRC	2,819	2096	4,213	4,522
Eswatini	71	65	226	259
Lesotho	74	70	198	213
Malawi	506	330	351	380
Mozambique	2,796	2,642	1,948	2,240
Namibia	624	370	695	765
South Africa	60,326	28,372	33,854	37,443
United Republic of Tanzania	1,822	1,741	1,402	1,612
Zambia	3,493	2,650	2,406	2,589
Zimbabwe	2,771	1,952	1,922	2,118
Total (All)	**82,214**	**45,865**	**50,152**	**55,645**
Total (Interconnected Only)	**73,866**	**38,847**	**46,096**	**50,850**

Historically, a significant proportion of energy traded on SAPP's competitive markets could not be executed due to transmission constraints (driven by existing bilateral contracts) or could not be matched due to pricing mismatches [14]. In the 2018/2019 SAPP reporting year, SAPP reached an all-time high of 32.3% competitive market share (see Section 3 for further historical trends) [12]. Generally, the current SAPP market effectively operates as a facilitation of trade between national utilities, focused on opportunistic trade of surplus generation or shortfalls in consumption (in normal and potential emergency situations). These trades are also generally constrained by available transmission capacity on cross-border interconnectors, which has historically constrained the volumes of international trade [15]. It is also worth noting that transmission constraints were less severe during 2018/2019, with 13.1 GWh (0.7% of matched energy) going untraded due to transmission constraints—down from 28.4 GWh (1.3%) the previous year. The inadequacy of cross-border transmission infrastructure has long been a known bottleneck for fully utilizing the region's generation capacity, preventing energy exchange between countries. Moreover, Angola, Tanzania, and Malawi remain isolated from the SAPP interconnected grid, further restricting the ability to share further new generation capacity with other SAPP members [16].

SAPP wholesale markets are implemented in the SAPP Market Trading Platform (MTP). The supporting documentation that describes this platform and ownership of the system sits with the SAPP-CC and is not available publicly or through a structured access regime (as a new market entrant). This adds risk and complexity to understanding and participating in SAPP markets (even for existing market participants), let alone new market entrants [15]. Moving forward, opportunities to address transmission constraints, pricing mismatches, data/information transparency as well as additional offerings within SAPP's existing markets, could increase SAPP's competitive market share [15] .

2.1 Renewable Energy Resource Potential in the SAPP Region

Hydropower is currently one of the dominant sources of electricity in many African countries. It contributes about 17% of the continent's total electricity generation. In specific countries like the DRC, Zambia, Mozambique, and Zimbabwe, the share of hydropower in the energy mix is significantly higher, often exceeding 80% of electricity production [17], [18]. Estimates suggest that Africa's total technical hydropower potential is around 1,800 terawatt-hours (TWh) annually, but only a small fraction of this, around 11%, is currently exploited. This substantial untapped potential exists mostly in the Congo River basin and Zambezi River Basin capable of supporting large-scale hydropower projects, shared by countries like the DRC, Zambia, Zimbabwe, and Mozambique. Hydropower has long been regarded as a cornerstone of the African energy mix due to its ability to provide dispatchable renewable electricity displacing carbon and pollutant emitting alternatives. Additionally, its integration into the renewable energy mix can help balance the variable nature of variable renewable energy (VRE) sources like solar and wind. This is particularly important as the continent ramps up its renewable energy targets to meet growing energy demand while reducing dependence on fossil fuels. However, overreliance on hydropower poses risks, particularly due to variability in rainfall patterns and the resultant impact on water reservoir levels. Prolonged droughts in hydropower-dependent countries like Zambia and Zimbabwe have already caused numerous electricity shortages in recent history, highlighting the vulnerability of these systems to natural variability and potential further climate change impacts. As hydropower infrastructure is highly sensitive to fluctuations in river flow, it is imperative to diversify the energy mix and incorporate other renewable energy sources.

Africa has a high global solar irradiation, with average yearly levels exceeding 2,000 kWh/m^2. This makes the continent one of the most promising regions globally for solar energy generation, with a total technical potential estimated at over 60,000 TWh/year, representing nearly 40% of estimated global solar resource [19]. As seen in Figure 2, resource quality in most parts of Southern Africa exceed 5.5 kWh/m^2-day with most areas of Namibia, South Africa, Botswana, Zimbabwe and Zambia exceeding 6 kWh/m^2-day), highlighting how most countries have a good to sometimes excellent solar resource for viable solar projects.

For onshore wind, resource quality in parts of Namibia, South Africa, and Botswana have the highest wind speeds and resulting power densities (as shown in Figure 3), making them ideal for wind energy deployments in the SAPP region [20]. This does not preclude other countries for wind development in any manner but is instead intended to highlight countries in the region with the best technical wind resource.

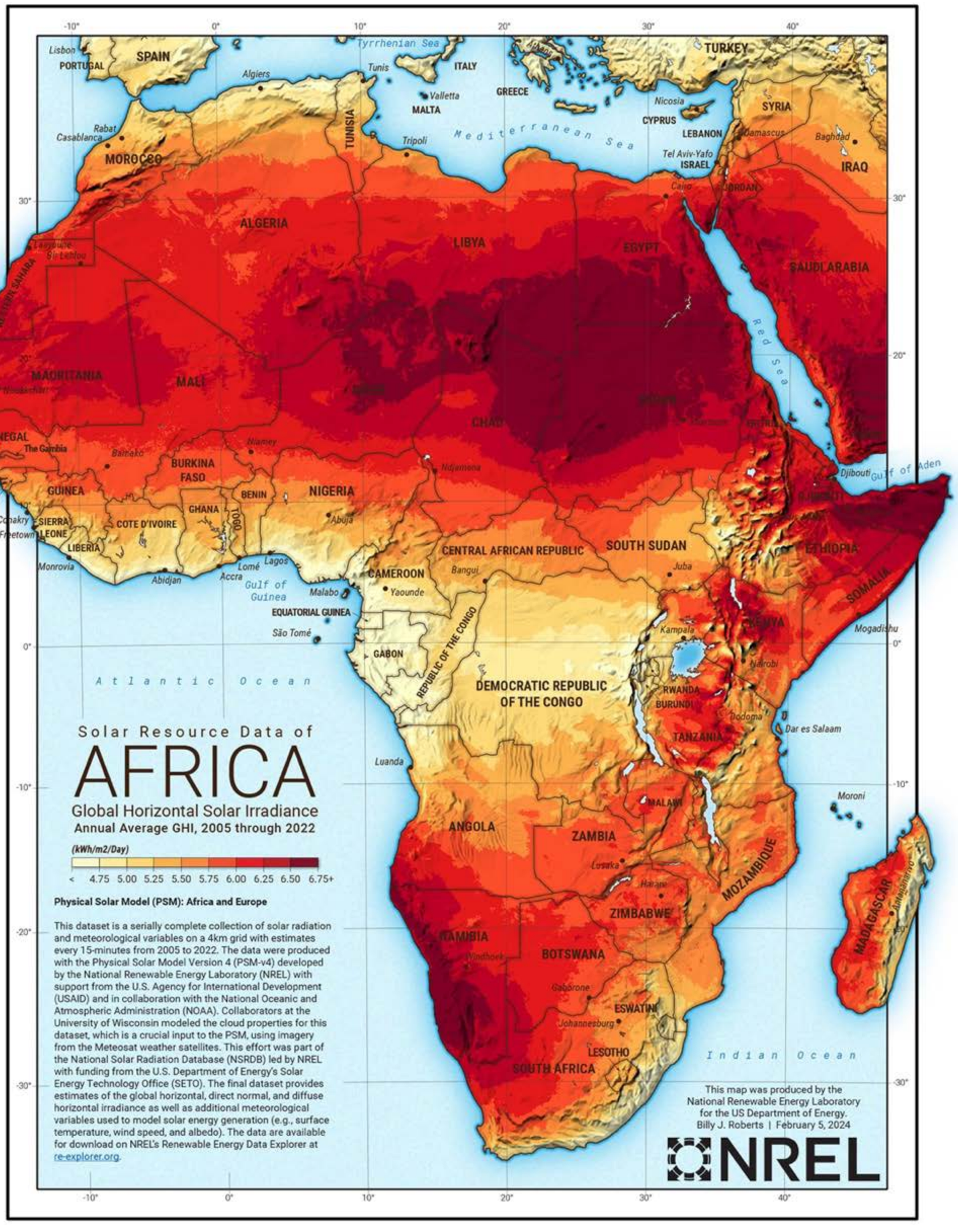

Figure 2. Africa's Global Horizontal Solar Irradiance (GHI) (generated from [21])

Solar resource is demonstrated through Global horizontal irradiance (GHI) (applicable for solar PV resources)

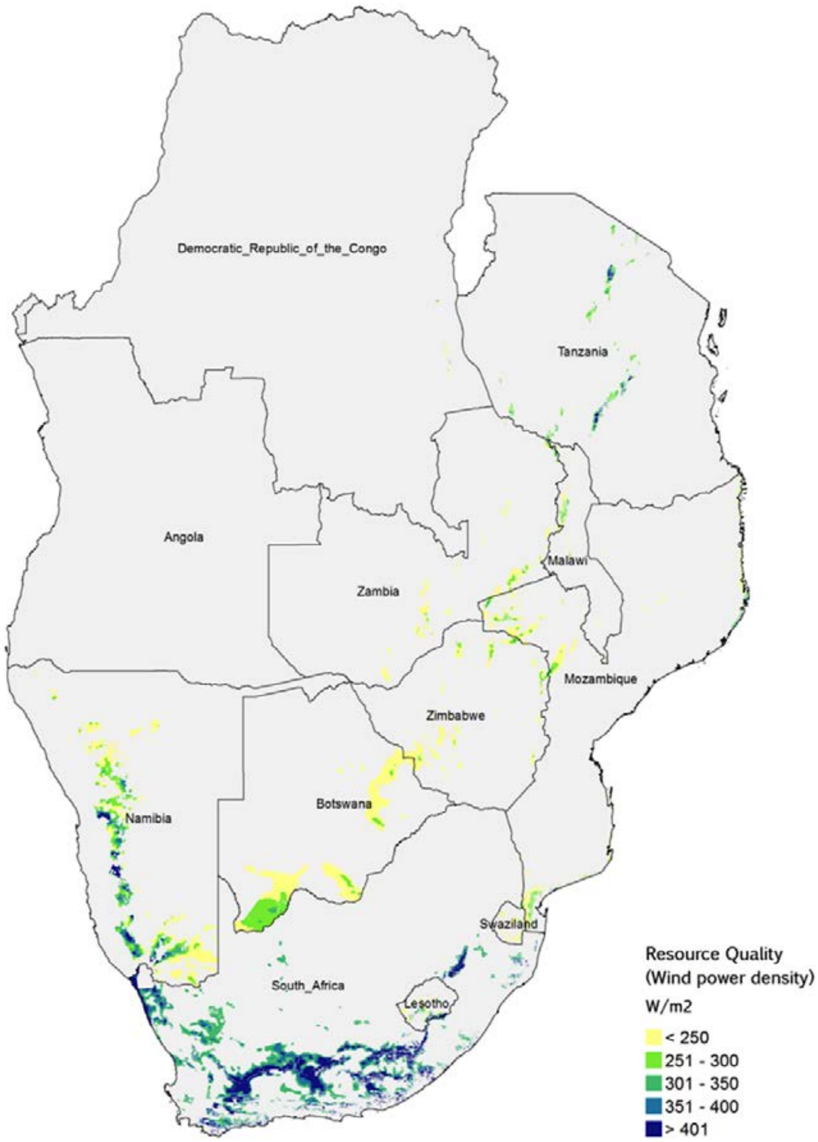

Figure 3. Wind power density of wind resources in the SAPP [6]

Map is filtered based on multi-criteria analysis undertaken in [6]

2.2 SAPP Authority and Market Arrangements

The SAPP was created in 1995 by the Southern African Development Community (SADC) via an Inter-Governmental Memorandum of Understanding to form an electricity power pool within the region. While a regional organization with members from twelve countries, the SAPP does not have direct authority or influence over the member countries or participants [22]. SAPP member countries regulate their own electricity sectors, including any generation units and infrastructure within their country's borders. This includes any legislative, regulatory, and rules changes. All Independent Power Producers (IPPs) are held to the regulatory standards outlined by their corresponding host nation. SAPP's authority is limited to managing operations and transactions on transmission interconnections between members and the use of intermediate, transit, or wheeling in a third country for transactions between members [22]. The individual countries regulate electric generating sources and infrastructure to the delivery point at the interchange border.

The interconnected high-voltage transmission system in the Southern African region is controlled by three operators providing control area services that balance generation with demand and interconnector power flows as follows:

- **Eskom control area:** Eskom (South Africa), Botswana, Lesotho, Southern Mozambique, Namibia, and Swaziland.
- **ZESCO control area:** Zambia (including ZESCO and CEC) as well as DRC (SNEL).
- **ZESA control area:** Zimbabwe (ZESA) and Northern Mozambique (EDM (North) and HCB).

Currently, regional electricity trading in SAPP is predominantly through bilateral agreements[4] supplemented by SAPP competitive market trading. The region originally focused on co-operation and regional resource-sharing, then transitioned to more competitive wholesale electricity markets, which were introduced in 2016 within the SAPP MTP. This included a range of competitive markets summarised below [9]:

1. **Monthly forward physical market (FPM-M)** where hourly contracts are concluded for a month ahead.
2. **Weekly forward physical market (FPM-W)** where hourly contracts are concluded for a week ahead.
3. **Day-ahead market (DAM)** where hourly contracts are concluded for each hour for the next day.
4. **Intra-day market (IDM)**, which is a continuous market where trades are concluded up to one hour before delivery.
5. **Balancing market (BM)**: newly introduced, aimed at providing real time balancing services (generation and consumption) to SAPP system operators based on a competitive market.

Even with these markets, most regional electricity trade in the Southern African region still comprises bilateral contracts between national utilities. Between 2014-2020, 80-90% of interregional electricity trade was conducted through bilateral contracts, which are still predominately fossil fuel-based [23], and is further demonstrated in Section 3.

The historical and continued preferences by national power utilities for bilateral electricity trade in SAPP relative to competitive wholesale electricity trade limits the ability to trade on competitive SAPP markets and potentially improve economic efficiency of electricity trade (see Section 3 for more specifics on this). This is further exacerbated by other drivers, including fragmented domestic regulatory frameworks and inter-regional transmission constraints. The absence of new interconnector transmission capacity and seeming lack of appetite for market-based transactions limits opportunities for renewable energy investment and growth despite large potential for renewable energy in the region. In turn, opportunities are forestalled to meet expected electricity demand growth, achieve decarbonization goals, and capture significant savings for generation and transmission costs.

[4] Bilaterial agreements are directly between the buyer and seller for either short- or long-term and for firm or non-firm energy.

2.3 SAPP Governance Structure and Regulatory Oversight

SAPP is accountable to the SADC Integrated Council of Ministers, which comprises SADC Energy Ministers. The SAPP is governed by four main agreements, descriptions of which can be found below:

1. Inter-Governmental Memorandum of Understanding
    A. This is the original founding document establishing SAPP. This was signed in 1995 and updated in 2006 by member countries. This allows domestic utilities and suppliers to participate in SAPP.
2. Inter-Utility Memorandum of Understanding
    A. This document created management and operating principles while expanding SAPP. This includes any electricity supply from SADC or non-SADC to join SAPP as a member.
3. Agreement Between Operating Members
    A. This document established the rules of operation and pricing for the interconnection portion of SAPP. This includes how members will coordinate, cover expenses, share benefits, and maintain system reliability.
4. Operating Guidelines
    A. This document includes the technical aspects of SAPP, including standards and operating guidelines for SAPP members. All interconnected utilities must comply with the requirements within the Guidelines to ensure utilities operate the system safely, efficiently, effectively, and in a sustainable manner.

Additional governing documents can be approved as necessary through the appropriate governance structures, as summarized in Figure 4.

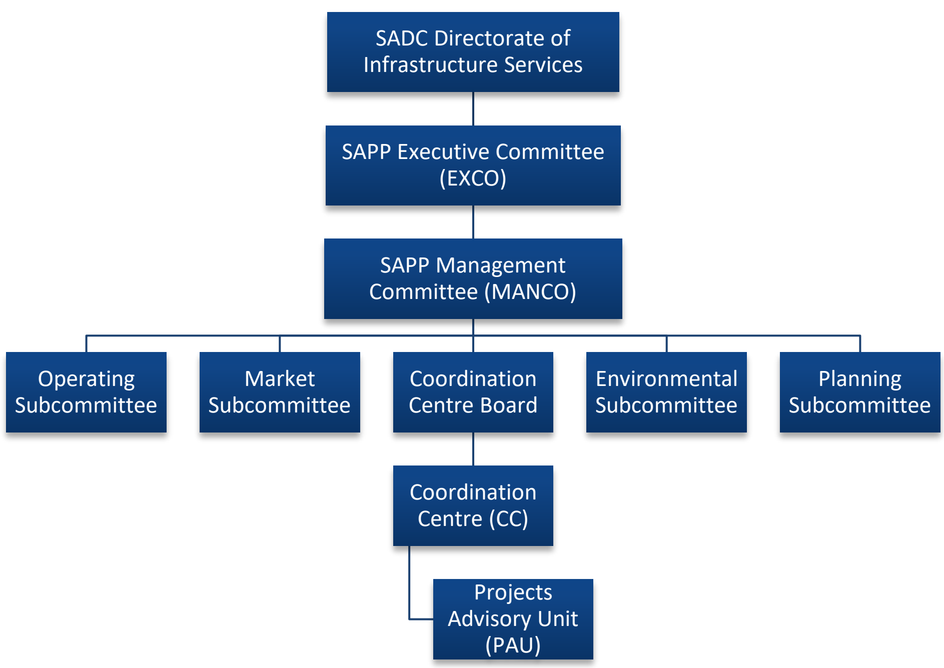

Figure 4. SAPP governance structure

Figure created using publicly available information.

The SAPP is managed by SAPP members through the SAPP Executive Committee (EXCO), the SAPP Management Committee (MANCO), the SAPP-CC, as well as four technical area subcommittees including the Operating Subcommittee, Markets Subcommittee, Planning Subcommittee, and Environmental Subcommittee. The EXCO includes the chief executives of all SAPP members. The MANCO includes senior executives of SAPP members. The SAPP-CC manages and operates SAPP as full-time staff members under the SAPP-CC Board or senior executive members of SAPP. SAPP's Project Advisory Unit (PAU), which is part of the SAPP-CC structure, is responsible for the preparation and implementation of identified priority projects within SAPP. SAPP's PAU utilizes grant funding and is based in Johannesburg, South Africa.

Additional working groups can be created by the three main committees and the four subcommittees. These working groups may be focused on specific topics requiring further research with subject matter experts; however, these experts do not need to be SAPP members. Currently, there are three permanent working groups that support the EXCO, MANCO, and SAPP-CC with technical expertise and operational support. These include the Human Resource Working Group, the Finance Working Group, and the Legal Working Group.

SAPP committees and subcommittees have bi-annual meetings to discuss SAPP operations. MANCO meets with various subcommittees and the EXCO meets shortly after the MANCO meetings to discuss and consider solution options from MANCO. EXCO is required to accept new members as SAPP membership grows, meaning new chief executive officers from all members are included in EXCO. In addition to these meetings, there is an annual Traders and Controllers Forum for operational staff to discuss trading and operations of SAPP. Matters addressed during the Forum may be flagged for discussion with the SAPP Subcommittees for consideration.

Subcommittee and committee meetings are attended by member representatives. The meetings rotate and are hosted by various members. Chairpersons are elected annually, with the ability to hold the position for two terms. Decisions are reached by consensus or through a two-thirds voting majority of those at the meeting.

3 Obstacles to Competitive Markets and Renewable Energy Generation Deployment

As mentioned in Section 2.2, most regional electricity trade in the Southern African region is still comprised of bilateral contracts between national utilities. In fact, after excluding the peak competitive inter-regional electricity trade of 32% in the 2018/2019 SAPP reporting year, an average of 17.6% was competitive (82.4% was bilateral trades). This ranged from 10-32% between 2014/2015 and 2023/2024 (68-90% bilateral trades) [23]. This is demonstrated graphically in Figure 5 where the historical and continued dominance of bilateral electricity trade in SAPP relative to competitive wholesale electricity trade is shown. This limits the ability to trade on competitive SAPP markets and potentially improve economic efficiency of electricity trade. This potential economic inefficiency is driven by bilateral contracts being treated as firm physical contracts and dispatch of these higher-cost contracted resources instead of lower-cost options [24]. In turn, this inefficiently utilizes the limited transmission capacity that exists in the region and contributes to the inability to trade potentially lower-cost energy on matched offers in the competitive SAPP markets [24].

