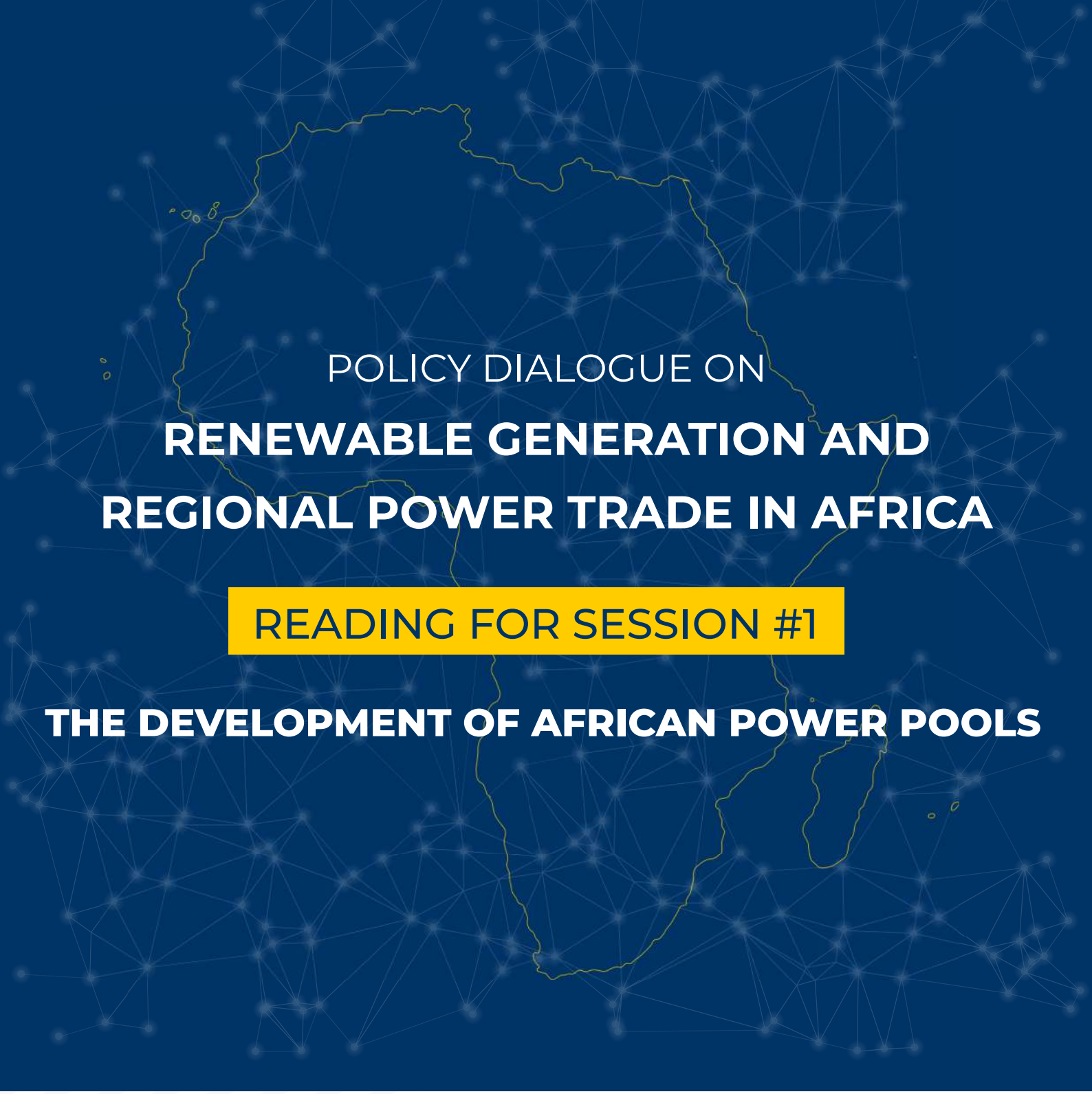


POLICY DIALOGUE ON

RENEWABLE GENERATION AND REGIONAL POWER TRADE IN AFRICA

READING FOR SESSION #1

THE DEVELOPMENT OF AFRICAN POWER POOLS

AFRICAN SCHOOL OF REGULATION

AFRICAN SCHOOL OF REGULATION

Policy dialogue on

RENEWABLE GENERATION AND REGIONAL POWER TRADE IN AFRICA

Reading for Session #1

THE DEVELOPMENT OF AFRICAN POWER POOLS[1]

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[1] Prepared by Mohamed A. Eltahir Elabbas, February 2023, IIT Comillas University.