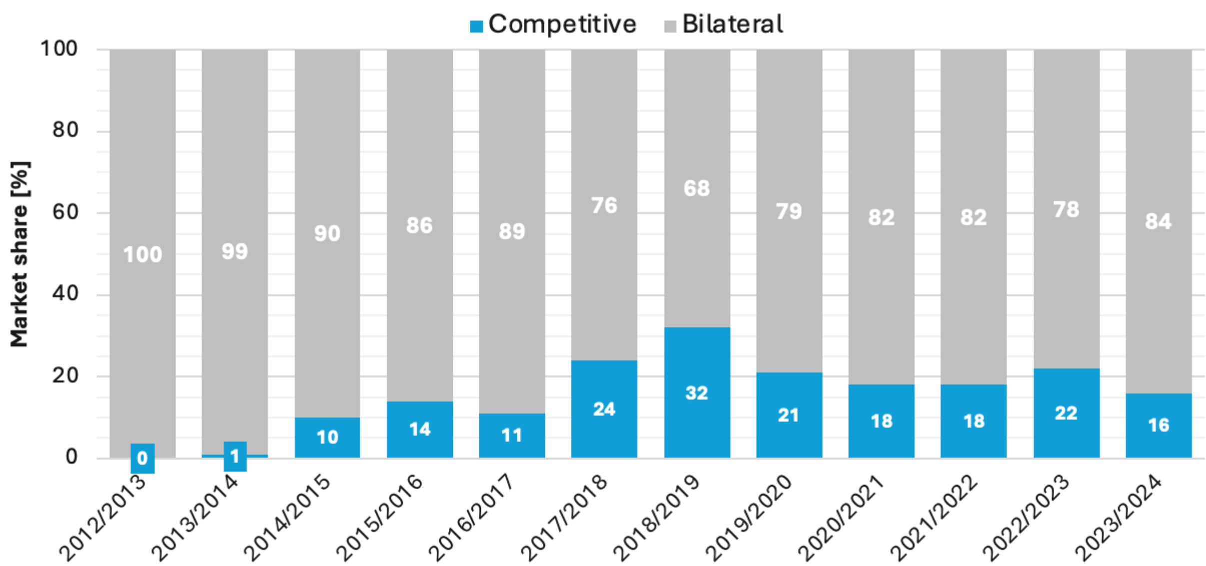

Figure 5. Annual trends in the share of total energy traded in SAPP (based on [15])

A wide range of existing obstacles serve to limit opportunities for renewable energy investment and growth despite the large potential for renewable energy in the region. This resource potential could not only contribute to meeting expected electricity demand growth and decarbonization goals but also has the potential to lead to significant electricity cost savings in the region.

This section describes some of these existing obstacles in two main areas, namely:

1. Obstacles to well-functioning competitive markets
2. Obstacles that inhibit renewable energy deployment.

These obstacles were identified through review of data and literature and interviews with practitioners and experts in the region. To better understand these obstacles, NREL requested feedback from stakeholders in the SAPP region, including these practitioners and experts. This stakeholder feedback was used to help identify the most critical obstacles to address when aligning solution options to on-the-ground challenges.

A total of 17 stakeholders completed the feedback form, with respondents self-identifying in the categories highlighted in Figure 6. The feedback form was initially developed through literature review, then revised throughout the stakeholder interview process. The feedback forms were distributed by NREL and SAPP-CC to a targeted list of respondents that represent existing and potential SAPP market stakeholders.

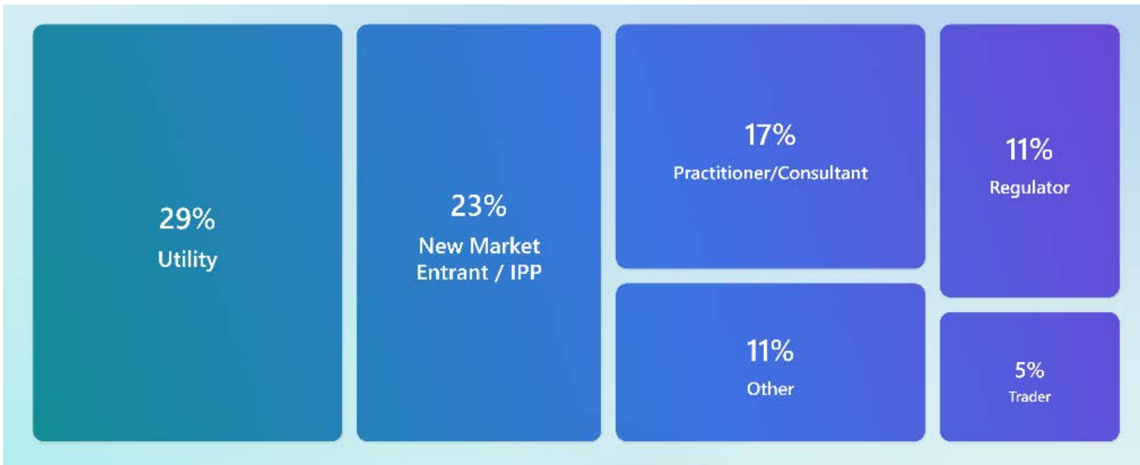

Figure 6. Composition of feedback form respondents

In the following sections, the obstacles are described, followed by a summary section that characterizes the obstacles based on competitive market principles, then prioritizes the obstacles based on feedback form responses. The characterization and prioritization inputs help guide NREL in connecting potential solution options in a global inventory (Appendix B) to the final strategy options (Section 5).

3.1 Competitive Market Obstacles

SAPP began in 1995 as a cooperative power pool to share resources between the hydropower-rich northern network and the thermal generation-rich southern network and took steps to move towards a competitive pool through the 2006 MOU revisions [25]. In general, economic theory dictates key characteristics of perfectly competitive markets include, at minimum [26], [27] [28]:

- **Homogenous Products:** All products being sold in the market are homogenous.[5]
- **Many Buyers and Sellers:** There are many buyers in the market to buy products, and many sellers to supply products.
- **Price Takers:** Individual suppliers cannot impact the market price (i.e., do not have market power).
- **No Barriers to Entry and Exit:** There are no barriers to suppliers entering or exiting the market.
- **Perfect Information:** Buyers and sellers have all relevant market information (e.g., price, product quality, etc.) needed to make decisions.

Theory dictates that perfectly competitive markets lead to efficient allocation of economic resources (i.e., Pareto efficiency). However, most competitive markets do not meet all the criteria for perfect competition

[5] We recognize that electrons traded in electricity markets are themselves homogenous, but the upstream fuel sources used to generate these electrons are heterogenous. The upstream product differentiation results in attribute values (e.g., renewable energy credits) or attribute costs (e.g., carbon emissions) that may or may not be priced in different markets.

and are instead considered markets with some degree of imperfect competition. Insofar as possible, the obstacles identified in this research are characterized by which key principle of perfect competition the obstacle violates. Although achieving perfect competition is not reasonable, understanding if there are areas of concentration in these obstacles is a useful endeavor.

For electricity markets, moving from vertically integrated monopolies to competitive wholesale generation markets is expected to improve generator operational efficiencies, reduce fuel and other variable costs, incentivize lower-cost generators to join the market, and other potential benefits [29].

3.1.1 Competitive Market Obstacle Characterization and Prioritization

As can be seen in Table 3, most SAPP competitive market obstacles identified impact the principle of barriers to market entry or exit [30], [31], followed by the principle of having many buyers and sellers in the market, and finally, violating the principle of perfect information.

Table 3. Characterizing Competitive Market Obstacles by Violated Principle of Perfect Competition

	Homogenous Product	Many Buyers and Sellers	Price Takers	No Barriers to Entry and Exit	Perfect Information
Supply-Side Market Concentration (HHI)		X	X		
Economics and Finance					
Lack of Credit Worthy Off-Takers		X		X	
Single Buyer Model		X		X	
Below Cost Utility Tariffs				X	
Regulatory and Technical					
Lack of Enabling Regulations				X	
No Regional Regulatory Authority				X	
Inconsistent Rules Across Region				X	X
Transparency and Governance					
Lack of Market Transparency and Data Access					X
Governance Rules Bias				X	
Infrastructure					
Insufficient Infrastructure for Interconnection and Interchange				X	
Regional Priorities					
Internal Self-Sufficiency Goals		X			
Insufficient, Uncoordinated Planning				X	

Barriers to market entry are known to provide an advantage to incumbent firms in the market by restricting competition from new firms entering the market. The electricity sector in general—independent of location—is thought to have high barriers to entry due to significant regulatory requirements, risks related to uncertainty about future demand and input costs, grid connection dependencies and strategic behavior from vertically integrated utilities, and certain structural barriers [32]. Structural barriers to market entry include large capital cost requirements, economies of scale, long-lived assets, high sunk costs, and long project lead times [33]. While there is no universally accepted definition of barriers to entry in economic texts [34], the 1979 definition used by Franklin M. Fisher seems appropriate in the context of this research, which is *"a barrier to entry is anything that prevents entry when entry is socially optimal"* [34]. Some of the market barriers to entry identified in this section may be consistent with general electricity sector barriers to entry, but most are unique to the SADC region.

As shown in Figure 7, stakeholders identified insufficient transmission infrastructure for interconnection and/or regional movement of electricity as the most meaningful obstacle to competitive markets in the SAPP region. This was followed by the dominance of single-buyer markets and lack of or weak nation-state regulatory frameworks to support regional SAPP activities.

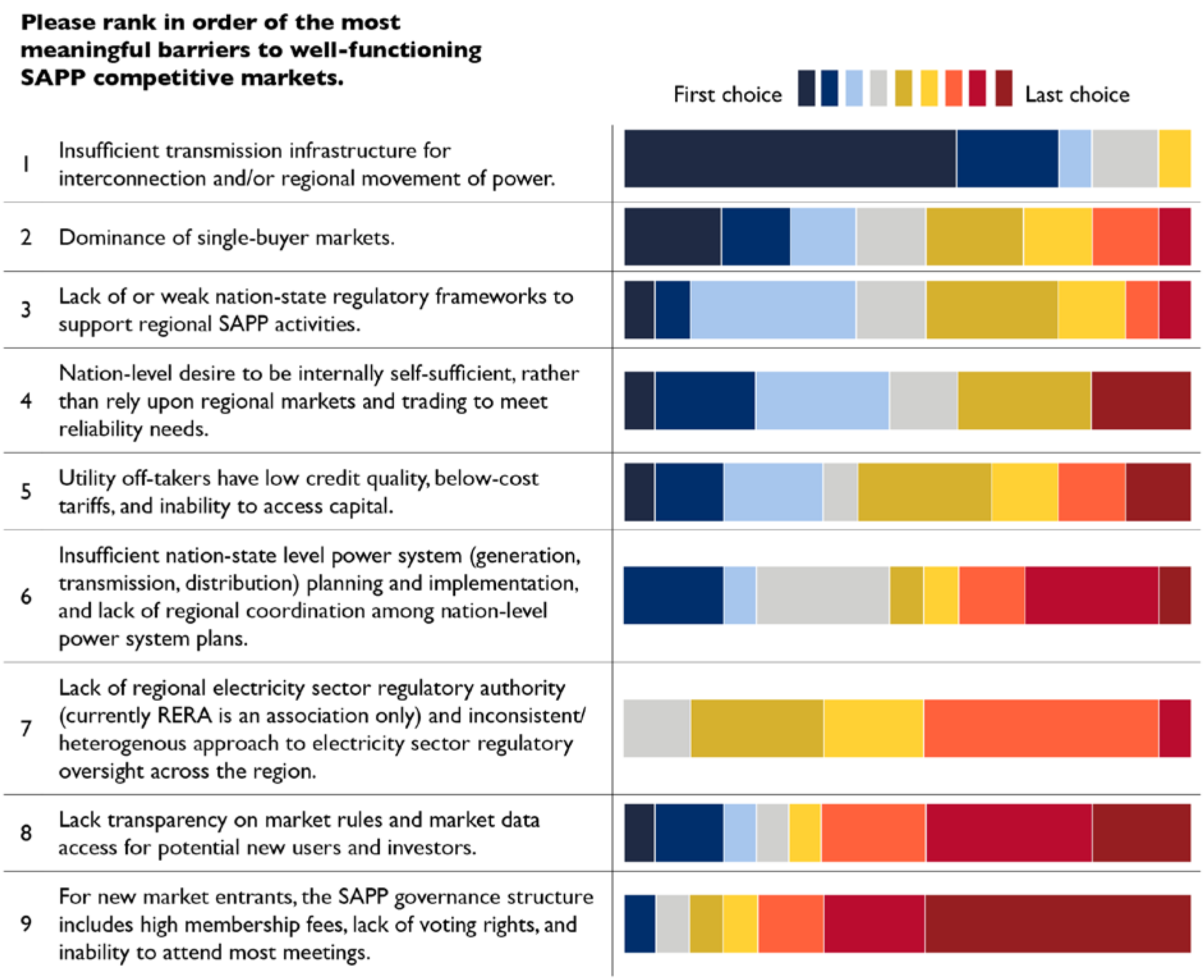

Figure 7. Stakeholder priorities on competitive market obstacles

3.1.2 Market Supplier Concentration

Although competitive markets can lower costs for consumers, they are not a panacea. Market power, or the potential ability for a firm to manipulate market prices, is a potential concern. For example, a firm with significant influence on the market could exercise physical or economic withholding of resources to impact market prices and maximize profits. In response, competitive electricity markets require market monitoring and market power mitigation to correct for actual or perceived market power abuses [35]. As explored further in Section 3, the vast majority of SAPP trade occurs bilaterally, and liquidity in competitive markets is relatively low. Nonetheless, it is critical to monitor and maintain the health and performance of these existing competitive markets to increase consumer and investor confidence and grow these markets. As such, market concentration is one of many potential metrics to monitor.

As a demonstration, we use a well-known market monitoring metric, the Herfindahl-Hirschman Index (HHI), to explore supply-side market concentration in the SAPP DAM for a particular period. With respect to perfect competition, the HHI can provide insights into whether there are many or few sellers in the market and if these sellers are price takers (i.e., many sellers) or have the potential to be price makers (i.e., few sellers). As shown in Table 4, the HHI sums the square of the dollar-based market share of all (n) sellers (s) in a market.

$$HHI = \sum_{i=1}^{n}(100 * s_i)^2$$

Equation 1

In general, the HHI is lower when there are many firms selling in the market (i.e., closer to perfect competition) and gets larger when there are fewer firms selling in the market (i.e., closer to a monopoly). An HHI of 10,000 corresponds to a single selling firm. The U.S. Department of Justice considers markets with an HHI score over 1,800 as "highly concentrated" [36]. Using data from 2022-2023, the HHI for the SAPP DAM was calculated from cleared sales volumes and cleared prices. The HHI value for the SAPP DAM during a one-year period when data was publicly available is shown in Table 4, along with market concentration threshold from the U.S., China, and the European Union. The SAPP's DAM HHI of 2,885 indicates a highly concentrated market.

Table 4. HHI Values for SAPP DAM Using Available Data

Note: HHI thresholds are often used alongside incremental changes to thresholds resulting from mergers to determine market concentration.

Period	HHI	HHI Thresholds
SAPP (DAM) **Oct 1, 2022–Sept 31, 2023**	2,885	10,000 (Single Firm [i.e., Monopoly])
		>1,800 (Highly concentrated) U.S. Department of Justice [36]
		>1,800 (Anti-competitive) China State Administration for Market Regulation (Draft) [37]
		>2,000 (Highly concentrated) European Union [38]

As shown in Figure 8, over the period covering October 1, 2022, through September 30, 2023, there was one dominant market seller (Firm B) with about 48% of the overall market share, with a handful of smaller market suppliers [39]. It is also clear that during this period there is one dominant market buyer (Firm G).[6] More data and analysis are required to understand the historic and contemporary trends around market concentration in the SAPP DAM, but the authors understand that this demonstration of market concentration is likely generalizable across historical trading years.

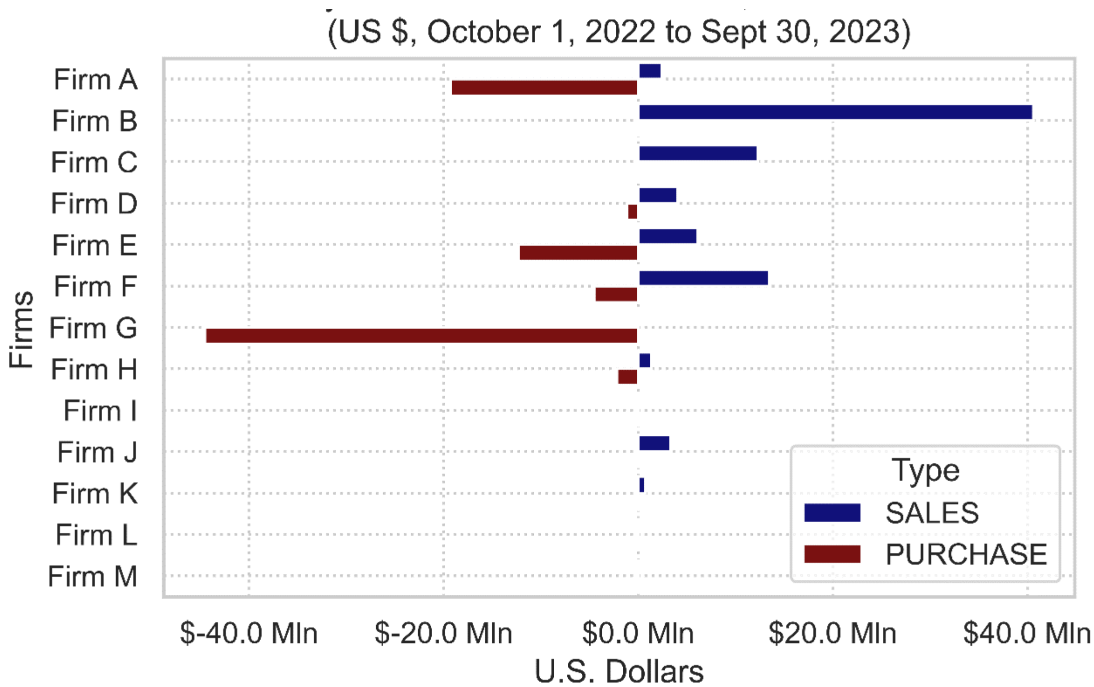

Figure 8. SAPP DAM market transactions summary [39]

Information previously on www.sappmarket.com (not available or accessible as of September 2024).

3.1.3 Financial Credit-Worthy Off-Takers

New supply entry is hampered by the inability of project developers to identify credit worthy off-takers (i.e., buyers). This is in part due to the dominance of the single utility buyer market models ("single-buyer model"), which limit the amount of electricity that can be procured by large energy consumers, industrial entities, manufacturers, etc. [40].[7] A challenge with this model is that many national utilities in the SAPP region have poor credit quality. This functionally limits the number of bankable new electricity infrastructure projects because the restricted pool of potential buyers is perceived as too risky (i.e., off-takers unlikely to pay).

[6] The name of the firms transacting in the SAPP DAM have been purposefully anonymized.
[7] Reforms in Namibia shifting towards a Modified Single Buyer Model (MSB) implemented in September 2019 were followed by SAPP engaging with the Electricity Control Board of Namibia and NamPower to facilitate direct transaction relationships between electricity buyers and IPPs for a portion of IPP project off-take, highlighting opportunities for regional trade.

Many national utilities are in poor financial condition for various reasons, including (but not limited to):

- Industrial policy objectives intentionally suppressing electricity prices to incentivize increased industrial activities;
- Weak regulatory frameworks and regulatory institutions;
- Political incumbency suppressing cost-reflective tariffs; and
- Currency risk when indexing long-term PPAs to foreign currency (e.g., U.S. dollars)[8].

Utilities with poor credit quality may not be able to raise capital or access off-balance sheet financing to support new generation investments. Raising revenues through tariff rate increases is also challenging, as many of the national utilities do not have cost-reflective rates [42]. In turn, absence of cost-reflective tariffs further deteriorates the attractiveness for utilities as off-takers. For project developers, their ability to access reasonable-cost financing is hampered by the low credit quality and low tariff rate compensation of the utility off-taker. The dominance of the single-buyer model restricts project developers away from higher-credit-quality off-takers, such as large energy users or corporations that are less risky counterparties, thus enabling more attractive financing terms.

3.1.4 Regulatory and Technical Obstacles

SAPP can work with its members to develop rules over its own governance and operations. However, for IPPs and other market participants to transact in SAPP markets, their host nations must have regulatory rules in place that enable participation. Many nations do not have these, leading to uncertainty over regulatory requirements or an inability to trade internationally, which is a barrier to entry.

The Regional Energy Regulators Association of Southern Africa (RERA) found a lack of national regulatory frameworks to address: licensing; metering; cross-border disputes; lack of harmonized tariffs; lack of common rules for accessing the grid; congestion management; lack of consistent grid codes; lack of planning coordination; and other issues were all bottlenecks to private sector investment [43]. There is no regional regulatory authority in place[9] with the authority to require nations to develop these enabling rules, though the RERA has developed model rules for nations to voluntarily adopt.[10] In absence of a consistent regional regulatory framework for SAPP participation, there is considerable heterogeneity between nations with respect to electricity sector regulations and the enabling regulatory frameworks [44], [45].

3.1.5 Transparency and Governance Obstacles

As discussed in Section 3.1, perfectly competitive markets require that buyers and sellers have perfect information about market products and prices. Lack of access to data and market transparency was one obstacle identified in our research. Additional information disclosure and transparency may enhance potential investor confidence in SAPP's competitive markets. In general, market transparency and access to market data help existing market participants and potential investors make better decisions, whilst simultaneously assisting to support in detecting market manipulation [28].

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[8] Many power purchase agreements (PPAs) are indexed to U.S. dollars, so if a national currency depreciates against the U.S. dollar, the PPA-related costs rise [41].

[9] See Ricardo Energy and Environment's "Framework for Regulatory Oversight for the EA-SA-IO Region," June 15, 2020, available at https://rerasadc.com/documents-and-downloads/.

[10] See for example RERA's SADC Regional Grid Code available at https://rerasadc.com/documents-and-downloads/.

Another potential obstacle is SAPP's governance structures, which have the potential to disadvantage new market entrants compared to the incumbent National Utilities and Operating Members. These disadvantages can include high annual membership fees, lack of voting rights, and an inability to attend or contribute to formalized periodic SAPP meetings. For example, based on the 2019 SAPP financial year, a single Market Participant would have paid $20,000 in SAPP membership fees, while an interconnected National Utility member would have paid ≅$73,000, non-interconnected National Utility member would have paid ≅$51,000, and an Operating Member would have paid ≅$54,000 [22].[11] This means a single small project developer (e.g., over 5 MW) could be paying an annual membership fee that is 27%–39% of the cost of an incumbent National Utility membership with national internal transmission network and multiple assets, or the membership fee of an Operating Member that operates multiple large generating plant (e.g., over 300 MW).