Introduction

In Africa, five regional power pools are under development to promote power trade at supranational scale. A regional power pool is an organisation involving several national power systems that coordinates their operation and planning in order to maximise the benefits of power trade. The degree of coordination ranges from simple unspecific agreements on energy transactions to detailed regulations for operation and planning among national power systems. Hence, to establish an efficient regional market, a power pool must have a common legal and regulatory framework, a system planning and operation framework, and a commercial framework. Two institutions with sufficient technical capability and executive power are of the essence for the success of power pools: a regional regulatory authority with jurisdiction on cross-border trade and a regional system operator with the information and capacity to operate and plan the capacity expansion of the power system at regional level. In addition to these soft institutions, there has to be sufficient infrastructure to produce to export (generation plants) and trade (transmission network) power.

There are five regional power pools in Africa, which, according to when they were established, are the Maghreb Electricity Committee (COMELEC) in the north, the Southern African Power Pool (SAPP) in the south, the Western African Power Pool (WAPP) in the west, the Central African Power Pool (CAPP) in the centre, and the Eastern African Power Pool (EAPP) in the east. These power pools have different levels of development. This technical note shall provide a descriptive development of the five power pools highlighting their different levels of development and organisation. A separate document focuses with greater details on SAPP, WAPP, and EAPP institutions to draw conclusions on the impact of governance and development approaches on the power pool performance. For each power pool, we present the objectives that have been fulfilled, the state of development of regional infrastructure (generation and transmission), and the volume of trade. Brief descriptions and also comments on governance and performed have been provided for the CAPP and COMELEC at the end of this document.

Many cross-border regulatory arrangements are being employed throughout the African continent at bulk power system level, generally without competitive markets at national level. Some regions like Southern Africa and more recently West Africa have implemented organised regional markets at different levels of development. Given this diversity of situations, this document will avoid using the term “market” when referring to common general situations in Africa and will use the term “power system organisational structures” instead, as recommended by IRENA recently.[2]

This technical note applies to all regional power system structures existing in Africa at bulk power system level, regardless of the level of liberalisation of the trade of power, i.e., of the existence

[2] The term “power system organisational structures” can be used to refer to the systems, institutions, procedures and social relations through which electricity services are exchanged and rewarded. It encompasses all systems, from liberalised power systems (based primarily on market mechanisms) to vertically integrated systems. For a liberalised power system, the term “power market” is equivalent to “power system organisational structure”. See IRENA (2022), “Re-organising power systems for the transition”, International Renewable Energy Agency, Abu Dhabi.

of a market, which could be spontaneous or organised, because the main regional power trade challenges are common to all of them.