Decisions about SAPP markets are made by consensus or 2/3rd majority vote of eligible members in meeting attendance [22]. Operating Members may participate in all committees and lower-level sub-committees and working groups at SAPP, and have voting rights in the SAPP executive committee, working groups, subcommittees, and MANCO. National power utilities can chair committees and subcommittees, participate in all meetings, and have full voting rights. Expected new market entrants that are likely to enter as Market Participants are only allowed to vote at the annual SAPP Traders and Controllers Forum and may or may not be able to attend other SAPP committee meetings. This means market participants have little to no influence in the SAPP governance process, which is influenced primarily by national power utilities allowed to attend convened committee meetings. This is potentially challenging if SAPP market rules do not evolve to accommodate the needs of new market entrants in competitive SAPP markets where additional new market participants should support increased competitive markets and the potential for increased volumes from generation capacity investment.

3.1.6 Insufficient Enabling Infrastructure

Numerous studies have identified insufficient transmission capacity as a challenge to new project development in the SAPP region [14] [46] . Insufficiency relates to both insufficient transmission capacity to execute trades (internal and cross-border), the ability to move power throughout the region through interchanges (after bilateral contracts between national power utilities are settled), and issues related to processing new generator interconnection requests and the costs of network upgrades to accommodate new interconnection. Existing transmission capacity is primarily used to accommodate bilateral trades, leaving limited available transmission capacity to accommodate market-based trading [14]. Although these bilateral agreements offer security of supply in some instances, they are treated as firm, physical obligations and are dispatched even when lower-cost alternatives are potentially available, resulting in inefficient use of transmission assets and higher costs [24].

Around the beginnings of the SAPP DAM, 40%-50% of SAPP DAM trades were being limited on a daily basis due to transmission constraints [46]. In 2016-2017, of the total 3 TWh of matched trade in SAPP competitive markets, approximately 2 TWh (67%) of total competitive energy traded was curtailed due to transmission constraints [14]. This issue was particularly evident in FPM-W, where only 52.5% of matched energy was cleared for trading [47]. During the 2023/24 SAPP year, SAPP competitive markets experienced significant declines in trade volumes, with a total of 1,245 GWh traded, representing a 22% decline from the previous year. Key contributing factors to this decline was an increase in bilateral trade, the resulting limited availability of transmission capacity (after bilateral trade execution) and supply

[11] These data were derived by USAID from a total contribution budget of $1,084,815 with $73,298.31 from nine (9) national utilities that are connected, $51,308.82 from three (3) national utilities that are not connected, and $54,240.75 from five (5) operating members.

availability in competitive markets. Between April and August 2024, only 330 GWh was traded, a reduction of 44% from the 592 GWh traded during the same period in the prior year.

Long-distance interregional transmission corridors can maximize renewable energy resources, reduce electricity costs, and provide more reliable resources than relying on local or regional resources alone, in addition to providing critical support in clean energy goals [48]. Increased public awareness combined with some regional changes have begun to shift the dynamics in the SAPP region related to infrastructure challenges. This is illustrated with well-respected organizations reporting on these challenges [49] [50], [51]. Regional players are beginning to address these challenges, including SAPP and Eskom. A prime example are the recent targets from SAPP to address the challenges of insufficient infrastructure via creating a platform for the building of high-voltage transmission line interconnectors aimed at linking countries together through the Regional Transmission Infrastructure Financing Facility (RTIFF) [52]. A separate example seeking to address these infrastructure challenges includes the recent division of Eskom into three separate entities (i.e., Generation, Transmission, and Distribution) with the legal separation of these functional areas – the transmission division became the National Transmission Company of South Africa (NTCSA) as of April 2024 [53]. Another example of this includes the unbundling of Empresa Nacional de Electricidade (ENE) in Angola into Rede Nacional de Transporte (RNT) and Empresa Pública de Produção de Electricidade (PRODEL).

3.1.7 Sovereign Priorities

The estimated economic benefits of regional trading and SAPP markets have been well documented, including 2009 estimates of U.S. $48 billion (U.S. $8.7 billion in net present value at the time) [54], [55]. These benefits are in the form of savings from coordinated region-wide generation and transmission expansion planning. These savings are meaningful, given that an estimated U.S. $ 90 billion of investment is expected to be needed within the SADC region to provide electricity services through 2030 [43]. Implementation of the RERA Market and Investment Framework (MIF) is meant to increase private sector participation in the *"expansion and development of the SADC power sector which will also provide greater security to energy supply, greater market competition, a more secure and stable power system operation, more efficient and economically viable utilities, as well as reduced member state reliance on the imports of expensive foreign controlled energy resources"* [45]. Despite these benefits, there may be other priorities and goals that prompt nation-states to prioritize internal self-sufficiency of power supply (i.e., resource adequacy) over reliance on international trading and regional markets [14]. For example, importing countries may be skeptical of the regional market's ability to deliver reliable electricity (even through firm contracts), preferring to invest in domestic resources even if at a higher cost [56]. Some SAPP member nations formally or informally prioritize grid access and dispatch rights to national utilities and domestic producers [45].

Electricity sector planning practices of nations within the SAPP footprint are highly heterogeneous, with different planning standards, scopes, practices, timelines, and objectives [57]. For example, some nations have least-cost expansion or integrated resource plans in place and others do not [57]. There is a minor relationship between national planning and regional activities (including various iterations of the SAPP Pool Plan—which is not prescriptive) [58], and a lesser link to planning for electricity trade facilitation [14]. National utilities tend to plan independently, sometimes disregarding any regionally coordinated planning that may be in place (like the aforementioned SAPP Pool Plan) [46]. These issues may be self-perpetuating, in that lack of balancing national priorities with regional coordination could prevent progress on regional outcomes, further prompting nations to focus on domestic resources. As the penetration of time-varying renewable energy resources increases, so may the benefits of regional coordination [48], [59].

3.2 Renewable Energy Development Obstacles

In theory, zero-fuel cost renewable energy resources should benefit from well-functioning competitive markets that dispatch based on lowest cost [60]. However, there may be additional issues overlapping with or beyond competitive market fundamentals that inhibit renewable energy project deployment. This section describes some of these issues in the context of SAPP specifically, as identified in literature and in interviews with experts. The most frequently encountered issues are grouped into three categories:

- Renewable Energy Development (Section 3.2.1)
- Economics and Finance (Section 3.2.2)
- Regulatory and Technical (Section 3.2.3).

Some of the identified obstacles could be directly influenced by SAPP (e.g., adjusting a specific wholesale market rule or introducing new wholesale markets entirely), while other obstacles SAPP may not have the ability to influence at all (e.g., regional risk profiles, costs of equipment). Yet, other obstacles could be indirectly influenced by SAPP by improving competitive market fundamentals or engaging further with regulators and regional regulatory institutions (like RERA). For example, by increasing information access and lowering barriers to entry, financing costs have the potential to be reduced *if* investors view the markets as more transparent and less risky. This section begins with a characterization of the issues and prioritization based on stakeholder input through the feedback form.

3.2.1 Renewable Energy Development Characterization and Prioritization

As seen in Table 5, all the renewable energy development obstacles are characterized as impacting the competitive market principle of barriers to market entry (and exit). SAPP only has indirect authority over many of these obstacles, meaning the coordination center cannot address these issues without member support.

Table 5. Characterizing SAPP Renewable Energy Development Obstacles by Violated Principle of Perfect Competition

	Homogeneous Product	Many Buyers and Sellers	Price Takers	No Barriers to Entry and Exit	Perfect Information	SAPP has Direct, Indirect, or No Influence
Economics and Finance						
Limited Access and High Cost of Funding				X		Indirect
Lack of Credit Worthy Off Takers				X		Indirect
Lack of Functional and Consistent RE Incentives				X		Indirect
Limited Funding for Pre-Finance Project Development				X		Indirect/None
Higher Project Costs Due to Imported Equipment				X		None
Higher Project Costs Compared to Other Technology Options				X		None
Regulatory and Technical						
Lack of Interconnection Queue and System Impact Studies				X		Direct
No Commercial Arrangements for Balancing Service for RE				X		Direct
Imbalance Requirements that Disadvantage RE Resources				X		Direct
Uncertainty Over RE Project Quality, Performance, Output				X		Indirect

As shown in Figure 9, stakeholders identified lack of viable commercial arrangements to facilitate variable renewable energy balancing through interregional transmission as the most meaningful obstacle to renewable energy deployment in the SAPP region. This was followed by lack of functional and consistent nation-level or regional-level renewable energy incentive policies and higher project costs related to reliance on imported renewable energy equipment.

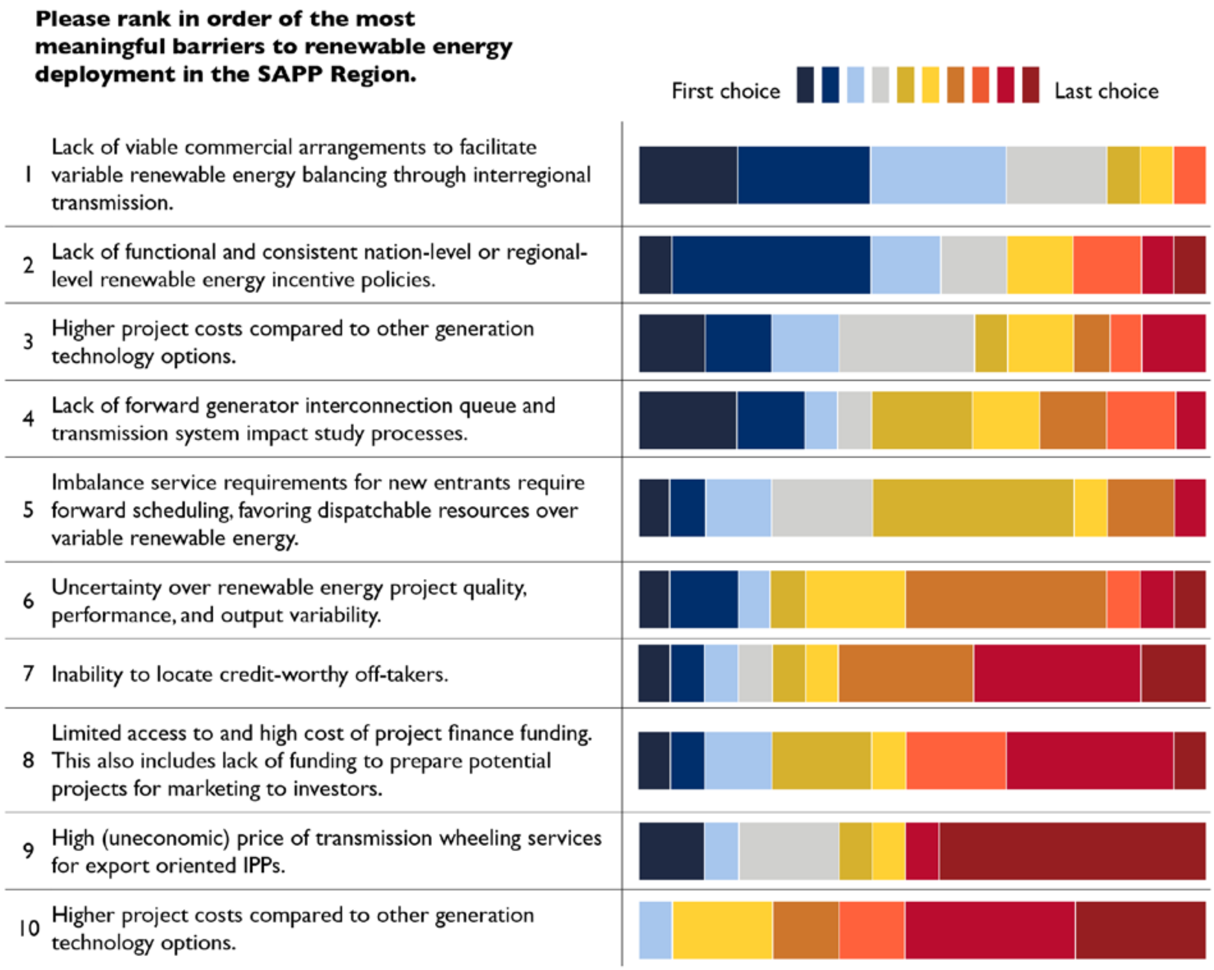

Figure 9. Stakeholder feedback on the most meaningful barriers to renewable energy deployment

3.2.2 Economics and Finance

Renewable energy projects tend to lack available funds to prepare projects for private sector financing [46]. For example, technically feasible projects may lack the funds to support project documentation to bank or lender standards. According to the World Bank, regional energy projects in SAPP often require significant technical and financial support from the public sector to make them bankable for the private sector and to attract private sector attention [61]. Even when pre-financing funding is available, project developers may have limited access to financing, or the cost of available financing may be too high to support viable project economics [62]. Financing costs are influenced by a myriad of factors, including the lender's perception of investment risk (including off-taker risk, technological risk, regulatory risk, political risk) [63]. Specific to SAPP, regulatory risk includes the incomplete, inconsistent, and uncertain approach to electricity sector regulations, and the political risk associated with state ownership of incumbent, vertically integrated utilities. All things equal, projects that have a high probability of delivering a return of investment (i.e., payback of principle) and a return on investment (i.e., a profit) will be considered lower risk. Higher risk projects may not be able to access financing, or the risk premium on the capital (i.e., the required profit margin) will increase to levels that make the project economically infeasible. There are many factors that can impact a lender's perception of risk. Power purchase agreements or other long-term contracts with credit-worthy counterparties is a factor that can help reduce lender risk perception for a renewable energy project. In SAPP, the dominance of the single-buyer model restricts the ability for project developers to locate credit worthy off-takers, as many of the available off-takers (i.e., national power utilities) exhibit lower credit ratings and are not seen as credible off-takers from the perspective of potential funders.

Renewable energy projects in the SAPP region may also experience certain factors that increase base project costs. For example, lack of an established domestic manufacturing base for renewable energy components results in the need to import these components, increasing landed costs [46]. Renewable energy projects may have higher upfront costs, as they are capital-intensive relative to other technology options, though operating costs are substantially lower due to lower fuel as well as operations and maintenance costs [64]. Incentives can play an important role in helping manage these higher upfront costs renewable energy projects face. In the SAPP region, although there are some exceptions,[12] there is a lack of functional and consistent national-level or region-level renewable energy incentives for deployment or manufacturing [46].

3.2.3 Regulatory and Technical

In addition to facing obstacles related to economics and finance, renewable energy projects may also face regulatory and technical challenges. As newer and non-dispatchable energy technologies, wind and solar renewable energy projects may face obstacles related to uncertainty over project quality, performance, and output variability. New market entrants must receive certain regulatory approvals from their host country as a prerequisite to gaining SAPP membership.[13] In addition, new entrants are obligated to minimize negative impacts on the system and must have arrangements in place with their host transmission system owner/operator to provide balancing support [22]. However, few countries have system balancing rules in place or rules for international electricity exports and trading, leaving these arrangements to be negotiated on an often unsolicited basis [22].

Imbalances occur when the amount of electricity that transacts in real time deviates from the amount of electricity that was scheduled in advance to transact. System balancing services are critically important for renewable energy projects that have variable output, as are rules to facilitate export of surplus electricity when the resource is available (e.g., wind, solar). SAPP introduced a Balancing Market (BM) in 2022 where renewable energy projects could, in theory, procure balancing services. However, this market has remained inactive, with no trades recorded since its inception. In contrast, the DAM has been the most active, with a gradual increase in volumes providing reference prices for other markets. The lack of commercially available methods to facilitate renewable energy balancing, combined with the need for balancing agreements in the absence of well-defined rules, continues to disadvantage renewable energy projects compared to dispatchable resources [67].

[12] Some notable exceptions include the South African Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) and the Uganda Renewable Energy Feed-in-Tariff (REFIT).
[13] SAPP recently developed a *"conditional membership"* option to facilitate participation in SAPP for a merchant solar PV plant developer in September 2023. This conditional membership helped alleviate concerns from funders, meeting bankability requirements by confirming potential participation on SAPP markets upon commercial operation of the project [65]. Upon commercial operation of its first merchant plant, the company received full unconditional membership to SAPP in April 2024 [66].

For any new generator to access the transmission grid, a request must be submitted to the transmission owner/operator, and certain studies must be conducted to understand if additional network investments are required to address any potential negative impacts on the grid from interconnection. Across the SAPP region, there is lack of common rules for how prospective generators can access the grid [43]. This lack of standards, transparent and non-discriminatory interconnection processes in the region was one of several motivations that led RERA to develop its Regional Grid Code in 2022 [68].[14] During this research, lack of certainty on interconnections rules, coupled with lack of transparency on interconnection study timeframes and costs, was cited by developers as a challenge when developing new projects.

[14] More information on RERA's Regional Grid Code can be found under the SADC Regional Grid Code Study tab at https://rerasadc.com/documents-and-downloads/.

4 Solution Options To Facilitate Competitive Markets and Increase Renewable Energy in the SAPP

4.1 Summary of Global Solution Options Inventory

A wide range of solution options is potentially available for the SAPP region, which can be considered in parallel with the investigation of potential obstacles to competitive markets and renewable energy project deployment. A set of global solutions is compiled as an inventory in detail in Appendix B and in summary form in Table 6. Although this set of global solution options is not necessarily comprehensive, it is deemed a reasonable set for potential consideration in further future investigations of facilitating increased use of regional competitive markets and renewable energy deployment in the region.

Table 6. Summary of Global Solutions Inventory (see Appendix B for further details)

Solution Option	Brief Description
Carbon Pricing (B.1)	A fee or tax applied to each MWh generated based on the carbon intensity (e.g., kilograms of CO_2 per MWh) of the generator's output.
Clean Electricity Markets (B.2)	A requirement that utilities source a certain percentage of electricity sold to customers with eligible clean energy resources.
Contracts for Differences (B.3)	A contractual risk management mechanism where the price of energy is guaranteed at a certain level, therefore hedging against market price volatility.
Open Access Transmission Requirement (B.12)	A regulatory requirement that transmission owners/providers make transmission service openly available to third parties on a non-discriminatory basis at published tariff rates.
Independent System Operator (ISO)/Regional Transmission Operator (RTO) (B.6)	Independent operators of third-party-owned transmission systems that facilitate open access to transmission and can administer competitive wholesale markets, conduct transmission planning, and perform other functions.
Interregional Transmission Expansion Planning (B.7)	Transmission expansion planning process that identifies net-beneficial transmission transfer capacity investments between regional/national transmission systems.
Buyer-Side Market Offtake Models (B.8)	Procurement options that expand opportunities for large energy users, corporations, and others to contract directly with generators for electricity off-take.
DER Aggregation for Wholesale Market Participation (B.9)	Market participation models that allow output from multiple distributed energy resources (DERs) to be bundled or aggregated and bid into wholesale markets.
Capacity Mechanisms (B.10)	Market-based and other mechanisms to secure sufficient generation and load management capacity to ensure resource adequacy and related reliability.
Balancing Markets and Other Ancillary Services and Products (B.11)	Commercial mechanisms to help generators meet requirements to manage supply and demand imbalances. These are especially important for VREs when actual output departs from expected output.

In the remainder of this section, we provide additional background on some of the potential solutions most aligned with the priority obstacles identified in Sections 3.1 and 3.2.

4.1.1 Independent Operation of National and Cross-Border Transmission Systems

Independent operation of the national and regional interconnected Southern African transmission systems can improve the efficiency of system operations, facilitate cross-border exchanges, and better manage power flows and congestion on these system(s) [45]. Independent entity-administered planning can also help improve reliability through coordinated transmission expansion planning, and ensure nondiscriminatory access to these bulk power system(s) [45].

There are several organizational alternatives to vertically integrated utilities both owning and operating their transmission system that have been applied around the world [69]. These include, but may not be limited to, the following three models or variations therein:

- **Independent transmission operators (ITO)** – The vertically integrated utility maintains ownership and operation of the transmission system, but rules are put in place requiring independence in decision-making, legal form, organization, and other aspects of structure and operations.[15]
- **Ownership unbundled transmission system operators (OU TSO)** – The vertically integrated utility divests ownership of the transmission system. A separate entity owns, operates, maintains, and plans the development of the transmission system.
- **Independent system operators (ISO)** – The vertically integrated utility maintains ownership of the transmission system, but an independent third party operates, maintains, and plans the development of the system.[16]

The European Union's 3rd Energy Package in 2009 required vertically integrated utilities to certify with their national regulators that they met one of the three transmission system operator (TSO) models above or qualified for a special case/exception. As seen in Figure 10, most of the EU's TSOs initially opted for the OU TSO model (around 70%), followed by the ITO model (12%) and the ISO model (6%) [70]. On the other hand, as seen in Figure 11 in the U.S. the ISO model (along with the multi-state regional independent transmission operator or RTO model) is more prevalent, with 66% of U.S. load located in ISO/RTO territories [71], [72].

[15] This model could be compared to the U.S. standard of conduct rules in FERC Order 889 of 1996 that required transmission owners to separate their wholesale power marketing and transmission operations, but did not require firm-level unbundling or asset divestiture.
[16] In the U.S., ISOs do not perform maintenance activities on the transmission system. There may be other nuanced differences between the U.S. and EU definitions of ISOs.

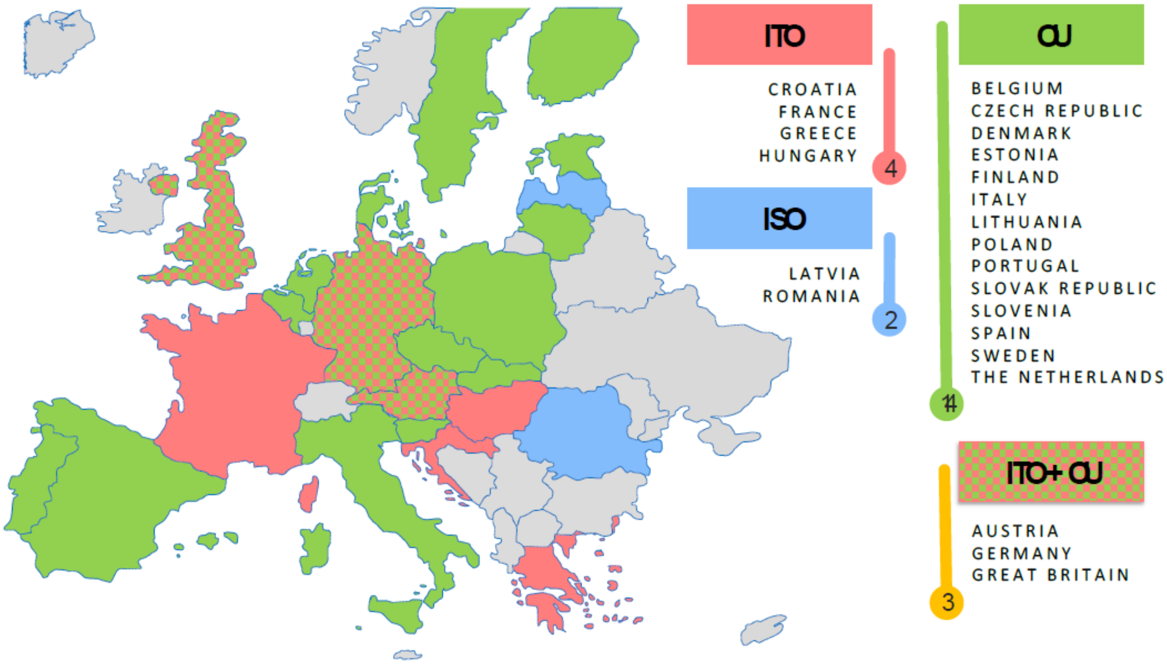

Figure 10. Map of transmission ownership structure and regulatory scheme in the European Union [70]

Image is used with permission from CEER

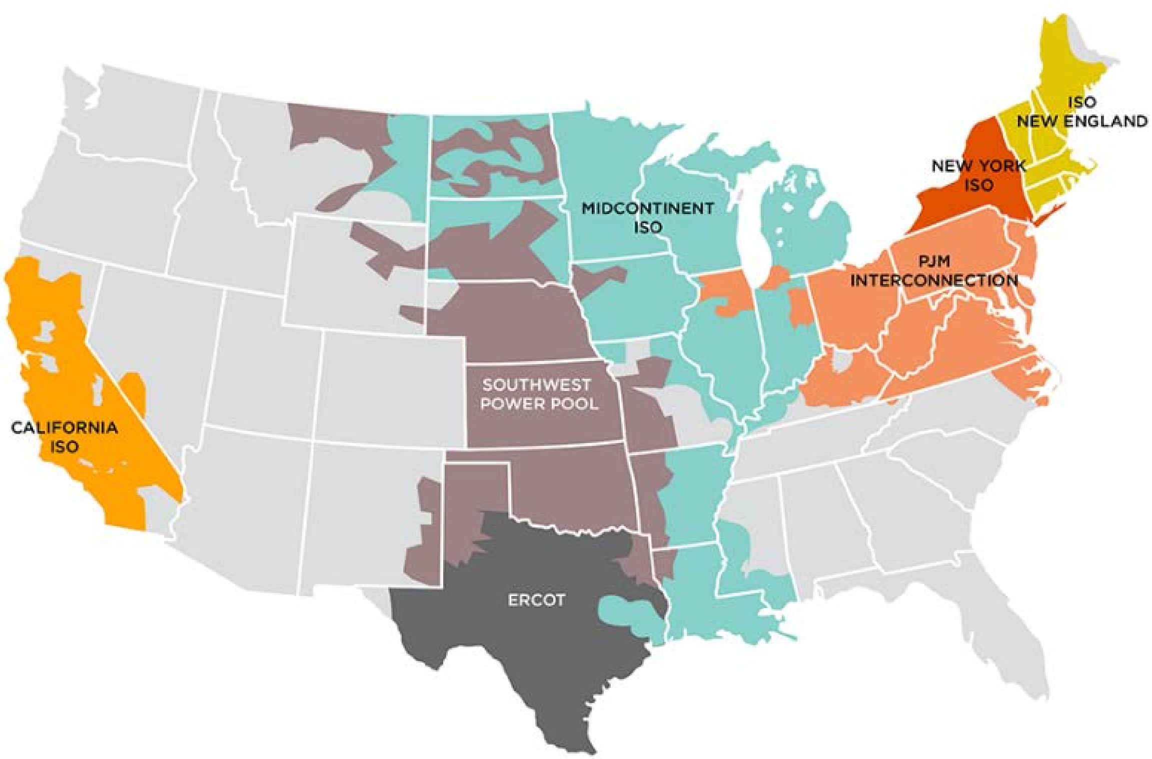

Figure 11. Map of U.S. ISOs and RTOs [71], [72]

Given the state ownership of electric utilities in the SAPP region, differences in national priorities across the region, and the delays and challenges associated with ownership unbundling of state-owned transmission systems,[17] the independence provided by the ISO model may provide the greatest benefit while also being the most difficult to implement. Independent operation of an open-access transmission system facilitates generation competition by ensuring fair access to the transmission system at reasonable rates. A single-nation or single-state (single-province) independent operator is typically referred to as an ISO whereas a multi-state (multi-province) or multi-nation independent operator is typically referred to as an RTO. For the SAPP region, an RTO could administer processes associated with cross-border transmission facilities. ISO/RTOs could facilitate transmission access by independently administering certain transmission grid processes and procedures on a non-discriminatory basis while simultaneously interfacing with national SOs. Transmission owners still own these transmission assets, while the ISO/RTO operates these assets in a manner that prevents discriminatory behavior, such as transmission owners preventing competitors from accessing the transmission system. For example, in the United States, federal regulators encouraged utilities to join ISOs after learning utilities were exercising transmission dominance by only offering available transmission capacity to competitors at high rates and inflexible terms, were requiring excessive amounts of time and information for interconnection requests, or were refusing to wheel electricity through their territories [73].

In the SADC region, national utilities could transfer operation of their transmission systems to ISOs, while the SAPP RTO could operate the cross-border interconnection portions of the transmission system. RERA's 2015 "Market and Investment Framework" called for ISOs (referred to as independent transmission system operators) to take over operation of transmission systems in each member state [45].

4.1.2 Open Access and Rate Unbundling Requirements

To be effective, the RTO/ISO construct must be implemented in conjunction with open-access transmission tariff requirements and implementing transmission tariffs for utilities to make unused transmission capacity openly available to competitors at reasonable tariff rates. This also means transmission owners cannot preferentially treat their own assets by withholding capacity or charging their affiliates lower rates. Open-access transmission tariffs functionally require unbundling of rates into their component parts, including generation, transmission, distribution and delivery charges. Unbundling of rates may also involve vertically integrated utilities to pursue accounting, functional/management, legal, and/or ownership separation [69]. As shown in Figure 12, each step in this process to increase the separation of formerly vertically integrated utilities can decrease political influence over these entities and increase independence [74].

[17] See, for example, the restructuring of the South African electricity supply industry with the establishment of the National Transmission Company of South Africa (NTCSA).

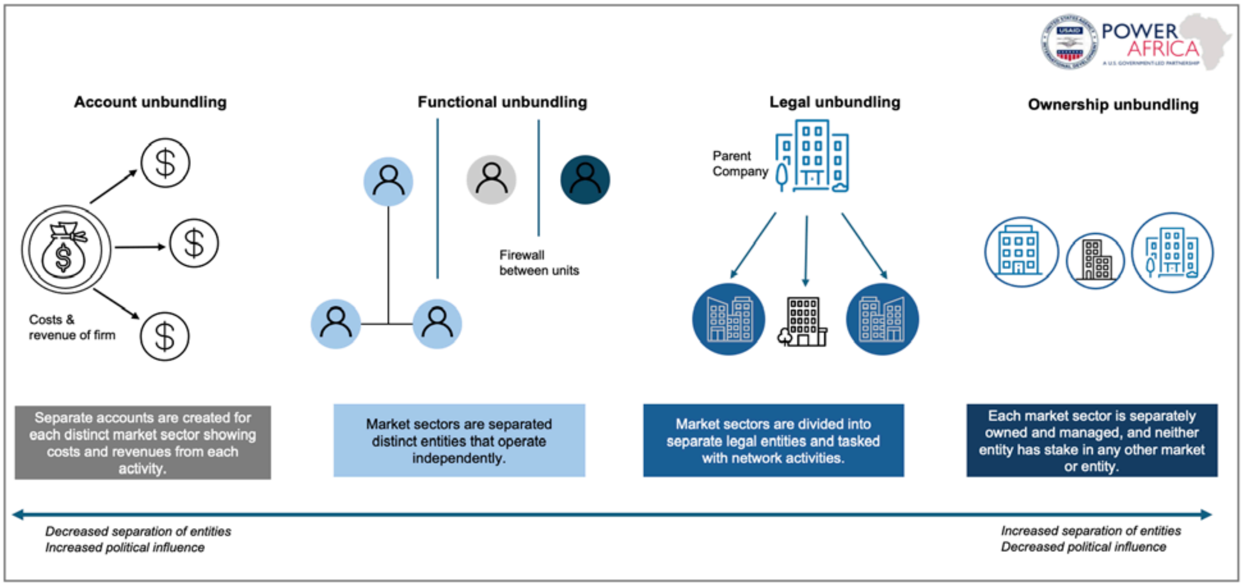

Figure 12. Components of unbundling (recreated from [74])

Real-time software-based information systems are needed to make open-access transmission system information available to potential users of the system and allow transmission providers and customers to communicate about capacity and requests, and to execute transactions. In the U.S., for example, FERC Order 889 of 1996 required each transmission owner to develop or participate in an open-access same-time information system (OASIS) that would make certain information available to potential transmission customers [75]. OASIS's existing requirements include allowing customers to make requests for transmission services, view and download data to inform business decisions, access information related to any denial of requests, view data on available transmission capability and method of calculation, prices for transmission and ancillary services and products, and more.[18]

4.1.3 RTO/ISO Administration of Competitive Markets

Beyond operating transmission assets, RTO/ISOs can independently administer competitive markets and market clearinghouses where numerous types of buyers and sellers may be qualified to transact [45]. A SAPP RTO could administer markets with numerous participation models that could open opportunities to move beyond the single-buyer or modified single-buyer model--for example, by allowing large energy users to directly transact, as well as resource aggregators, and intermediaries such as marketers and brokers that connect potential sellers and buyers. RTOs can also operate the ancillary services markets that are likely going to be needed in a higher-VRE environment [76], [77]. Independent system operators can better manage congestion by reflecting congestion costs in energy markets with location-based transmission congestion pricing, called locational marginal pricing. Independent system operators can perform security-constrained economic dispatch of generators, enabling least-cost transmission congestion management and lowering of production costs while prioritizing the reliability of the integrated transmission system above all else. This can be done on a real-time-only basis (i.e., an energy imbalance market) or with day-ahead scheduling and commitment coupled with real-time dispatch. In addition to facilitating open access and nondiscriminatory operations of an interconnected transmission system, RTO/ISOs can deliver a wide range of additional benefits depending on the scope of

[18] A complete list of OASIS's current information posting requirements is available on the electronic code of federal regulations, Title 18, Chapter 1, Subchapter B, Part 37, Section 6, available at https://www.law.cornell.edu/cfr/text/18/37.6.

the operator's activities. For context, the idea of an independent system operator administering a competitive market is not new for the region. For example, RERA's Market and Investment Framework called for an independent market operator for the balancing market [45].

4.1.4 Integrated Transmission Planning and Competitive Procurement

Given the system operational awareness of RTO/ISOs, they are in a strong position to facilitate region-wide transmission capacity expansion planning through market-based or planning-based mechanisms. They can also engage in inter-national transmission expansion planning integrated into a process whereby potential competitive transmission expansion solicitations are implemented. More technically sophisticated models that co-optimize generation and transmission capacity expansion options to identify the least-cost solution to a specific reliability need are available. Regional market mechanisms can be layered on top of national planning-based mechanisms to facilitate entry of private sector investments, like IPPs and merchant transmission facilities. Viable, cost-reflective cost allocation mechanisms can be created to facilitate transmission builds and merchant transmission financed by customers and private investors. Viable, cost-reflective cost allocation mechanisms can be created to facilitate new transmission builds and merchant transmission financed by customers and private investors.

4.1.5 Regional Energy Regulatory Authority

Currently, the existing RERA can only provide solution options and does not have the authority to implement or enforce electricity regulations. In 2012, the SADC's regional infrastructure development master plan recommended that RERA be raised to a regional authority with greater powers to dictate the pace of regulation development and other activities across the region [46]. In 2019, a framework report for the establishment of a regional energy regulatory authority for cross-border transactions in the SADC was released by RERA, further supporting the regional regulatory authority concept to address the lack of clear and enforceable electricity regulations across the region that is inhibiting needed infrastructure investments [44]. A 2020 report commissioned by Regional Association of Energy regulators of Eastern and Southern Africa (RAERESA) recommended the development of a new regional regulatory authority for the SADC region, as well as a regional regulator for Eastern Africa and the Indian Ocean countries [78]. The goal of the regional regulators would be to harmonize regulatory practices that would create a "level playing field" across the three regions in order to increase investor confidence in pursuing new projects, and to assist in the process of integrating the Eastern and Southern African electricity power pools [78]. Several other reports have highlighted the need to strengthen RERA as a regional energy regulatory authority [79], [80], [81].Currently, the existing RERA can only provide solution options and does not have the authority to implement or enforce electricity regulations.

While these reports differ in detail, the general notion of a Southern Africa Regional Energy Regulator (SARERA) would include, but may not be limited to:

- Issuing (and sometimes enforcing) regulations to address prices, cross-border wheeling charges, nondiscriminatory open access, quality of service, technical standards, market rules and market monitoring requirements and resource adequacy.
- Facilitate investments by supporting regional energy initiatives, encouraging national regulators to harmonize national standards with cross-border standards, and standardizing strategic environmental assessment methods.
- Increasing staffing capacity, maintaining a database of energy resources, performing training, and mediating disputes.
- Ability to set requirements that are binding on member states.

Since SADC participation is voluntary in nature, establishing a regional regulatory authority with significant implementation and enforcement powers is particularly challenging. While not explored in this research, several existing references address pathways to implementing this solution option [44], [79].

4.1.6 Market Monitoring

Market monitoring and oversight are critical to maintaining the legitimacy, integrity, and confidence in competitive markets and planning processes. These markets are expected to lower costs for consumers by harnessing the power of cost competition to reduce prices. However, careful market monitoring is required to detect and mitigate market manipulation, gaming, and other anti-competitive behavior that can potentially occur. It is critical that market monitoring activities be conducted by entities that are independent from the entities operating or administrating these markets [82]. It is also important that market monitors be provided with the mechanisms to refer such anti-competitive behavior to an entity with appropriate mitigation and enforcement jurisdiction. Mechanisms to mitigate market power abuses should be designed for the specifics of a particular wholesale electricity market [35].

It is envisioned that SARERA should have market monitoring and intervention capabilities [44], [78], [79]. Regulatory entities with authority over cross-boundary electricity trades generally do have such powers granted or have the power to require and enforce market monitoring. For example,

- The U.S. Federal Energy Regulatory Commission (FERC) regulates cross-state (i.e., interstate) transmission of electricity and wholesale electricity markets. FERC requires RTOs/ISOs to have market monitors in place and perform specific duties [83].
- The E.U. Agency for the Cooperation of Energy Regulators (ACER) is a decentralized agency that is independent from EU members and institutions.[19] ACER and national energy regulators implement the regulations on wholesale energy market integrity and transparency (REMIT),[20] which is an EU-wide framework to detect and deter wholesale energy market abuse.
- In India, the Central Electricity Regulatory Commission (CERC) sets tariffs for government-owned utilities, facilitates cross-border trades, performs market monitoring, and conducts a host of other activities.[21] In addition, India's Central Electricity Authority (CEA), a policy and standards organization that also plays a role in cross-border trading, performs certain electricity market monitoring duties.[22]

FERC and CERC represent federal or national organizations that share energy jurisdiction with states, whereas ACER relies upon the broader EU Commission regulations to compel national member compliance [79].

4.1.7 Data and Transparency

One of the core functions of a regional regulatory authority would be to improve the transparency of the market in order to improve the investment climate [44]. Market and data transparency are critical for consumers to make better business decisions, for existing market participants to optimize for efficient operations, and to enable appropriate surveillance and oversight of markets by regulators. For example,

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[19] More information about the EU's ACER can be found at https://www.acer.europa.eu/the-agency/about-acer.
[20] More information on the EU's REMIT regulations can be found at https://www.acer.europa.eu/remit/about-remit, and the legislation can be found at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011R1227.
[21] More information about India's CERC can be found at https://www.cercind.gov.in/ and on CERC's market monitoring activities at https://www.cercind.gov.in/market_monitoring.html.
[22] More information on India's CEA can be found at https://cea.nic.in/?lang=en and on its market monitoring activities at https://cea.nic.in/creation-of-market-monitoring-cell-electricity-markets/.

FERC required that market monitors have access to RTO/ISO data to enable market monitoring activities [83]. ACER maintains a website of publicly available market dashboards and dataset collections on its website.[23] European Union regulations (REMIT EU No. 1227/2011) require market participants to provide ACER with certain wholesale market transaction data, allows ACER to share these data with other authorities, allows ACER to make certain nonsensitive data public, and requires ACER to protect certain sensitive data.[24] As explored in Section 3.1.5, transparency and data access can help buyers and sellers in a market make better decisions and avoid adverse selection (i.e., bad choices). Increasing the quantity and availability of good-quality data improves the ability of competitive markets to delivery fair prices (i.e., prices that are both horizontally and vertically equitable) [84].

4.2 Solutions Within SAPP's Authority

Neither SAPP nor RERA can require independent sovereign nations in the SADC to take actions related to interconnected transmission systems in the region. SAPP and RERA can make suggestions, solution options, model rules, templates, and other actions to facilitate desired action, but they currently cannot require or enforce these on member nations. SAPP can develop rules over its markets, operations, etc. with the approval of its members. Since nationally owned utilities currently control the vote-based decision-making on rule approvals within SAPP's governance structure, it is unlikely SAPP could establish rules without national support. As a result, SAPP's ability to directly address many of the obstacles identified in this research may be limited unless addressed at the appropriate national level in each SADC nation. Through the SADC, member nations can develop binding SADC region protocols based on consensus agreement.

In this section, we attempt to identify actions within or somewhat within SAPP's authority (i.e., meaning requires approval by SAPP members) that could be pursued to potentially address some of the obstacles identified in Section 3. These were developed by NREL after literature review and semi-structured interviews with the SAPP-CC, subject matter experts, and practitioners in the region. They are prioritized in the next subsection based on input from stakeholders through our feedback form.

4.2.1 Prioritization of Potential Solutions Within SAPP's Authority

As shown in Figure 13, stakeholders prioritized development of new cost allocation and other finance mechanisms to facilitate new transmission builds as the most meaningful potential solution under SAPP's authority. This was followed by SAPP conducting training to educate new or potential market participants on key aspects of transacting in the SAPP markets.

[23] ACER's publicly available market monitoring data is available at https://www.acer.europa.eu/gas/market-monitoring/market%20monitoring%20report%20-%20early%20publications, with more information on data and methods at https://www.acer.europa.eu/electricity/market-monitoring-report.
[24] EU Regulation No. 1227/2011 (REMIT) is available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011R1227.

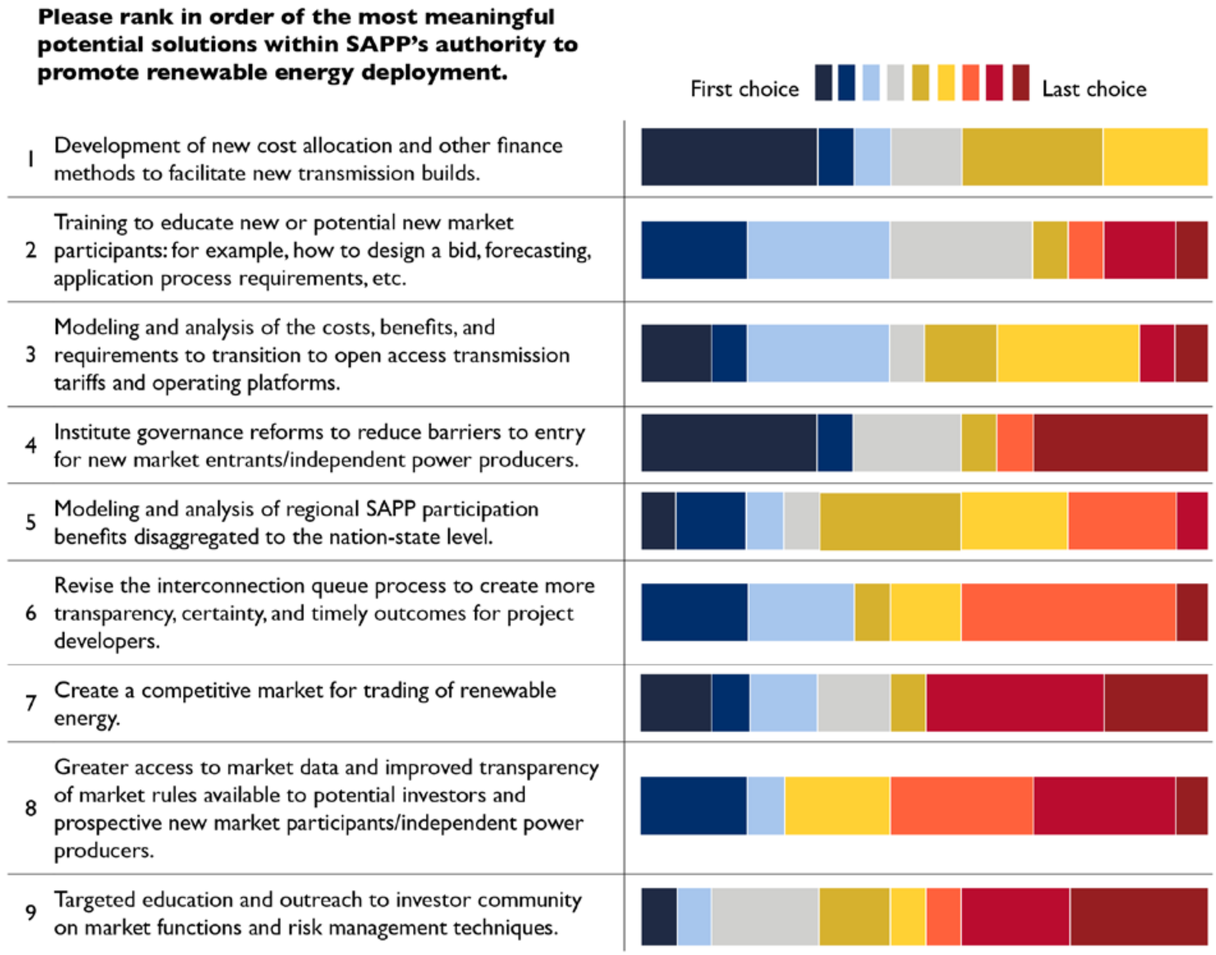

Figure 13. Stakeholder feedback on the most meaningful potential solutions in SAPP's authority to promote renewable energy deployment

4.2.2 Education and Outreach

SAPP could continue to engage in several forms of education and outreach to support competitive markets and renewable energy deployment. Estimates exist for the potential region-wide economic benefits SAPP markets could offer, including highlighting the benefits associated with establishing the initial market, and with potential market reforms [43] [14], [85], [86]. This includes SAPP's estimation of $90 billion required in investment over the next two decades with an expected savings of $34 billion in net present value terms between now and 2040 if a regional approach to planning was enacted, compared to aggregating national planning processes [14], [43]. Region-wide benefits calculation could be disaggregated down to the national level to better inform and help engage individual nations in supporting the regional market.