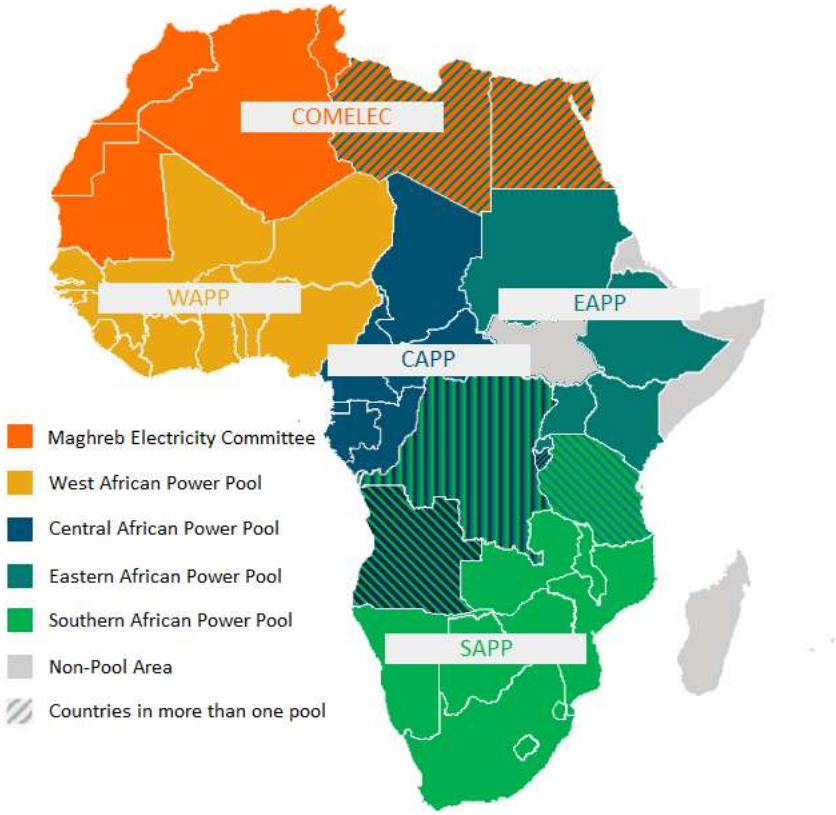


Figure 1. Power pools in Africa.

1. The Southern African Power Pool – SAPP

Among the five power pools that exist today in Africa, SAPP is the most advanced and the only one that has a functioning market. The development of the Southern African Power Pool was a result of international cooperation in the energy sector. In the 16th summit at Johannesburg, the nations of the Southern African Development Community (SADC) (excluding Mauritius) signed an Inter-Governmental Memorandum of Understanding for the creation of SAPP in 1995 as a cooperation among the national electricity companies. All member states of SADC are members of SAPP with the exception of the four unconnected islands. thus, the SAPP includes as "members" the national utilities of Angola, Botswana, Democratic Republic of Congo (DRC), Lesotho, Malawi, Mozambique, Namibia, South Africa, Eswatini, Tanzania, Zambia, Zimbabwe. In addition, the SAPP has several "operating oembers" that are not national power utilities. To establish a regional market, SAPP implemented the following steps:

1. Establish legal documents and trade agreements: The Inter-Governmental Memorandum of Understanding (IGMOU) and the Inter-Utility Memorandum of Understanding (IUMOU).

2. Establish commercial market rules for trade: The Agreement Between Operating Members and the Market Book of Rules.

3. Establish a wholesale energy market: Consisting of a Day-Ahead Market (DAM), a Forward Physical Market-Weekly/Monthly (FPM-W/M), and an Intra-Day Market (IDM)

4. Admit IPPs participation.

5. Establish a regional market operator: The coordination centre.

6. Establish a regional grid development unit: The Project Advisory Unit (PAU) and the Regional Transmission Infrastructure Financing Facility (RTIFF) (*work in progress*).

1.1 The regional infrastructure

The regional transmission infrastructure of SAPP connects nine countries out of twelve and has a total interconnection capacity of 10,891 Megawatts (MW). Each connected country has at least two interconnections, except for DRC and Lesotho, and the largest interconnection capacity is 3,370 MW between South Africa and Mozambique. Figure 1 shows the power grid of SAPP and the peak demand for each country.

The installed generation capacity portfolio of SAPP, shown in Figure 2, consists of 65% fossil fuels (of which 60% is coal), 17% hydro, 8% solar, 4% wind, 4% pumped hydro, 2% nuclear and <1% biomass and waste. The lion's share of the regional installed capacity goes to South Africa, with 64.2 GW installed capacity that counts for 73% of the total. The second-largest installed capacity is Angola, with 9%, and Zambia, with 4% of the total capacity among the connected countries.

72% of the total electricity generated in 2021 came from South Africa, which produced 93% of the whole fossil fuel generation in the region. The two following largest producers among the connected members are Zambia and Mozambique, which both supply almost equally, 49% of the total hydro-generated electricity. Nuclear energy, only in South Africa, produced 4% of the regional generated electricity.