To promote new market entry, SAPP-CC could provide periodic education and outreach training to at least two targeted groups of stakeholders. First, training could be developed that is geared towards the investor community that is run publicly on a periodic basis using hybrid technology options to increase attendance and engagement. This training could be structured as outreach to investors, educating these stakeholders on the investment opportunity through SAPP, how the markets function, what risk management strategies are available, and other related topics. A second set of periodic trainings would target potential new market entrants, educating these stakeholders on how to become a SAPP member, how to transact in the market (e.g., how to design a bid, forecasting techniques, etc.), and other topics. By ensuring these resources are also kept for future reference (including audio-visual recording and production), resources can be made available asynchronously to stakeholders for future reference and longevity. SAPP-CC could also host in-person workshops to bring investors and potential new market entrants together to explore topics of mutual interest and to facilitate dialogue.

SAPP could continue to commission and publish important studies that facilitate regional dialogue around potential market reforms, complimenting the work of RERA and others. Such studies could include exploring the costs, benefits, and implementation pathways towards an open-access transmission tariff requirement, rate unbundling, and establishment of a regional transmission operator. Rather than advocacy pieces, these studies could be analysis-driven and capture a wide range of potential new market entrants, SAPP members, and stakeholder perspectives on the opportunities and challenges associated with such broad-based reforms. RERA's work on the Target Market Model and various detailed implementation frameworks are examples of the detailed, transformative reform proposals envisioned in [43], [45]. The Target Market Model was identified in the 2016 *"Implementation Plan for Market and Investment Framework for SADC Power Projects"* and represents a unified market structure that would be supported by a revised set of legal, regulatory, operational, and other frameworks [43]. Following the work of RERA or through its own, SAPP could engage its members over these models and frameworks and, if implemented, the benefits and challenges that may arise to further potential implementation of reforms.

4.2.3 Transparency and Governance

As explored in Section 3.1, market buyers and sellers need robust market data and information to make informed decisions. Clear market rules, data transparency, and timely information can boost investor confidence, help maintain healthy competitive markets and improve economic outcomes. On the other hand, lack of transparency prevents detection of market manipulation, inhibits sound decision-making by participants, and may cause investors to hesitate on lending to potential future market entrants. The importance of market and even firm-level transparency may be even more important in times of financial stress, to protect investors, improve liquidity, and lower the cost of capital [87], [88], [89].

The improved availability of market data transparency, visualization, programmatic access, and reporting (as is the case in several global public wholesale markets) should be a high priority for SAPP. There is substantial value-add in undertaking this for:

- **SAPP-CC:** To undertake faster analysis and summaries of monthly, quarterly, and annual SAPP market performance. Simultaneously, enabling SAPP-CC to track and control data access (through application programming interface or API keys) for reporting to SAPP members and the general public as appropriate.
- **Existing SAPP market participants:** Data to improve operational efficiency (potential to reduced costs), enable better decision-making as regional traders, and reduce risk considering future uncertainty.
- **Potential SAPP market participants:** Data to inform and enable improved decision-making for potential investment in new infrastructure (generation and transmission), increasing SAPP market participation levels, trading volumes, and wholesale market liquidity.
- **Academic interest:** Numerous individuals and academic institutions who desire to undertake analysis of SAPP wholesale markets and investigate research questions with supporting quantitative publicly available data.

Although the legacy public SAPP market platform previously partially served this purpose[25], at the time of writing, historical data has been removed, and data is not being updated or made publicly available.

SAPP could also explore with its members instituting governance reforms to lower barriers to new market entry. Specifically, lowering fees for new market entrants, expanding the nature and number of meetings new entrants can attend and contribute to decision-making beyond the annual Trader's Forum, expanding voting rights at decision-making meetings, and reducing the time and burden associated with SAPP membership applications. Expanding certain voting rights is particularly important, as new market entrants operate new technologies and have unique perspectives on market design and operations. Failing to integrate these transformative perspectives could forestall beneficial market evolution.

4.2.4 Regulatory and Technical

One important component to facilitate new cross-border transmission infrastructure builds is developing pricing mechanisms that allow project costs to be allocated to and recovered from project beneficiaries.

- **From 1995-1998**, the SAPP tariff used a simple fixed wheeling charge per unit of electricity transmitted through a zone, which increased by the number of zones transversed (i.e., postage-stamp methodology) [90].
- **In 1999**, SAPP transitioned to a MW-kilometer load flow method (i.e., quantity-distance) based on the proportion of transmission infrastructure assets located in a country that was used to transfer electricity. While this was seen as an appropriate way to facilitate bilateral trades and market clearing prices based off these trades, this method discouraged longer-distance trades, did not address congestion management, and did not facilitate open markets where transaction counterparties are not known ahead of time [90].
- **In 2005-2006**, SAPP retained an engineering consulting firm, Power Planning Associates Limited, to develop a new transmission cost allocation and recovery methodology, which led to the two-part wheeling charge method currently in use [91]. This two-part method includes a network cost of wheeling and revenue shared by a transmission network service provider and a network price for users of the transmission network providers assets [91].
- **In 2013**, SAPP commissioned AF Mercados to develop a wheeling charge method more appropriate for the DAM, which led to development and initial implementation activity in 2015 of a computer-based cross-border marginal participation method with balancing nodes [91]. These initial implementation activities with the new method resulted in large differences between wheeling costs and revenues compared to the previous method, leading to concerns and pursuit of a new path rather than implementation [91].

It is reported that since 2016, SAPP has explored the Entry-Exit method, based on metered import and export at a transmission node, and other potential methods of transmission cost allocation and recovery, but has not moved forward. SAPP recently appointed the Climate Fund Managers as the manager of its potential USD $1.3 billion Regional Transmission Infrastructure Financing Facility (RTIFF) that aims to build more cross-border transmission infrastructure [92]. This is a critical step toward attracting private and public investment into infrastructure to facilitate SAPP transactions.

It is also critically important to ensure that investors have a suitable, transparent, and cost-reflective wheeling charge method to recover capital and operating costs of this infrastructure to maintain liquidity and growth. Our focus here has been on cost recovery for new transmission facilities. However, it is also

[25] See the public-facing SAPP website (https://www.sappmarket.com/).

important to note that establishing cost-reflective tariff charges for existing transmission facilities is also important. For example, existing transmission assets that are not fully depreciated must be able to recover sunk costs, and existing facilities must be able to cover replacement and operation and maintenance costs.

In 2016, the SADC Energy Ministers approved the Market and Investment Framework for SADC Power Projects, which among other things identified obstacles to regional trading and proposed an operating framework to address these obstacles [93]. A regional grid code was proposed, along with common approaches to grid interconnection procedures and other strategy options to improve regional electricity system integration. If implemented, the regional grid code and complementary actions are expected to improve accountability, efficiency, and transparency, along with improving coordinated operations [68]. Although SAPP does not have the authority to require implementation of the regional grid code, SAPP can work with its members and other stakeholders to develop the regional grid code requirements and language, which is what occurred in 2021-2022 [93].The regional grid code that was subsequently developed includes a host of sub-codes,[26] as well as governance procedures that focus on transparency and non-discrimination [68]. In theory, the regional grid code will take precedence over national grid codes for all matters related to interconnected networks and would guide national grid evolution and adaptation. An operational sub-code within the regional grid code would provide the legal basis for requirements in SAPP's operating guidelines, while a planning code would provide the legal basis for SAPP's transmission and generation planning criteria [68]. The regional grid code could be administered by the SADC energy minister level or a regional energy regulator, such as the proposed SARERA.

Included in the regional grid code are sub-codes for interconnection standards. Grid interconnection agreements stipulate the costs, procedures, and activities required for a generation facility to interconnect to the transmission grid. Requests from prospective generation projects to interconnect to the transmission system generally involve certain system impact studies to understand how interconnection may impact the network and if any network upgrade investments are required to correct and issues associated with interconnection, and who pays for these upgrades. In SAPP, there are no standard interconnection requirements or model agreements for use across the region [94]. RERA has identified the development of interconnection agreements and study requirements as a critical component of developing a nondiscriminatory framework of access to the regional and national transmission systems [43]. Project developers face unknown costs associated with interconnection requirements that have the potential to undermine project economics. In addition, lack of clarity on interconnection agreement processes and requirements can result in development lags that negatively impact project realization. Greater clarity on requirements and process and timeline consistency across the region would provide project developers with greater certainty on interconnection.

SAPP could also create the framework for and implement (with member support) a competitive market for trading of renewable energy or renewable energy attributes, such as a renewable energy credit (REC) market.[27] A bundled renewable energy and attribute market could be as simple as an information exchange platform to connect potential buyers and sellers for negotiation of long-term contracting or could facilitate day-ahead and real-time trading.

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[26] The regional grid code study can be found on RERA's website at https://rerasadc.com/documents-and-downloads/. Early drafts of the regional grid code included a preamble, general conditions, glossary and definitions, and a series of sub-codes on planning, operations, connection, information exchange, metering, and markets.

[27] A REC market is typically implemented as a market-based compliance mechanism for renewable portfolio standards (RPS) that require utilities to supply a percentage of retail sales with renewable energy. Each MWh of eligible renewable electricity qualifies as one REC, and RECs can be traded in the open market.

5 Strategy Options

There is unmet demand for reliable electricity in the SAPP region, which if met would facilitate economic development and improve quality of life for people in the SADC. National utilities are in difficult financial positions and facing constraints on contributing capital to electricity system infrastructure needed to meet this demand. In theory, the private sector could provide the capital required for developers to build this essential electricity generation and transmission infrastructure (along with potential public-private partnering arrangements), but there are critical obstacles standing in the way. These critical obstacles can be generally characterized by:

1. Barriers to new market entry (within each country and at the regional SAPP level)
2. A lack of private sector confidence in the SAPP regional wholesale electricity markets.

Contributors to the private sector's lack of confidence in SAPP markets include lack of market transparency[28], lack of regional oversight of the SAPP markets[29], and heterogenous national-level regulatory frameworks. Lack of confidence in turn may translate into investments being seen as too risky to pursue. Barriers to new market entry refers to structural, market design, or other characteristics that make it difficult for new resources to enter the market. There are barriers to entry of new generation supply resources, as well as new transmission resources. Our implementation strategy options focus on addressing these two critical obstacles—lack of confidence in the SAPP energy and ancillary service markets and barriers to market entry for new generation and transmission—to unlock and leverage private sector investment into regional transmission and generation projects.

While this research does not address in specific detail the implementation challenges or pathways associated with these strategy options, the strategy options in this research are consistent with and complementary to RERA's 2015 Market and Investment Framework [45], 2016 Implementation Plan for the Market and Investment Framework [43], and the various reports detailing the implementation of a regional regulatory authority for Southern Africa [46], [57], [78], [79]. The fact that similar strategy options have existed for over a decade but have not been implemented speaks to the strength of the headwinds facing implementation. Yet, the consistency and persistence of these strategy options—namely, independent operation of transmission systems, open-access requirements with rate unbundling and cost-reflective tariffs, and establishment of a regional regulatory authority—supports the legitimacy and potential of these actions.

5.1 Reducing Barriers to Market Entry

The following activities would serve to reduce barriers to entry for new market participants and are identified as strategy options from the research.

Transition SAPP (or an alternate potentially new institution) from coordination of market activities (a market operator) to an independent Regional Transmission Operator (RTO) to maximize access, operating efficiency and existing cross-border transmission interconnectors. Four key functions of the SAPP RTO should include:

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[28] Particularly for potential new market entrants, third-party investors, members of the public and specific categories of existing members (Operating Members).

[29] Although market surveillance is currently undertaken to a certain extent by SAPP-CC, this is not periodically published beyond SAPP members (a concern for new market entrants, third-party investors and members of the public) and there are no region-wide structural enforcement mechanisms. In addition, the market operator (SAPP-CC) is unlikely the appropriate entity to be simultaneously implementing market operations and market surveillance.

- **Independent operation of regional system** of cross-border transmission facilities, while facility ownership remains unchanged.
- **Implementation of open-access transmission tariff** requirements, which necessitates rate unbundling and providing transmission service to third parties at set tariff rates. This also requires a platform for sharing data with customers about available transfer capacity and enabling customers to procure transfer capacity.
- **Coordinated inter-regional transmission expansion planning** and development of a competitive private sector transmission pathway. This requires cost-reflective tariff rates and workable cost allocation and recovery mechanisms.
- **Administration of competitive markets** that ensures required markets (e.g., balancing market) are functional and send adequate price signals for investments. These markets would also allow new participation models that allow for different types of buyers and sellers to transact in the market, such as large energy users, aggregators, marketers and brokers, ancillary service providers, etc.

Transition operation of national transmission systems from vertically integrated national utilities to ISOs. Ownership unbundling can also be explored. These ISOs should:

- **Implement open-access transmission tariffs** requirements, rate unbundling, and a platform to share data with potential customers and enable customers to procure available transmission capacity.
- **Transmission system planning** that is open and transparent, facilitates competitive transmission procurement, and involves cost-reflective rates and workable cost allocation mechanisms. There would be a mechanism for coordination of national and regional system planning and cost allocation.

5.2 Further Increasing Private Sector Confidence in SAPP Markets

Reducing barriers to market entry on its own has the potential to improve investor confidence in SAPP markets. However, trust in these markets would greatly benefit from additional actions, specifically a regulatory authority with region-wide oversight and powers, market monitoring, and improved data and market transparency. The following activities would serve to further increase investor confidence in the market through enhanced regulatory consistency and improved transparency and monitoring.

Establish a regional regulatory authority for the SADC region that will:

- **Create consistency throughout the region** and facilitate investment by:
    - Issuing regulations to create consistency and address critical needs such as wheeling charges, open-access requirements, quality of service, market rules and resource adequacy.
    - Encouraging national regulators to harmonize national standards with cross-border standards
    - Increasing regulatory staffing capacity and training
    - Set requirements that are binding on member states.
- **Require independent market monitoring** that includes both surveillance for market power and other manipulation and an ability to refer instances of abuse to the regional (and/or national) regulator for market mitigation to correct for anti-competitive behavior. Market monitors could also assess the revenue adequacy of rates (for example), if existing wheeling charges are insufficient to recover legacy costs.
- **Enhance the availability of data and information transparency** over the markets. These data will help improve buyer and seller decision-making and will enable market surveillance. These requirements would be in addition to platforms for transmission data, availability, and procurement.

This could include publicly accessible information dashboards and downloadable data, as well as increased access to data by market monitors who have confidentiality provisions in place to protect sensitive information.

As shown in Table 7 and Table 8, the strategy options proposed in this research address most, but not all, of the identified and stakeholder-prioritized obstacles to well-functioning competitive markets and deployment of renewable energy projects in the SADC region. Many of the strategy options in this research re-emphasize changes that have been proposed by SADC, RERA, SAPP, and others in the region. Although this research does not address the challenges associated with implementing these strategy options, this research recognizes that actions like these are critical to building private sector confidence in the markets and unlocking the capital needed to address electricity reliability needs in the SADC.

Table 7. Aligning Potential Strategy Options With Identified Obstacles (competitive markets)

	Independent Operations	Open Access Requirement w/ Data and Procurement	Transmission Expansion Planning and Competition	Market Administration	Information Transparency	Regional Regulatory Authority	Market Monitoring
Supply-Side Market Concentration (HHI)	X	X	X	X	X		X
Economics and Finance							
Lack of Credit Worthy Off-Takers				X	X		
Single Buyer Model				X			X
Below Cost Utility Tariffs		X					
Regulatory and Technical							
Lack of Enabling Regulations	X	X			X	X	X
No Regional Regulatory Authority						X	
Inconsistent Rules Across Region						X	X
Transparency and Governance							
Lack of Market Transparency and Data Access					X	X	X
Governance Rules Bias						X	X
Infrastructure							
Insufficient Infrastructure for Interconnection and Interchange	X						X
State Priorities							
Internal Self-Sufficiency Goals	X	X	X	X	X	X	
Insufficient, Uncoordinated Planning			X		X	X	

Table 8. Aligning Potential Strategy Options With Identified Obstacles (renewable energy deployment)

	Independent Operations	Open Access Requirement w/ Data and Procurement	Transmission Expansion Planning and Competition	Market Administration	Information Transparency	Regional Regulatory Authority	Market Monitoring
Economics and Finance							
Limited Access and High Cost of Funding	X	X	X	X	X	X	
Lack of Credit Worthy Off Takers	X	X	X	X	X	X	
Lack of Functional and Consistent RE Incentives							
Limited Funding for Pre-Finance Project Development							
Higher Project Costs Due to Imported Equipment							
Higher Project Costs Compared to Other Technology Options							
Regulatory and Technical							
Lack of Forward Interconnection Queue and System Impact Studies	X	X	X		X	X	
No Commercial Arrangements for Balancing Service for RE				X	X	X	X
Imbalance Service Requirements that Disadvantage RE Resources							
Uncertainty Over RE Project Quality, Performance, Output			X	X	X	X	

5.3 Additional Challenges and Solution Options

With respect to potential solution options under SAPP's control, stakeholders prioritized development of new cost allocation and other finance mechanisms to facilitate new transmission builds as the most meaningful potential solution under SAPP's authority. This was followed by SAPP conducting training to educate new or potential market participants on key aspects of transacting in the SAPP markets. SAPP-CC can and has studied, developed, analyzed, and modeled new transmission cost allocation mechanisms. However, these new mechanisms cannot be implemented without the required level of member support. SAPP-CC can perform training and analysis for potential new market entrants and potential investors, which may assist in reducing barriers to entry.

Stakeholders were given the opportunity to provide additional insights in our feedback form, many of which were indirectly addressed in this research. Specifically, stakeholders opined that:

- **Lenders are not likely to finance projects that depend solely on market access and prefer long-term PPAs**. In turn, the reliance on PPAs squeezes out the ability for projects to be developed on market revenues alone. *If implemented, the ISO and RTO reforms suggested in this research should improve investor confidence in market outcomes.*
- **There is insufficient regulatory staff capacity.** Greater focus is required on building the staffing capacity needed to perform this work. *This challenge was not directly addressed in this research, though could be assisted through regional regulatory capacity. The issue of regulatory staff capacity-building was also addressed in detail in workstream B of the RAERESA report* [78].
- **There is a lack of available methods to hedge against variability and intermittency.** In turn, this results in inefficient optimization (local versus global) or reliance on battery energy storage systems or reserves. *Other than improving the existing balancing market, this point was not addressed. Future work could explore physical and financial hedging mechanisms and ancillary services market development.*
- **Some networks are weak (low short-circuit levels)**, caused by large geographies and lack of generation resources across their networks. *This challenge was not directly addressed in this research, though could be assisted through improved transmission system operations and planning. For example, the short-circuit current rating of the network could be monitored by the independent operator and planning efforts could help identify lowest cost investments to prioritize for network upgrade.*
- **There is a need for a regional coordinated credit enhancement approach to renewable energy development.** *This challenge was not directly addressed in this research, though the RTO/ISO solution options and enhanced regional regulatory oversight could improve investor confidence.*
- **Smart grid capabilities to support variable renewable energy resources are inadequately considered, developed, and deployed.** *This challenge was not directly addressed in this research, though enhanced regional regulatory oversight could assist, for example, by putting in place requirements for certain least-cost smart grid technologies.*
- **Economies of scale to lower costs are not being achieved in renewable project development.** More can be done to facilitate multi-nation or multi-party project development. *This challenge was not directly addressed in this research.*

6 Conclusions

The SADC region has significant unmet demand for reliable electricity, as well as plentiful natural resources to support renewable electricity generation projects. Capital to invest in new transmission and renewable energy generation assets is a missing key to unlocking the region's resource potential to meet human and economic development needs. As a result, private sources of capital and combined public-private sector arrangements are important options, as nationally owned utilities are unable to provide capital due to unsustainable tariff levels, high debt burdens, and associated low credit quality. Unfortunately, private investors lack confidence in SAPP competitive markets for a host of reasons including insufficient transmission capacity, lack of market transparency, a heterogenous and insufficient approach to energy sector regulation (each country adopts substantively different regulatory frameworks that can be incompatible with competitive regional wholesale electricity markets), and many other factors explored in this research. Lack of confidence translates into proposed projects in the SAPP region seeming too risky (e.g., increasing financing costs or projects being infeasible to implement) and private sector investments not occurring.