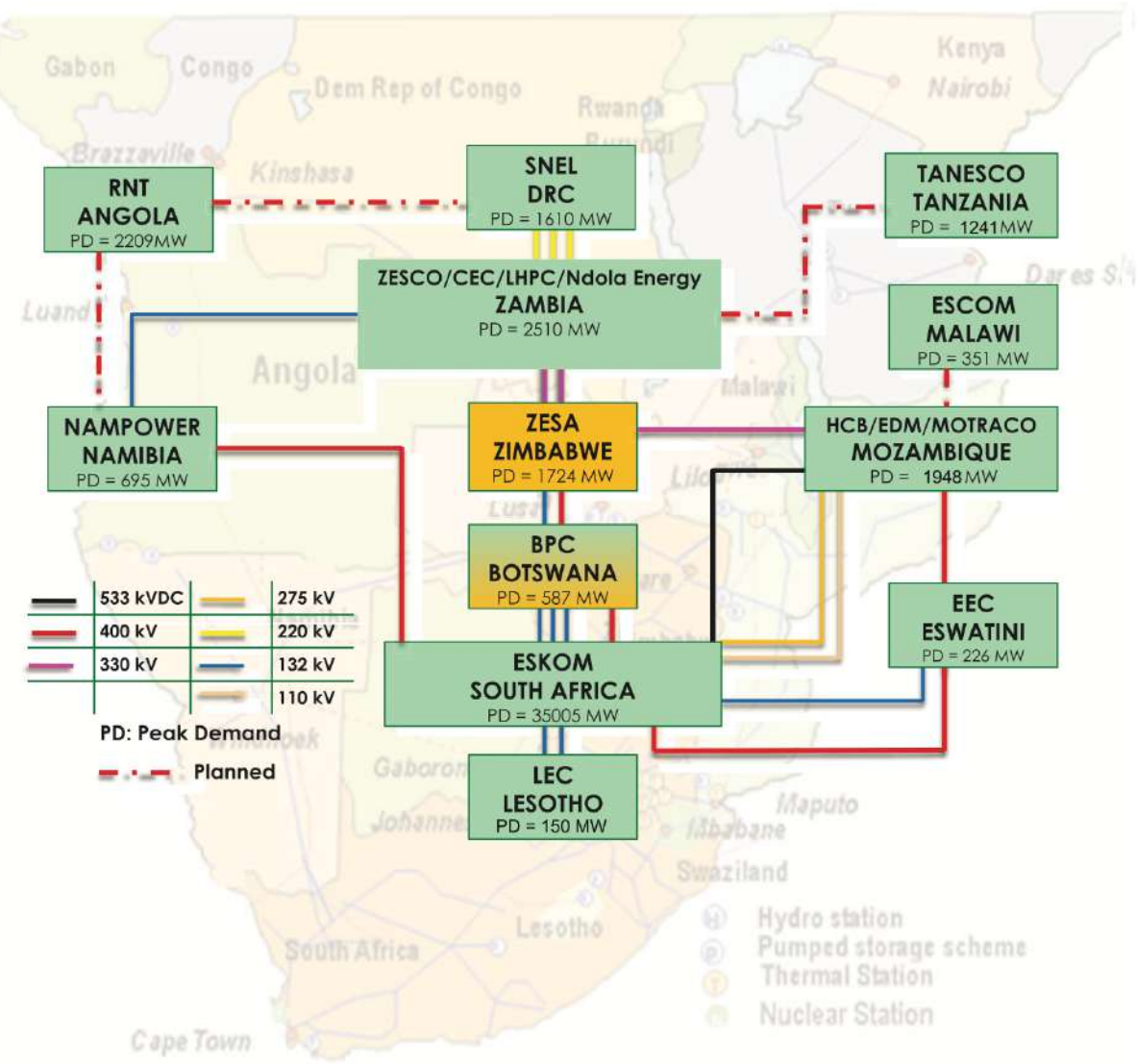
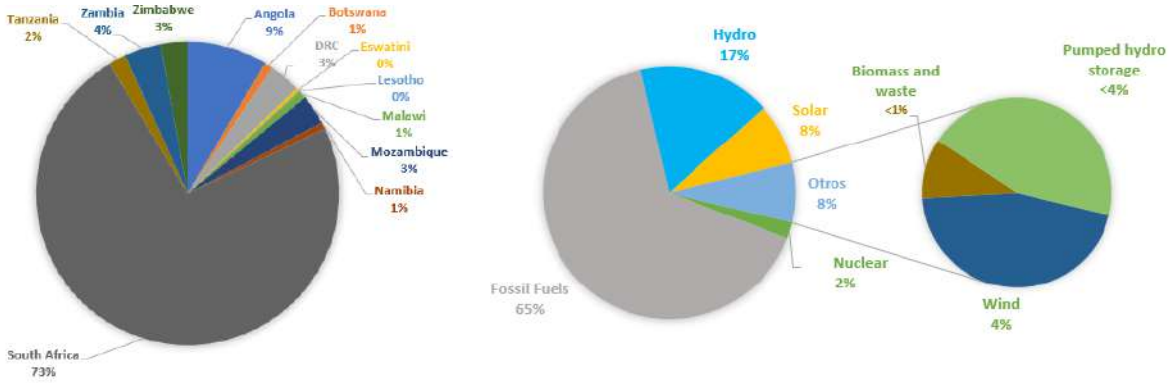