The SADC region could continue the status quo of incremental market growth based on relatively small private and public sector contributions and continue to deal with unserved demand. Instead, the region could institute transformational and challenging electricity sector reforms aimed at boosting investor confidence and increasing market entry to further address the availability, accessibility, and affordability of electricity systems in the region. These reforms primarily involve transferring operation of transmission assets to independent entities; requiring nondiscriminatory open access to transmission systems; coordinating transmission planning in a manner that facilitates competitive procurement; developing cost-reflective, unbundled transmission tariffs; establishing a regional regulatory authority with regional powers; requiring independent market monitoring; and improving data and transparency of competitive markets.

This research recognizes the implementation challenges associated with these strategy options but does not focus on implementation details. It further recognizes that the strategy options identified in this research represent an end-state goal for the region and do not consider each member's state of readiness to transition. Transition to this end-state is likely to be incremental, will require political and regulatory shifts, and may require some participants to lead while others follow.

Implementing these reforms will inherently reduce incumbent national utility control over the existing electricity system as a prerequisite to developing a more independent, competitive electricity enterprise. While some national utilities may fare well in this transition, others will not. It is unlikely that negatively impacted utilities will voluntarily implement the strategy options in this and similar reports, since they will face financial and political barriers. Yet it is critical to not just understand the benefits of more independent and competitive regional wholesale electricity markets, but also to explore how national utilities in their current form that are potentially negatively impacted by these reforms are able to redefine their roles as the sector evolves.

References

[1] International Energy Agency (IEA), “Africa Energy Outlook 2022,” IEA, 2023. [Online]. Available: https://iea.blob.core.windows.net/assets/220b2862-33a6-47bd-81e9-00e586f4d384/AfricaEnergyOutlook2022.pdf

[2] K. Eurek, P. Sullivan, M. Gleason, D. Hettinger, D. Heimiller, and A. Lopez, “An improved global wind resource estimate for integrated assessment models,” *Energy Econ.*, vol. 64, pp. 552–567, May 2017, doi: 10.1016/j.eneco.2016.11.015.

[3] International Renewable Energy Agency (IRENA) and African Development Bank (AfDB), “Renewable energy market analysis: Africa and its regions,” IRENA (International Renewable Energy Agency); African Development Bank (AfDB), Market Analysis, 2022. [Online]. Available: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jan/IRENA_Market_Africa_2022.pdf

[4] N. A. de L. Beaumelle *et al.*, “The Global Technical, Economic, and Feasible Potential of Renewable Electricity,” *Annu. Rev. Environ. Resour.*, vol. 48, no. Volume 48, 2023, pp. 419–449, Nov. 2023, doi: 10.1146/annurev-environ-112321-091140.

[5] International Renewable Energy Agency (IRENA), “Africa 2030: roadmap for a renewable energy future,” IRENA (International Renewable Energy Agency), Abu Dhabi, United Arab Emirates, 2015. [Online]. Available: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2015/IRENA_Africa_2030_REmap_2015_low-res.pdf

[6] International Renewable Energy Agency (IRENA) and Lawrence Berkeley National Laboratory (LBNL), “Renewable Energy Zones for the Africa Clean Energy Corridor; Multi-criteria analysis for planning renewable energy deployment,” 2015.

[7] A. A. Eberhard, O. Rosnes, M. Shkaratan, H. Vennemo, and Weltbank, Eds., *Africa’s power infrastructure: investment, integration, efficiency*. in Directions in development Infrastructure. Washington, DC: World Bank, 2011. doi: 10.1596/978-0-8213-8455-8.

[8] Theo Janse van Rensburg and Kgotso Morema, “Reflections on load-shedding and potential GDP,” South African Reserve Bank, 2023. [Online]. Available: https://www.reservebank.co.za/content/dam/sarb/publications/occasional-bulletin-of-economic-notes/2023/reflections-on-load-shedding-and-potential-gdp-june-2023.pdf

[9] L. Musaba, “The development of the SAPP competitive electricity market,” in *IEEE Power Engineering Society Inaugural Conference and Exposition in Africa*, Durban, South Africa, 2005, pp. 11–15.

[10] J. Solomons, “Reflections on load-shedding and potential GDP,” 2014.

[11] Southern African Power Pool, “Southern African Power Pool SADC Grid Map.” Accessed: Jun. 11, 2024. [Online]. Available: https://www.sapp.co.zw/

[12] Southern African Power Pool, “Southern African Power Pool 2021 Annual Report,” SAPP, Zimbabwe, Annual Report, Sep. 2021. Accessed: Feb. 20, 2024. [Online]. Available: https://www.sapp.co.zw/sites/default/files/Full%20Report%20SAPP.pdf

[13] Eskom Holdings SOC Limited, “Eskom Data Portal.” Accessed: Aug. 31, 2024. [Online]. Available: https://www.eskom.co.za/dataportal/

[14] Infrastructure and Cities for Economic Development, “Opportunities to Support and Increase Regional Power Trading in Southern Africa: Version 2,” UK Department of International Development, Feb. 2019. [Online]. Available: http://icedfacility.org/wp-content/uploads/2019/07/ICED_SouthernAfricaPowerTrading.pdf

[15] Southern African Power Pool (SAPP), Electricity Control Board (ECB), and NamPower, "SAPP and MSB Market Access Guide," 2023. [Online]. Available: https://www.ecb.org.na/wp-content/uploads/2023/08/SAPP_MSB_Market_Access_Guide.pdf
[16] "Power deficit, transmission constraints mar SAPP electricity trade | African Energy." Accessed: Sep. 12, 2024. [Online]. Available: https://www.africa-energy.com/news-centre/article/power-deficit-transmission-constraints-mar-sapp-electricity#full
[17] "Climate Impacts on African Hydropower – Analysis," IEA. Accessed: Sep. 12, 2024. [Online]. Available: https://www.iea.org/reports/climate-impacts-on-african-hydropower
[18] International Hydropower Association (IHA), "Africa hydropower Profile." Accessed: Sep. 12, 2024. [Online]. Available: https://www.hydropower.org/region-profiles/africa
[19] R. Gonzalez Sanchez, I. Kougias, M. Moner-Girona, F. Fahl, and A. Jäger-Waldau, "Assessment of floating solar photovoltaics potential in existing hydropower reservoirs in Africa," *Renew. Energy*, vol. 169, pp. 687–699, May 2021, doi: 10.1016/j.renene.2021.01.041.
[20] G. Wu, R. Deshmukh, K. Ndhlukula, T. Radojicic, and J. Reilly-Moman, *Renewable Energy Zones for the Africa Clean Energy Corridor*. 2015. doi: 10.13140/RG.2.1.4005.4644.
[21] M. Sengupta, Y. Xie, A. Lopez, A. Habte, G. Maclaurin, and J. Shelby, "The National Solar Radiation Data Base (NSRDB)," *Renew. Sustain. Energy Rev.*, vol. 89, pp. 51–60, Jun. 2018, doi: 10.1016/j.rser.2018.03.003.
[22] USAID, "SAPP Guidelines for New Entrants, Rev 2," Aug. 2021. [Online]. Available: https://pdf.usaid.gov/pdf_docs/PA00Z4JM.pdf
[23] J. Wright and J. van Coller, "Long-term system adequacy in the Southern African Power Pool (SAPP) based on a review of historical capacity balances and electricity trade : A case for Capacity Mechanisms," *J. Energy South. Afr. JESA*, 2018.
[24] Ignacio J. Perez Arriaga, "The Southern Africa Power Pool," presented at the The Pan-Arab Energy Trade Conference, Cairo, Nov. 06, 2019. [Online]. Available: https://www.arabfund.org/wp-content/uploads/2024/03/CAIRO-2019-SAPP-Perez-Arriaga.pdf
[25] Southern African Development Community, "Revised Intergovernmental Memorandum of Understanding Regarding the Southern African Power Pool (SAPP)," Feb. 2006.
[26] Corporate Finance Institute, "Imperfect Competition," Corporate Finance Institute. Accessed: Jun. 27, 2024. [Online]. Available: https://corporatefinanceinstitute.com/resources/economics/imperfect-competition/
[27] Lumen Learning (Boundless), *Economics*. LibreTexts, 2018. Accessed: Jul. 31, 2024. [Online]. Available: https://socialsci.libretexts.org/Bookshelves/Economics/Economics_(Boundless)
[28] Greenlaw, Steven, Shapiro, David, and MacDonald, Daniel, *Principles of Economics 3e*. OpenStax.org. Accessed: Jul. 31, 2024. [Online]. Available: https://openstax.org/details/books/principles-economics-3e
[29] R. Haas and H. Auer, "The prerequisites for effective competition in restructured wholesale electricity markets," *Energy*, vol. 31, no. 6, pp. 857–864, May 2006, doi: 10.1016/j.energy.2005.03.008.

[30] D. Harbord and T. Hoehn, "Barriers to entry and exit in European competition policy," *Int. Rev. Law Econ.*, vol. 14, no. 4, pp. 411–435, Dec. 1994, doi: 10.1016/0144-8188(94)90024-8.
[31] R. Wilson, "Entry and Exit," in *The Economics of Imperfect Competition and Employment: Joan Robinson and Beyond*, G. R. Feiwel, Ed., London: Palgrave Macmillan UK, 1989, pp. 260–304. doi: 10.1007/978-1-349-08630-6_8.
[32] D. Benatia and T. Koźluk, "The Determinants of Entry in The Electricity Generation Sector in OECD Countries: A Focus on Renewable Energy," OECD, Paris, Dec. 2016. doi: 10.1787/5f30bc75-en.
[33] Tom Hird, Paul Reynolds, Daniel Young, Johanna Hansson, and Yuliya Moore, "Barriers to Entry in Electricity Generation," Competition Economists Group (CEG), Jun. 2012. [Online]. Available: https://www.aemc.gov.au/sites/default/files/content/d36e31ee-0cfc-4ab8-be12-b673cf0d8a79/CEG-Report.PDF
[34] R. P. McAfee, H. M. Mialon, and M. A. Williams, "What Is a Barrier to Entry?," *Am. Econ. Rev.*, vol. 94, no. 2, pp. 461–465, 2004.
[35] X. Lin, B. Wang, Z. Xiang, and Y. Zheng, "A review of market power-mitigation mechanisms in electricity markets," *Energy Convers. Econ.*, vol. 3, no. 5, pp. 304–318, 2022, doi: 10.1049/enc2.12067.
[36] U.S. Department of Justice and Federal Trade Commission, "Merger Guidelines," Dec. 2023. [Online]. Available: https://www.justice.gov/d9/2023-12/2023%20Merger%20Guidelines.pdf
[37] O'Melveny Worldwide, "China's SAMR Publishes Draft Horizontal Merger Review Guidelines - O'Melveny." Accessed: Sep. 02, 2024. [Online]. Available: https://www.omm.com/insights/alerts-publications/china-s-samr-publishes-draft-horizontal-merger-review-guidelines/
[38] European Union, "Guidelines on the assessment of horizontal mergers under the Council Regulation on the control of concentrations between undertakings," 2004. Accessed: Sep. 02, 2024. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52004XC0205%2802%29
[39] Southern African Power Pool (SAPP), "SAPP Electricity Trading," SAPP Electricity Trading. [Online]. Available: www.sappmarket.com
[40] Laszlo Lovei, "The Single-Buyer Model," The World Bank, Dec. 2000. [Online]. Available: https://documents1.worldbank.org/curated/ar/779321468780281965/pdf/22403-Replacement-file-225LOVEI.pdf
[41] Energy Regulation Board of Zambia, "Zambia Energy Regulation Board Annual Report 2022," ERB, 2022. [Online]. Available: https://www.erb.org.zm/wp-content/uploads/ERB-2022-Annual-Report.pdf
[42] Eskom Holdings SOC Limited, "ESKOM 2022 Financial Statement," Eskom, 2022. [Online]. Available: https://www.eskom.co.za/wp-content/uploads/2022/12/2022_annual_financial_statements.pdf
[43] Deloitte Financial Advisory Services, "Implementation Plan for the "Market and Investment Framework for SADC Power Projects," RERA, Apr. 2016. [Online]. Available: https://rerasadc.com/wp-content/uploads/2021/03/362_D2_Market-and-Investment-Framework-for-SADC-Power-Project_Implementation-Plan.pdf
[44] Economic Consulting Associates, "Development of a framework and roadmap for the establishment of a Regional Energy Regulatory Authority for SADC," Nov. 2019.

[45] Deloitte Financial Advisory Services, “Market and Investment Framework for SADC Power Projects – Recommended Market Model,” RERA, Sep. 2015. [Online]. Available: https://rerasadc.com/wp-content/uploads/2021/03/299_D1_Market-and-Investment-Framework-for-SADC-Power-Project_Wholesale-Market-Model.pdf
[46] Peter Zhou, “Regional Infrastructure Development Master Plan: Energy Sector Plan,” SADC, 2012. Accessed: Aug. 01, 2024. [Online]. Available: https://www.sadc.int/sites/default/files/2021-11/Regional_Infrastructure_Development_Master_Plan_Energy_Sector_Plan.pdf
[47] “SAPP Market Monthly Report - Jan 2022.” [Online]. Available: https://www.sapp.co.zw/sites/default/files/Market%20Monthly%20Performance%20Report%20-%20January%20%202022_1.pdf
[48] D. Hurlbut *et al.*, “Interregional Renewable Energy Zones,” National Renewable Energy Laboratory, Golden, CO, Technical Report NREL/TP-6A20-88228, Mar. 2024. [Online]. Available: https://www.nrel.gov/docs/fy24osti/88228.pdf
[49] E. Stumpf, “Transmission for Transition: Solving the South African Energy Crisis Through Logistics,” *Power Magazine*, Jul. 26, 2023. [Online]. Available: https://www.powermag.com/blog/transmission-for-transition-solving-the-south-african-energy-crisis-through-logistics/
[50] The Global Development Policy (GDP) Center (Boston University), The interational Law Unit (University of Pretoria), The Southern Africa Development Communicty Development Finance Resource Center (SADC-DFRC), The SADC Centre for Renewable Energy and Energy Efficiency (SACREE), and The Development Bank of SOuthern Africa (DBSA), “Expanding Renewable Energy for Access and Development: The Role of Development Finance Institutions in Southern Africa.” [Online]. Available: https://www.bu.edu/gdp/2020/11/18/five-recommendations-to-boost-renewable-energy-finance-in-southern-africa/#:~:text=In%20Southern%20Africa%2C%20insufficient%20electricity,and%20provide%20access%20to%20all.
[51] B. Payton, “Africa’s race for transmission investment,” May 24, 2023. [Online]. Available: https://african.business/2023/05/energy-resources/africas-race-for-transmission-investment#:~:text=%E2%80%9CThe%20existing%20transmission%20infrastructure%20in,had%20originally%20planned%20to%20procure.
[52] W. Roelf, “New $1.3 bln energy fund for transmission links across Southern Africa,” *Reuters*, Mar. 05, 2024. Accessed: Jun. 25, 2024. [Online]. Available: https://www.reuters.com/sustainability/sustainable-finance-reporting/new-13-bln-energy-fund-transmission-links-across-southern-africa-2024-03-05/
[53] Eskom Holdings SOC Limited, “Eskom Achieves All Suspensive Conditions for the Merger Agreement with NTCSA,” Eskom. [Online]. Available: https://www.eskom.co.za/eskom-achieves-all-suspensive-conditions-for-the-merger-agreement-with-ntcsa/
[54] G. O. Anderson and A. Opok, “Southern Africa power pool: Benefits, achievements, challenges and sustainability,” *Int. J. Power Energy Syst.*, vol. 28, pp. 429–437, 2008.
[55] Economic Consulting Associates, “South African Power Pool Transmission & Trading Case Study,” Oct. 2009. [Online]. Available: https://documents1.worldbank.org/curated/ru/126211468323330432/pdf/773070v110ESMA0h0African0Power0Pool.pdf

[56] Castalia Strategic Advisors, "International Experience with Cross-Border Power Trading," RERA, 2009. [Online]. Available: https://rerasadc.com/wp-content/uploads/2021/03/e46_D4_Final-Report-International-Experience-with-Cross-Border-Power-Trading.pdf
[57] Economic Consulting Associates, LTD, "Electricity Planning in SADC: Status Rport in May 2021," May 2021. [Online]. Available: https://www.sapp.co.zw/sites/default/files/Electricity%20planning%20in%20SADC%20%28May%202021%29.pdf
[58] SAPP, "SAPP Pool Plan | Southern African Power Pool." Accessed: Feb. 23, 2024. [Online]. Available: https://www.sapp.co.zw/sapp-pool-plan-0
[59] G. Brinkman, M. Bannister, S. Bredenkamp, and B. Vyakaranam, "Atlantic Offshore Wind Transmission Study," U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Mar. 2024. [Online]. Available: https://www.nrel.gov/docs/fy24osti/88003.pdf
[60] W. W. Hogan, "Electricity Market Design and Zero-Marginal Cost Generation," *Curr. Sustain. Energy Rep.*, vol. 9, no. 1, pp. 15–26, Mar. 2022, doi: 10.1007/s40518-021-00200-9.
[61] The World Bank, "International Development Association Project Paper on a Proposed Additional Grant in the Amount of US$8.5 Million.," PAD2462, Jun. 2019. [Online]. Available: https://documents1.worldbank.org/curated/en/309691562607404024/pdf/Africa-Southern-African-Power-Pool-Program-for-Accelerating-Transformational-Energy-Projects-Additional-Financing.pdf
[62] Muñoz Cabré M., Ndhlukula K., and Musasike T., "Expanding Renewable Energy for Access and Development: The Role of Development Finance Institutions in Southern Africa," Boston University, Global Development Policy Center., 2020.
[63] New Partnership for Africa's Development, "Africa Power Vision Concept Note and Implementation Plan: from Vision to Action," Jan. 2015. [Online]. Available: https://www.icafrica.org/fileadmin/documents/Knowledge/Energy/Power_Africa-AFRICA-POWER-VISION.pdf
[64] A. Miketa and B. Merven, "SAPP: Planning and Prospects for Renewable Energy," IRENA (International Renewable Energy Agency), Abu Dhabi, United Arab Emirates, 2013. [Online]. Available: https://www.osti.gov/etdeweb/servlets/purl/22110313
[65] SAPVIA, "Emesco's Schonau Solar Energy accepted as Conditional Member of SAPP." [Online]. Available: https://sapvia.co.za/emescos-schonau-solar-energy-accepted-as-conditional-member-of-sapp/
[66] Solarcentury Africa, "Solarcentury Africa Granted full unconditional Southern African Power Pool (SAPP) membership as a Market Participant." [Online]. Available: https://solarcenturyafrica.com/solarcentury-africa-granted-full-unconditional-southern-african-power-pool-sapp-membership-as-a-market-participant/
[67] SAPP CC, "The SAPP Markets Overview," Aug. 28, 2023. [Online]. Available: https://www.ecb.org.na/wp-content/uploads/2023/08/5.Regional_Competitive_Auction_Market.pdf
[68] Regional Energy Regulators Association of Southern Africa (RERA), "SADC Regional Grid Code Policy Brief (Draft) V4.0," RERA, Feb. 2022. [Online]. Available: https://rerasadc.com/wp-content/uploads/2022/03/SADC-RGC-Policy-Brief-Draft-v0.4-clean2.docx

[69] Alberto Pototsching and Ignacio J. Perez Arriaga, “Organizational models for system operation,” Florence School of Regulation, Nov. 2023. [Online]. Available: https://globalpst.org/wp-content/uploads/Pototschnig-Perez-Arriaga-231103.pdf
[70] Council of European Energy Regulators, “Status Review on the Implementation of Transmission System Operators’ Unbundling Provisions of the 3rd Energy Package,” CEER, Apr. 2016. [Online]. Available: https://www.ceer.eu/wp-content/uploads/2024/04/CEER-Status-Review-on-the-implementation-of-TSO-unbundling.pdf
[71] Federal Energy Regulatory Commission (FERC), “Electric Power Markets National Overview.” Accessed: Aug. 27, 2024. [Online]. Available: https://www.ferc.gov/electric-power-markets
[72] Sustainable FERC, “RTO Backgrounders,” Sustainable FERC Project. Accessed: Aug. 29, 2024. [Online]. Available: https://sustainableferc.org/rto-backgrounders-2/
[73] Federal Energy Regulatory Commission (FERC), “Order 888,” Apr. 1996. Accessed: Dec. 09, 2022. [Online]. Available: https://www.ferc.gov/sites/default/files/2020-05/rm95-8-00w.txt
[74] USAID, “Strengthening Utilities and Promoting Energy Reform (SUPER) Utility Unbundling & Electricity Market Reform,” USAID, May 2022. [Online]. Available: https://www.usaid.gov/sites/default/files/2022-05/2022-USAID-SUPER-Utility-Unbundling-Electricity-Market-Reform.pdf
[75] Federal Energy Regulatory Commission (FERC), “Open Access Same-Time Information System.” Accessed: Aug. 29, 2024. [Online]. Available: https://www.ferc.gov/OASIS
[76] Erik Ela, Michael Milligan, and Brendan Kirby, “Operating Reserves and Variable Generation,” NREL, Aug. 2011. [Online]. Available: https://www.nrel.gov/docs/fy11osti/51978.pdf
[77] Greening the Grid, “Ancillary Services,” Greening the Grid. Accessed: Sep. 11, 2024. [Online]. Available: https://greeningthegrid.org/integration-in-depth/ancillary-services
[78] Graeme Chown, Maree Roos, Jian Bani, and Jonathan Hedgecock, “Framework for Regulatory Oversight for the EA-SA-IO Energy Market,” Ricardo Energy and Environment, Jun. 2020. [Online]. Available: https://rerasadc.com/documents-and-downloads/
[79] Regional Energy Regulators Association of Southern Africa (RERA), “The Business Case for SARERA: SADC Regional Energy Regulatory Authority.” [Online]. Available: https://rerasadc.com/wp-content/uploads/2021/03/EN-Business-Case-for-SARERA.pdf
[80] WS Atkins International Ltd, “Renewable Energy and Energy Efficiency Strategy and Action Plan (REEESAP 2016-2030),” Oct. 2016. [Online]. Available: https://www.sacreee.org/sites/default/files/2023-11/REEESAP_Report_2016-2030.pdf
[81] Southern African Development Community, “SADC Regional Indicative Strategic Development Plan (RISDP) 2020–2030,” SADC, Oct. 2020. [Online]. Available: https://www.sadc.int/sites/default/files/2021-08/RISDP_2020-2030.pdf
[82] Frank A Wolak, “Lessons from International Experience with Electricity Market Monitoring,” The World Bank, Sep. 2005. [Online]. Available: https://documents1.worldbank.org/curated/en/639831468140966929/pdf/wps3692.pdf
[83] Federal Energy Regulatory Commission (FERC), “Order 719,” FERC, 2008. [Online]. Available: https://www.ferc.gov/media/order-no-719

[84] R. Schmalensee, "Imperfect Information and the Equitability of Competitive Prices," *Q. J. Econ.*, vol. 99, no. 3, pp. 441–460, 1984, doi: 10.2307/1885959.
[85] M. A. E. Elabbas, L. de Vries, and A. Correljé, "African power pools and regional electricity market design: Taking stock of regional integration in energy sectors," *Energy Res. Soc. Sci.*, vol. 105, p. 103291, Nov. 2023, doi: 10.1016/j.erss.2023.103291.
[86] M. A. E. Elabbas, "African Power Pools: Institutions, Reforms, Issues and Challenges," Institute for Research in Technology, ICAI School of Engineering, Comillas Pontifical University, Madrid, Spain, Apr. 2023. [Online]. Available: https://www.iit.comillas.edu/documentacion/workingpaper/IIT-23-052WP/African_power_pools:_institutions,_reforms,_issues_and_challenges.pdf
[87] Mark Lang, Karl V Lins, and Mark Maffett, "Transparency, Liquidity, and Valuation: International Evidence on When Transparency Matters Most," *J. Account. Res.*, vol. 50, no. 3, pp. 729–774, Jun. 2012, doi: https://doi.org/10.1111/j.1475-679X.2012.00442.x.
[88] Treasury Market Practices Group, "White Paper on Data Availability and Transparency in the U.S. Treasury Securities Market," New York Federal Reserve Bank, Mar. 2023. [Online]. Available: https://www.newyorkfed.org/medialibrary/microsites/tmpg/files/DT_2023.pdf
[89] Nellie Liang and Pat Parkinson, "Enhancing Liquidity of the U.S. Treasury Market Under Stress," Brookings Institute, Dec. 2020. [Online]. Available: https://www.brookings.edu/wp-content/uploads/2020/12/WP72_Liang-Parkinson.pdf
[90] Deloitte Financial Advisory Services, "Technical Support for Continued Support on Regional Market Framework Implementation to the Regional Electricity Regulators Association of Southern Africa (RERA): Transmission Pricing Methodology," U.S. Department of State, Sep. 2018. [Online]. Available: https://rerasadc.com/wp-content/uploads/2021/03/a75_D6_Transmission-Pricing-Methodology.docx
[91] United States Agency for International Development (USAID), "Southern Africa Energy Program ZESCO Transmission Pricing: Working Report 1, Review of Documentation and Implications for Transmission Pricing," 2020. [Online]. Available: https://pdf.usaid.gov/pdf_docs/PA00X1HV.pdf
[92] Climate Fund Managers, "Climate Fund Managers appointed to manage SAPP's USD$1.3 Billion Regional Transmission Infrastructure Financing Facility (RTIFF) – Climate Fund Managers." Accessed: Sep. 12, 2024. [Online]. Available: https://climatefundmanagers.com/2024/03/05/climate-fund-managers-appointed-to-manage-sapps-usd1-3-billion-regional-transmission-infrastructure-financing-facility-rtiff/
[93] Ricardo, "The Development of the SADC Regional Grid Code for the Electricity Supply Industry: Draft Final Report," RERA, World Bank Grant No. TF-A4772, Feb. 2022. [Online]. Available: https://rerasadc.com/documents-and-downloads/
[94] Deloitte Financial Advisory Services, "Technical Support for Continued Support on Regional Market Framework Implementation to the Regional Electricity Regulators Association of Southern Africa (RERA): Model Grid Interconnection Agreement," U.S. Department of State, Jul. 2018. Accessed: Aug. 05, 2024. [Online]. Available: https://rerasadc.com/documents-and-downloads/
[95] J. Batalla, M. T. Costa-Campi, and E. Trujillo-Baute, "Chapter 6 - Wholesale Markets – Regulation of Electricity and Gas Industry," in *Handbook of Energy Economics and Policy*, A. Rubino, A. Sapio, and M. La Scala, Eds., Academic Press, 2021, pp. 239–274. doi: 10.1016/B978-0-12-814712-2.00006-3.

[96] CIGRE Working Group C5.32, "Carbon Pricing in Wholesale Electricity Markets," Technical Brochure, 2023. [Online]. Available: https://www.e-cigre.org/publications/detail/897-carbon-pricing-in-wholesale-electricity-markets.html
[97] L. Wu, "Interaction Between Renewable Energy Integration and Wholesale Electricity Markets: A Legal and Regulatory Perspective," *Handbook of Energy Law in the Low-Carbon Transition*. 2023. doi: 10.1515/9783110752403-015.
[98] M. Jiang, "How Public Policies Are Implemented: A Comparison of Urban Domestic Waste Classification Policy Implementation Models," *Sustainability*, vol. 14, no. 22, Art. no. 22, Jan. 2022, doi: 10.3390/su142215480.
[99] *Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652*, vol. Official Journal of the European Union. 2023. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202302413
[100] "The Climate Action Plan - Securing our Future Cutting Emissions, Creating Green Jobs, Protecting People and Planet," Government of Ireland. [Online]. Available: https://assets.gov.ie/203546/a183a324-40ed-49c9-b630-bab0fbdd2ce2.pdf
[101] Government of Ireland Department of the Environment, Climate and Communications, "Renewable Electricity Support Scheme (RESS)," Renewable Electricity Support Scheme (RESS). [Online]. Available: https://www.gov.ie/en/publication/36d8d2-renewable-electricity-support-scheme/#ress-3
[102] "U.S. State Renewables Portfolio & Clean Electricity Standards: 2024 Status Update," [Online]. Available: https://live-etabiblio.pantheonsite.io/sites/default/files/lbnl_rps_ces_status_report_2024_edition.pdf
[103] A. Colthorpe, "32GW CfD scheme for dispatchable renewables is 'biggest news in Australian electricity policy,'" PV Tech. [Online]. Available: https://www.pv-tech.org/32gw-cfd-scheme-for-dispatchable-renewables-is-biggest-news-in-australian-electricity-policy/
[104] Department for Energy Security and Net Zero, "Contracts for Difference." [Online]. Available: https://www.gov.uk/government/collections/contracts-for-difference#:~:text=A%20Contract%20for%20Difference%20(CfD,%2C%20a%20government%2Downed%20company.
[105] A. S. Ajagun, W. Mao, X. Sun, J. Guo, B. Adebisi, and A. M. Aibinu, "The Status and Potential of Regional Integrated Energy Systems in Sub-Saharan Africa: An Investigation of the Feasibility and Implications for Sustainable Energy Development," *Energy Strategy Rev.*, vol. 53, p. 101402, May 2024, doi: 10.1016/j.esr.2024.101402.
[106] M. B. Anwar, N. Guo, Y. Sun, and B. Frew, "Can Wholesale Electricity Markets Achieve Resource Adequacy and High Clean Energy Generation Targets in the Presence of Self-Interested Actors?," *Appl. Energy*, vol. 359, p. 122774, Apr. 2024, doi: 10.1016/j.apenergy.2024.122774.
[107] California Independent System Operator (CAISO), "2022 Annual report on market issues & performance," Annual Report, 2023. [Online]. Available: https://www.caiso.com/documents/2022-annual-report-on-market-issues-and-performance-jul-11-2023.pdf
[108] Directorate-General for Economic and Financial Affairs (European Commission), S. Busch, R. Kasdorp, D. Koolen, A. Mercier, and M. Spooner,

The development of renewable energy in the electricity market. Publications Office of the European Union, 2023. Accessed: Sep. 04, 2024. [Online]. Available: https://data.europa.eu/doi/10.2765/411281
[109] Australian Energy Market Commission (AEMC), "Transmission access reform." Accessed: Sep. 12, 2024. [Online]. Available: https://www.aemc.gov.au/market-reviews-advice/transmission-access-reform
[110] "Independent Market Monitor," PJM. [Online]. Available: https://www.pjm.com/about-pjm/who-we-are/pjm-board/independent-market-monitor
[111] ENTSO-E, "ENTSO-E Member Companies," ENTSOE. [Online]. Available: https://www.entsoe.eu/about/inside-entsoe/members/
[112] European Network of Transmission System Operators for Electricity (ENTSO-E), "Market Committee," What we do. Accessed: Sep. 12, 2024. [Online]. Available: https://www.entsoe.eu/about/market/#what-we-do
[113] D. Newbery, M. G. Pollitt, R. A. Ritz, and W. Strielkowski, "Market Design for a High-Renewables European Electricity System," *Renew. Sustain. Energy Rev.*, vol. 91, pp. 695–707, Aug. 2018, doi: 10.1016/j.rser.2018.04.025.
[114] "Grid Services from Renewable Generators," NYISO, 2021. Accessed: Jul. 10, 2024. [Online]. Available: https://www.nyiso.com/documents/20142/24130223/Grid%20Services%20from%20Renewable%20Generators%20Study.pdf/b47e9923-c2bd-faa6-e81d-29300dd56df2
[115] A. Hajigholam Saryazdi, "A Review of Global Electricity Market," Feb. 20, 2024, *Rochester, NY*: 4733363. doi: 10.2139/ssrn.4733363.
[116] M. B. Lindberg, "The power of power markets: Zonal market designs in advancing energy transitions," *Environ. Innov. Soc. Transit.*, vol. 45, pp. 132–153, Dec. 2022, doi: 10.1016/j.eist.2022.08.004.
[117] R. Liu, Y. Liu, and Z. Jing, "Impact of Industrial Virtual Power Plant on Renewable Energy Integration," *2020 IEEE/IAS Industrial and Commercial Power System Asia, I and CPS Asia 2020*. pp. 1198–1202, 2020. doi: 10.1109/ICPSAsia48933.2020.9208506.
[118] V. Haberle, A. Tayyebi, X. He, E. Prieto-Araujo, and F. Dorfler, "Grid-Forming and Spatially Distributed Control Design of Dynamic Virtual Power Plants," *IEEE Transactions on Smart Grid*, vol. 15, no. 2. pp. 1761–1777, 2024. doi: 10.1109/TSG.2023.3311481.
[119] Jarrad G. Wright, "Formulation of a Capacity Mechanism for the Southern African Power Pool (SAPP) for Sustained Long-Term System Adequacy," PhD, University of the Witwatersrand, 2019. [Online]. Available: https://wiredspace.wits.ac.za/items/4fdb14b1-1a5a-4d97-b45a-1b7330ef82ed
[120] Federal Energy Regulatory Commission (FERC), *Open Access Same-Time Information System (formerly Real-Time Information Networks) and Standards of Conduct*. [Online]. Available: https://www.ferc.gov/sites/default/files/2020-04/rm95-9-00k.txt
[121] "International Experience with Open Access to Power Grids," Energy Sector Management Assistance Program. [Online]. Available: https://documents1.worldbank.org/curated/en/687851468147866316/pdf/789770REVISED000Power0Grids0KS16013.pdf
[122] Southern African Power Pool (SAPP), "SAPP Annual Reports." Accessed: Feb. 23, 2024. [Online]. Available: https://www.sapp.co.zw/annual-reports

Appendix A. Stakeholder Feedback Form

As part of this research, a Feedback Form was developed. Stakeholders were asked for contact information and to self-identify within one of six (6) sectors: Utility, New Market Entrant/IPP, Trader, Practitioner/Consultant, Regulator, or Other. Stakeholders were then asked to rank order responses to three questions related to barriers and opportunities and were given text boxes to enter any additional thoughts.

1. Please rank in order of the most meaningful barriers to well-functioning SAPP competitive markets. *[highest on the list is more meaningful, lowest on the list is less meaningful]*

- Lack of weak nation-state regulatory frameworks to support regional SAPP activities.
- Dominance of single-buyer markets.
- Utility off-takers have low credit quality, below-cost tariffs, and inability to access capital.
- Insufficient transmission infrastructure for interconnection and /or regional movement of power.
- Nation-level desire to be internally self-sufficient, rather than rely upon regional markets and trading to meet reliability needs.
- Lack of regional electricity sector regulatory authority (currently RERA is an association only) and inconsistent/heterogenous approach to electricity sector regulatory oversight across the region.
- Lack transparency on market rules and market data access for potential new users and investors.
- Insufficient nation-state level power system (generation, transmission, distribution) planning and implementation, and lack of regional coordination among nation-level power system plans.
- For new market entrants, the SAPP governance structure includes high membership fees, lack of voting rights, and inability to attend most meetings.

2. Please rank in order of the most meaningful barriers to renewable energy deployment in the SAPP Region. *[highest on the list is more meaningful, lowest on the list is less meaningful]*

- Lack of functional and consistent nation-level or regional-level renewable energy incentive policies.
- Higher project costs related to reliance on imported renewable energy equipment.
- Lack of forward generator interconnection queue and transmission system impact study processes.
- Lack of viable commercial arrangements to facilitate variable renewable energy balancing through interregional transmission.
- Imbalance service requirements for new entrants require forward scheduling, favoring dispatchable resources over variable renewable energy.
- Higher project costs compared to other generation technology options.
- Uncertainty over renewable energy project quality, performance, and output variability.
- Inability to locate credit-worthy off-takers.
- Limited access to and high cost of project finance funding. This also includes lack of funding to prepare potential projects for marketing to investors.
- High (uneconomic) price of transmission wheeling services for export oriented IPPs.

3. Please rank in order of the most meaningful potential solutions within SAPP's authority to promote renewable energy deployment. *[highest on the list is more meaningful, lowest on the list is less meaningful]*

- Training to educate new or potential new market participants: for example, how to design a bid, forecasting, application process requirements, etc.
- Modeling and analysis of the costs, benefits, and requirements to transition to open access transmission tariffs and operating platforms.
- Modeling and analysis of regional SAPP participation benefits disaggregated to the nation-state level.
- Development of new cost allocation and other finance methods to facilitate new transmission builds.
- Revise the interconnection queue process to create more transparency, certainty and timely outcomes for project developers.
- Greater access to market data and improved transparency of market rules available to potential investors and prospective new market participants/independent power producers.
- Create a competitive market for trading of renewable energy.
- Targeted education and outreach to investor community on market functions and risk management techniques.
- Institute governance reforms to reduce barriers to entry for new market entrants/ independent power producers.

Appendix B. Selected Global Inventory of Solutions Options

Table B. Global Inventory of Solutions Options

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
B.1 Carbon Pricing - the cost applied to carbon pollution to encourage polluters to reduce the amount of greenhouse gas emissions they emit into the atmosphere. This can be done through mechanisms such as carbon tax or a cap-and-trade system, which are designed to internalize the environmental costs of carbon emissions by making them economically visible.	Carbon pricing has been effectively used in several wholesale electricity markets to promote renewable energy by making carbon-intensive generation more expensive and shifting investments toward cleaner alternatives. i. European Union Emissions Trading System (EU ETS): Launched in 2005, the EU ETS is a cap-and-trade system that covers electricity generation and industry sectors. By limiting the total emissions allowed and enabling the trading of emission allowances, the EU ETS has increased the cost of carbon-intensive energy sources, such as coal. This has incentivized investments in renewable energy, resulting in significant growth in wind and solar capacity across the EU [95]. ii. Regional Greenhouse Gas Initiative (RGGI): RGGI, initiated in 2009 across several Northeastern U.S. states, is another cap-and-trade program focused on reducing CO2 emissions from the power sector. The revenue from allowance auctions is reinvested in energy efficiency and renewable energy projects, contributing to the expansion of clean energy infrastructure in the region [96]. iii. South Africa’s Carbon Tax: South Africa implemented a carbon tax in 2019 targeting large emitters. The tax has driven companies to reduce their reliance on fossil fuels and invest more in renewable energy to avoid the financial burden associated with high emissions [97].	Implementing carbon pricing within the SAPP has the potential to reduce reliance on fossil fuels, particularly coal, by incentivizing the adoption of renewable energy sources such as solar, wind, and hydropower. The mechanism would create an economic framework that supports investment in clean energy technologies, while the revenue generated could be strategically allocated to fund renewable energy projects and enhance grid infrastructure. A coordinated approach at the regional level would facilitate consistent application across member states, enabling collective progress toward established climate and energy objectives.	• Establish/ delegate a SAPP-wide carbon pricing authority to oversee design, implementation, and enforcement. • Address economic disparities among member states through differentiated responsibilities or phased implementation. • Develop a robust monitoring, reporting, and verification (MRV) system for accurate emissions tracking. • Set clear guidelines for revenue allocation, prioritizing renewable energy projects and grid infrastructure.

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
	iv. Australia's Carbon Pricing (2012-2014): During its brief implementation, Australia's carbon pricing mechanism made coal-fired electricity more costly, leading to a significant increase in renewable energy investments, particularly in wind and solar [98].		
B.2 Clean electricity markets – these may also be referred to as Clean Electricity Standards (CES) or Renewable Portfolio Standards (RPS). Both a CES and an RPS are a policy mechanism used to either set mandatory targets of renewable energy technologies or may be goals to encourage the use of renewable energy technologies. Typically, these are focused on a certain percentage of retail electricity sales being renewable energy technologies or from low carbon or no-carbon emitting technologies.	Clean electricity markets utilizing either a CES or RPS may choose to do so through two main certificate processes. Most commonly, each renewable / low-carbon emitting / zero-carbon emitting resource would receive a credit based on its per MWh of generation. These credits or certificates (i.e., Energy attribute certificates (EACs)) can be traded or used to meet either a required CES or for use towards an RPS. Examples of EACs are Zero-Emissions Certificates (ZECs) and Renewable Energy Certificates (RECs). These certificates validate claims about the electricity sold and/or used while preventing generators from "double counting" their clean or renewable energy generated. These EACs can also be purchased, traded, sold, and used within the market based on pre-determined rules and/or market purposes. EACs may be bundled or unbundled where the purchaser can purchase just the EACs as "unbundled" or as "bundled" where they receive both the electricity and the EACs. EACs can be used for compliance purposes in a CES or RPS, voluntarily for business purposes, within greenhouse gas accounting for carbon accounting/management, or for emissions disclosures. Multiple global verification firms exist to verify and confirm renewable and/or zero-emissions associated with EACs. Examples include but are not limited to South Pole, 3Degrees and Terrapass. i. Within the European Union, an initial voluntary program was created under the Guarantee of Origin (GO) to promote renewable energy resources. The GO market transitioned to	Implementing an enforceable clean electricity standard via policy within SAPP or the member countries would encourage the use of renewable energy development and adoption. Requiring a specific amount of generation (i.e., in MW) from renewable resources would unlock new opportunities and increase renewable energy in the region.	• Create country specific or regional specific (i.e., SAPP wide) Clean Energy Standard or a Renewable Portfolio Standard to encourage adoption and development of renewable energy technologies. • As the region is rich in hydropower resources, the CES or RPS should focus on other renewable energy technologies (e.g., solar, wind, geothermal, etc.).

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
	become the European Energy Certificate (EECS) standard creating a centralized program to trade certificates. Within the EU, there have been multiple renditions of targets or goals of renewable energy generation at a national level or at the EU level. The first of these targets, the 2009 Renewable Energy Directive focused on renewable energy targets at a national level followed by the 2018 Renewable Energy Directive at the EU level. The EU level targets were updated in the 2023 Renewable Energy Directive which included a binding target of 32% for renewable energy sources within the total energy mix by 2030 [99]. ii. Ireland has a renewable energy target of 80% renewable energy for electricity by 2030 created in the Climate Action Plan [100]. The Government of Ireland has created the Renewable Electricity Support Scheme (RESS) to assist in the facilitation of their goals [101]. iii. Germany's *"Energiewende"* includes the national climate change strategy defined in the Climate Action Plan 2050 and the Renewables Energy Act. The Action Plan provides a long-term goal of greenhouse gas reduction as well as an increase in renewable energy generation combined with the goal of producing 65% of electricity from clean sources by 2030 and 80% by 2050. The Renewable Energy Sources Act includes monitoring. iv. The United States (U.S.) does not have a national RPS or CES, rather individual states have set their own targets. In the context of the U.S., an RPS is considered a "binding requirement for retail electric suppliers to procure		

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
	a minimum percentage of generation from eligible sources of renewable electricity," [102]. A CES in this context includes renewable energy technologies in addition to those with zero carbon emissions at the source of generation (e.g., nuclear and CCS) [102]. Of the 50 states, 29 plus the District of Columbia have a mandatory RPS. There are 16 states with a 100% CES. In the United States, RPS policies have been a key driver in the adoption of renewable energy technologies, nuclear and CCS) [102]. Of the 50 states, 29 plus the District of Columbia have a mandatory RPS. There are 16 states with a 100% CES. In the United States, RPS policies have been a key driver in the adoption of renewable energy technologies.		
B.3 Contract for Differences (CfDs) – A financial mechanism where an entity (typically a government or equivalent central body) guarantees a fixed price for energy producers. If the market price falls below the agreed price, the producer is compensated for the difference, ensuring stable revenue and encouraging investment in low-carbon energy sources.	Contract for Difference (CfD) contracts are a risk management/market creation government mechanism to support low carbon electricity generation. A CfD "incentivizes investment in renewable energy by providing developers of projects with high capital expenses and long lifetimes with protection from volatile wholesale prices while protecting consumers from paying increased support costs when electricity prices are high," [103]. CfDs have been used for renewables procurement in the United Kingdom and Australia. i. The Contract for Difference mechanism was used initially In the United Kingdom in October 2014 to replace the Renewable Obligations system. The scheme was used to support large scale renewable energy project deployment through fifteen-year contracts between the renewable generator and Low Carbon Contracts Company, a government-owned company. This has been accomplished through competitive	By utilizing the Contract for Difference (CfD) mechanism within SAPP member countries, governments can directly support low carbon electricity generation by reducing overall development risk. This could encourage development of renewable energy and energy storage projects.	• Countries can individually create a specific capacity target for renewable and/or low-carbon energy generation. This should include specific contract time frames and selection criteria.

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
	auctions where companies compete against each other before they are selected for the fifteen-year contract. This included the following renewable energy technologies: onshore and offshore wind, geothermal, solar PV, hydropower, ocean power, and biomass. Developers are "paid a flat indexed rate for the electricity they produce over a fifteen year period; the difference between the 'strike price' (a price for electricity reflecting the cost of investing in a particular low carbon technology) and the 'reference price' (a measure of the average market price for electricity in the Great Britain market" [104]. ii. The CfD scheme has been used in Australia to encourage development and investment in dispatchable renewable energy capacity and energy storage. This is expected to put Australia on track to meet their 2030 climate targets while delivering a total of 23GW of renewable energy generation [103].		
B.4 Dual procurement - Long-term Renewable Energy (LT-RE) procurement through mechanisms like competitive auctions, long-term Power Purchase Agreements (PPAs), Feed-in Tariffs (FITs), and Feed-In Premiums (FiPs); Short-term Flexibility (ST-Flex) to match supply-demand through wholesale and retail competitive markets.	Mechanisms such as competitive auctions and long-term PPAs are widely used to secure stable, long-term investments in renewable energy. FITs and FiPs have been effective in different jurisdictions to incentivize renewable energy generation by offering guaranteed payments for energy produced. Short-term flexibility mechanisms are employed in markets such as the EU's day-ahead and intraday markets, enabling efficient balancing of supply and demand [105] [106].	Implementing a dual procurement mechanism in the (SAPP market can facilitate the long-term stability of renewable energy investments while ensuring short-term flexibility to address variability in renewable energy generation. Potential for LT-RE procurement can be explored at a national level (individual countries) or at the regional level through a SAPP-established market mechanism. Additionally,	• Ensure harmonization of regulations across SAPP member countries to support both long-term contracts and short-term market participation. Develop expertise within SAPP for managing both procurement strategies effectively. • Design market rules that allow seamless integration of long-term contracts with

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
		addressing ST-Flex can be effectively managed through the SAPP market via appropriately defined market products focusing on flexibility. This is particularly relevant for integrating variable renewable energy sources such as solar and wind into the SAPP grid.	short-term flexibility mechanisms.
B.5 Transmission Data and Procurement Platform - A platform that provides real-time information on transmission availability, enabling fair and transparent access to transmission networks.	The Open Access Same-Time Information System (OASIS) is a key component of the U.S. electricity market, designed to provide non-discriminatory access to transmission services by standardizing the dissemination of transmission information. It is implemented across multiple Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs) to facilitate efficient market operations and transparency. Practical Examples: i. United States: OASIS is widely used across RTOs/ISOs, such as CAISO and MISO, to standardize transmission information dissemination and ensure equal access for all market participants [107]. ii. Europe: The European Network of Transmission System Operators for Electricity (ENTSO-E) offers similar transparency through initiatives like the Ten-Year Network Development Plans (TYNDP) and real-time grid information systems, which are inspired by OASIS principles [108]. iii. Asia-Pacific: In countries like Australia, the Australian Energy Market Operator (AEMO) has implemented comparable systems to enhance	Introducing the OASIS system in SAPP could enhance transparency and access to the transmission network, thereby facilitating greater participation of Independent Power Producers (IPPs) and encouraging investment in renewable energy projects. This aligns with SAPP's goals to increase regional integration and optimize the use of the existing transmission infrastructure.	• Upgrade and expand the current transmission infrastructure to support OASIS implementation (or similarly equivalent). Establish a regulatory framework that mandates the use of OASIS for all transmission services. • Provide training for SAPP member utilities and regulators on the use and benefits of OASIS.

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
	transmission access and market efficiency, aligning with OASIS's goals [109].		
B.6 Regional TSO/ISO - A Regional Transmission System Operator (TSO) or Independent System Operator (ISO) manages and coordinates the operation of the electrical grid across multiple jurisdictions, ensuring reliable electricity supply, efficient market operations, and facilitating the integration of renewable energy sources.	i. The Pennsylvania-New Jersey-Maryland Interconnection or PJM coordinates and manages the electrical grid through all and/or portions of thirteen states and one U.S. territory, operates wholesale electricity markets, develops rules for its wholesale electricity market, and conducts long-term transmission planning. a. PJM has an Independent Market Monitor (IMM) to oversee the market power within the PJM markets to ensure they remain competitive and non-discriminatory. The IMM operates independently of the PJM staff [110]. ii. The European Network of Transmission System Operators or the ENTSO-E represents forty transmission system operators in thirty-six countries. This includes providing grid access to market participants based on "non-discriminatory and transparent rules" [111]. a. ENTSO-E's market is overseen by the ENTSO-E Market Committee (MC). The MC includes six Working Groups and three projects that report to the MC. The MC ensures the market has a "harmonized framework via market network codes/guidelines and methodologies, coordinates project implementation throughout the different regions, and develops and maintains tools to ensure stakeholder transparency" [112].	The creation of a regional transmission system operator or independent system operator for SAPP would ensure regional coordination, reliable electricity, improve market efficiencies, increase renewable energy generation, and ensure long-term planning in addition to other economic benefits throughout the region.	• Ensure a clear regulatory framework exists to ensure rules, regulations, and processes are in place to oversee the operations and conduct of the RTO or ISO. This could be in the form of a regional regulator or a collaboration of multiple regulators. • Create an independent monitor to oversee the market to ensure it remains competitive and non-discriminatory.

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
B.7 Interregional Transmission Expansion Planning - Coordinated planning of transmission expansions across regions to enhance grid reliability and support renewable energy integration.	Interregional transmission expansion planning focuses on coordinating investments in transmission infrastructure across different regions or countries to ensure reliable grid operations, reduce congestion, and enable the integration of renewable energy. This approach has been successfully implemented in regions like the European Union through the Ten-Year Network Development Plans (TYNDP) developed by ENTSO-E, which ensures that grid expansions align with regional energy goals and the increasing penetration of renewables. Similarly, in the United States, FERC Order No. 1000 mandates interregional coordination and the establishment of cost allocation mechanisms for transmission projects that provide regional benefits. Interregional projects often utilize cost allocation methods utilizing the beneficiary-pays principle, which assigns costs based on the benefits derived by different regions or market participants; or postage stamp pricing, where costs are shared equally across all users, regardless of location. These methods help ensure that costs are fairly distributed and do not act as a barrier to investment in transmission infrastructure [108] [113].	SAPP could benefit from adopting interregional transmission planning to connect renewable energy-rich areas with demand centers across member states. Cost allocation methods, such as the beneficiary-pays principle, would help ensure that countries and market participants contributing to or benefiting from new transmission projects share the costs equitably. This approach would enhance grid reliability, reduce congestion, and facilitate the integration of renewables across the region.	• Strengthen collaboration among SAPP member states for joint planning and investment in transmission infrastructure. • Develop innovative funding mechanisms, possibly leveraging climate finance, to support large-scale transmission projects. • Establish common technical standards for transmission infrastructure across SAPP.
B.8 Buyer-side market offtake models - These models include mechanisms such as Corporate PPAs, where large buyers commit to purchasing electricity directly from renewable energy projects.	Such models are designed to shift the financial burden of power purchasing from utilities to private entities like large corporations, industries, or consortia of smaller buyers. Through mechanisms such as Corporate PPAs, companies commit to purchasing renewable energy for long-term periods directly from generators, ensuring stable revenue streams for renewable energy developers and reducing risks associated with market volatility. This model has gained significant traction in regions like Europe and North America, where have signed substantial agreements to power their operations with 100% renewable energy. These agreements often lock in fixed prices for electricity, mitigating future price volatility risks.	Buyer-side market offtake models offer a strategic opportunity for industries and large consumers to secure renewable energy directly from producers. This can help alleviate grid reliance issues, particularly in countries facing electricity shortages or unreliable service. The long-term revenue certainty provided by Corporate PPAs would also encourage investment in renewable energy projects across the region. Buyer-side models could play a pivotal	• Establish a legal framework that facilitates corporate PPAs and other buyer-side offtake agreements as alternatives to the single-buyer or modified single buyer model. • Develop platforms that connect renewable energy developers with potential corporate buyers. • Implement measures to manage the financial risks

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
	In the context of Southern Africa, large-scale consumers, including industrial sectors such as mining and manufacturing, may increasingly be interested in options to secure cleaner and more reliable energy sources. Buyer cooperatives or renewable energy aggregators pool the purchasing power of multiple smaller companies or industries to enter into large-scale PPAs. These models help reduce transaction costs and allow smaller entities to benefit from economies of scale typically available only to large corporations. By securing long-term energy supply agreements, these buyers not only ensure access to renewable energy but also help drive the development of new renewable energy projects by providing a stable demand base. Hedging against grid instability and supply insecurity is also a major motivator in adopting such models, particularly in regions with unreliable utility service or where renewable energy can offer more cost-competitive pricing compared to fossil fuels [105], [114].	role in advancing the integration of renewable energy in the SAPP region, as they provide an alternative to utility-driven power purchase agreements, facilitating greater private sector involvement.	associated with long-term offtake agreements.
B.9 Enabling DER participation in wholesale markets - Allowing Distributed Energy Resources (DERs) such as rooftop solar and battery storage to participate in wholesale electricity markets	Integrating DER's into wholesale markets can be a strategy to enhance grid resilience and optimize the use of renewable energy. These resources, which include small-scale power generation units, battery storage, and flexible demand response systems, can collectively provide significant grid services when aggregated and integrated into the broader market framework. Recent developments in peer-to-peer (P2P) energy trading and blockchain-based energy markets have shown how DERs can be directly traded in a decentralized manner, bypassing traditional market intermediaries. For instance, in South Korea, blockchain technology is being utilized to enable secure, transparent transactions of electricity generated from DERs, ensuring that small producers receive fair compensation for their contributions to the grid [115].	Enabling DER participation in SAPP wholesale markets could unlock new sources of flexibility, enhance grid resilience, and accelerate the integration of renewable energy.	• Develop market rules and products that accommodate the participation of DERs. • Adapt regulations to allow for aggregation and market participation of small-scale DERs. • Invest in technologies that facilitate the monitoring, control, and aggregation of DERs for market participation.

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
	Another promising application is the use of Virtual Power Plants (VPPs), where multiple DERs are aggregated to function as a single entity within the market. This approach has been particularly successful in countries like Germany, where VPPs not only participate in energy trading but also provide ancillary services such as frequency regulation and voltage support [116]. In Japan, VPPs have been employed to enhance grid stability, particularly in regions with high penetration of renewable energy sources like solar and wind [117]. Advanced Metering Infrastructure (AMI): The deployment of AMI in regions like Singapore has enabled real-time data collection and automated control of DERs, facilitating their participation in wholesale markets. This infrastructure allows for dynamic pricing and better demand-side management, enabling consumers to respond to market signals and contribute to grid stability [118].		
B.10 Capacity mechanisms - Policies designed to ensure sufficient generation capacity is available to meet peak demand. These mechanisms typically provide payments to power plants or other resources to be on standby or to maintain generation capacity, ensuring grid reliability and preventing blackouts.	The liberalization and restructuring of several electricity markets globally in the 1980s and 1990s where energy-only wholesale electricity markets are theoretically capable of delivering long-term system adequacy were found to be challenged by actual market outcomes (challenged resource adequacy). Although there is ongoing debate and preferences with respect to energy-only markets to ensure long-run economic efficiency, resource adequacy challenges in some markets have driven proposals and implementation of capacity mechanisms (CMs) to supplement energy-only markets. CMs can take many forms including the many design elements that comprise CMs. However, a general categorization of CMs into price-based (capacity	Previous research has examined the formulation of an appropriate capacity mechanism for SAPP [119] and found that by utilizing a framework to assess CMs that a CM in the form of regionally specific forward-looking capacity auction would be a favorable option for the region to consider. This is by no means prescriptive but is intended to introduce the concept of a regionally developed adequacy product in the form of a CM to supplement the already existing competitive SAPP markets.	• Choice of the appropriate form of CM will require further quantitative investigation to assess potential market outcomes and resulting performance. More specifically, with respect to capacity investment, resource adequacy, market dominance and supplementary outcomes including changing resource mix and associated renewable energy deployment.

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
	payments) and volume-based CMs has emerged. Further, volume-based CMs can be disaggregated into targeted (strategic reserves) or market-wide mechanisms (capacity obligations, reliability options, capacity auctions or capacity subscriptions). Many jurisdictions globally have implemented CMs in some form (some have also adjusted this over time based on experience). Selected examples are listed below: i. Capacity payments: Chile, Argentina, Peru, Bolivia ii. Strategic reserve: Sweden, Finland, Belgium iii. Capacity obligations: Previous PJM Capacity iv. Credit Market (CCM), Brazil, France v. Capacity auctions: MISO (USA), PJM (USA), NYISO (USA), United Kingdom vi. Reliability options: Colombia (hybrid of reliability options and capacity auction)	Further consideration of a CM for the SAPP region could support system adequacy especially as further VRE resources are deployed. This would intentionally incentivize capacity investment through competitive means at a regional level as is the intention of the SAPP.	• Enabling domestic (country-specific) regulatory framework adjustments to ensure harmonization with a regionally implemented CM. • Participation of all resources (supply-side and demand-side). • Key elements for consideration would need to include design elements of the chosen CM e.g. resource pre-qualification, lead-time, duration, performance incentives or penalties, financial warranties, market power. • Performance criteria would be core to the design and implementation of a potential CM and could include the incentives for providing the service by a supplier (resource adequacy contribution), static and dynamic efficiency, correctability, simplicity, acceptability (stakeholder equity), invisibility, robustness, timing and implementation costs.

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
B.11 Balancing markets and products - mechanisms within electricity markets where imbalances between supply and demand are corrected in real-time or near-real-time. These markets allow grid operators to procure balancing services—typically from generators or demand-response providers—to ensure that the amount of electricity being produced matches the amount being consumed, maintaining the stability of the grid.	Balancing markets are essential for maintaining grid stability, especially in power systems with a high share of renewable energy sources. These markets employ a variety of balancing products—such as frequency regulation, reserve capacity, and demand response—that are specifically designed to address real-time imbalances between electricity supply and demand. In these markets, entities such as generators, load-serving entities, and large consumers have a defined balancing responsibility, meaning they are required to manage their own supply and demand imbalances or face financial penalties. This responsibility incentivizes market participants to either invest in flexibility options, such as battery storage and fast-ramping generation, or to actively participate in balancing markets.	Implementing balancing markets and products in SAPP would support the integration of variable renewable energy sources by providing mechanisms to manage supply and demand imbalances. Defining clear balancing responsibilities for market participants is crucial to ensure grid stability and encourage investment in flexible resources. By learning from established markets in Europe, the United States, and Asia, SAPP can develop a robust balancing market tailored to the specific needs and challenges of its member states.	• Establish a clear and transparent market design that incentivizes participation in balancing services and clearly defines balancing responsibilities. • Enhance cross-border coordination among SAPP member states to ensure seamless operation of balancing markets and consistent enforcement of balancing responsibilities. • Invest in digital infrastructure and technologies to support real-time data exchange, market operations, and the deployment of advanced balancing products.
B.12 Open Access Transmission Requirement – refers to the principle that transmission networks must be made available to all electricity market participants on non-discriminatory terms. This means that all generators, whether private or public, should have the right to access and use the	Open access transmission requirements provide equal opportunity for market participants to utilize the existing transmission infrastructure for all interested parties regardless of who owns, has built, or has previously controlled the transmission infrastructure. To ensure fairness, these requirements generally include specific terms and conditions. Examples of this include the following: i. The United States Federal Energy Regulatory Commission (FERC) Order 888. a. Under FERC Order 888, all public utilities that "own, control or operate	By requiring open access to the transmission infrastructure, SAPP would unlock the growth of renewable energy development as both new and existing market participants would have non-discriminatory access to the transmission infrastructure.	• Require all transmission owners or those who control and/or operate facilities for transmission to create open-access transmission requirements to provide equal and non-discriminatory access to all market participants. • Implement the open-access transmission requirements with

Solution Option	Description and existing applications	Applicability to SAPP	Implementation Considerations
transmission grid to deliver electricity to consumers.	facilities used for transmission electric energy in interstate commerce to file open access non-discriminatory transmission tariffs that contain minimum terms and conditions of non-discriminatory service," [75] [120]. Order 888 requires utilities to file transmission tariffs to allow transmission access to all participants. ii. The Electricity Act in 1989 in the United Kingdom restructured the electricity market and created a regulatory body to oversee electricity. This restructuring eventually resulted in a market with specific trading arrangements and open access to transmission [121]. iii. Germany's electricity sector was restructured in 1998 to "mandate that network access be nondiscriminatory" [121].		transmission tariffs with specific terms and conditions to ensure non-discriminatory service.

Secondary interventions to incentivize renewable energy investment:

- **B.13 Net-metering:** Net-metering is a mechanism enabling homeowners to receive credit for solar energy added to the grid. This mechanism ensures homeowners are only billed for the "net" energy or the difference from what their solar systems generate and any consumption from their electric provider. In most instances individuals with solar systems typically use the electricity generated in their homes rather than generating excess for the grid. This mechanism helps electricity providers reduce load while providing homeowners with a greater financial incentive to invest in solar energy.
- **B.14 Energy efficiency incentives:** Incentives can include but are not limited to tax credits, rebates, and loans for specific types of technologies. These types of incentives are typically for renewable energy technologies such as wind and solar. Various entities may offer incentives based on their jurisdictional authority. A prime example within the United States are tax credits available for homeowners, business and/or commercial owners who invest in solar energy. In some instances, the buyer may qualify for state and federal tax credits, which is typically for the year of installation of the system.

- **B.15 Rate Unbundling:** Retail electricity rates may be unbundled to allow a customer to choose a specific retailer to supply their electricity rather than a single rate or provider charging a single rate for both the electricity and delivery costs of the electricity. Rate unbundling allows a retailer to purchase from wholesale electricity markets or to generate their own electricity in their plants. This increases retail competition and can decrease overall electricity rates while driving innovation and the potential for other services to be added. In these situations, typically a regional independent system operator is created or used to operate the competitive markets including the sale of electricity between generators and the load serving entities.

Appendix C. Additional SAPP Statistics

Table C- 1. SAPP Utility General Statistics (2020-2021)

Adapted From SAPP 2021 Annual Report [122]

Country	Utility	Installed Capacity (MW)	Operating Capacity (MW)	Maximum Demand (MW)	Peak Demand Plus Reserves	Sales (GWh)	Number of Customers	Number of Employees	Generation Sent Out (GWh)	Net Imports (GWh)	Net Exports (GWh)	Transmission System Losses (%)	Debtor Days
Angola	RNT	5878	4877	2209	2687	7922	251952	4009	9507	0	0	10	64
Botswana	BPC	892	322	587	675	3118	251773	1868	4204	312	0	4	69
DRC	SNEL	2880	2769	1610	1705	6886	861661	6774	8639	0	0	9	N/A
Eswatini	EEC	71	65	226	259	1058	182562	700	197	841	0	6	47
Lesotho	LEC	74	70	150	173	488	58900	563	332	294	1	11	32
Malawi	ESCOM	506	330	351	380	1476	374400	2398	2053	0	0	6	106
Mozambique	EDM / HCB / MOTRACO	2796	2642	1948	2240	2380	1010780	3244	16636	68	280	6	37
Namibia	NamPower	624	390	695	695	3648	3449	910	2672	1756	0	3	41
South Africa	Eskom	60326	48215	35005	40256	214121	5976557	47658	233503	3	4169	1	17
Tanzania	TANESCO	1565	1382	1120	1382	5956	2013839	6927	69934	0	0	6	107
Zambia	ZESCO / CEC / LHPC / Ndola Energy	2891	2736	2510	2887	13882	901047	6903	14654	657	1223	5	444
Zimbabwe	ZESA	2412	1400	1724	1896	7367	579006	5773	8513	1178	355	4	157

Table C- 2. SAPP Utility Actual Peak Demand 2010 to 2020

Adapted From SAPP 2021 Annual Report [122]

Historical Actual Peak Demand, MW											
Country	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Angola	723	870	1072	1072	1599	1599	1599	1869	2209	2361	2353
Botswana	553	542	578	578	610	610	610	610	610	578	626
DRC	1079	1050	1040	1166	1381	1381	1359	1376	1610	1603	1806
Lesotho	121	125	129	129	150	150	140	150	150	170	167
Malawi	260	277	278	278	326	326	323	373	316	335	340
Mozambique	501	616	706	706	830	830	1780	1850	1850	1870	1948
Namibia	449	611	611	611	629	629	629	647	695	643	640
South Africa	35850	36543	35896	35896	36170	36170	34122	38897	38897	32955	31470
Swaziland	204	200	205	205	221	221	232	232	238	245	233
Tanzania	802	890	890	890	935	935	1051	1051	1117	1153	1181
Zambia	1571	1690	1681	1760	1949	1953	2134	2195	2237	2146	1977
Zimbabwe	2029	2029	2029	1546	1671	1671	1521	1847	1724	1699	1546
Total Interconnected	**42357**	**43406**	**42875**	**42597**	**43874**	**45191**	**46546**	**47943**	**49381**	**50863**	**52355**
Total SAPP	**44142**	**45443**	**45115**	**44837**	**46471**	**46475**	**45500**	**51097**	**51653**	**45758**	**44286**

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