Figure 2. Peak demand and transmission capacity of SAPP regional power grid. Source: SAPP annual report, 2021.



(a) SAPP installed generation capacity share % per country in 2021.

(b) SAPP installed generation capacity share % by resources in 2021

Figure 3. SAPP generation portfolio in 2021. Data source: EIA, 2023.

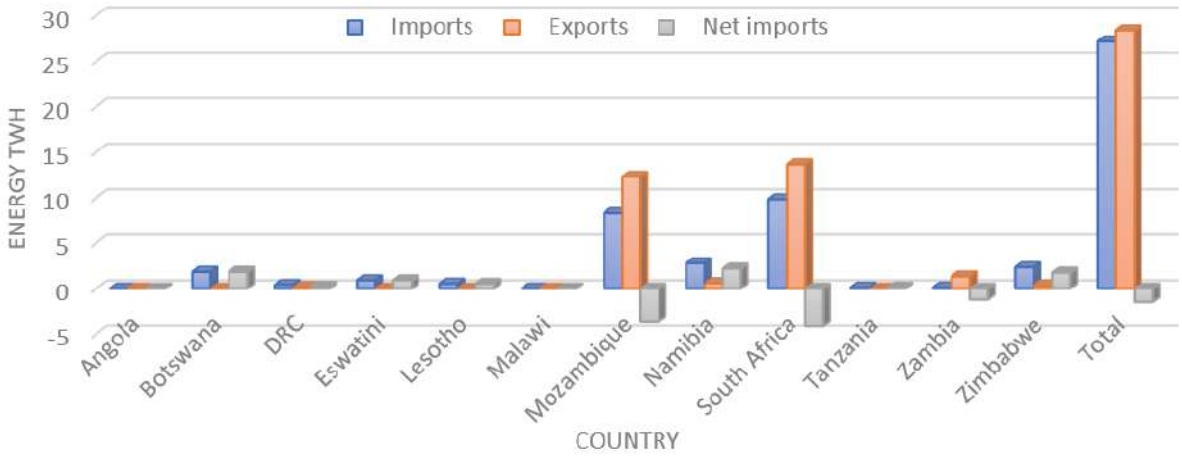


Figure 4. SAPP export and import (TWh) in 2021. Data source: EIA, 2023.

The energy trade patterns, shown in Figure 3, show that countries with a large installed generation capacity are the net exporters in the region; these are South Africa, Mozambique, and Zambia. Mozambique and Zambia export their cheap hydropower during rainy seasons while importing electricity during dry seasons. South Africa exports its surplus from its coal generation fleet while importing cheap electricity from hydro when its neighbours have excess generation.

These three countries are responsible for 87% of the total energy trade in the SAPP. Three countries in SAPP are entirely energy importers – Botswana, Eswatini, and Lesotho. Lesotho is particularly dependent on South Africa in its energy consumption, as it is not just landlocked but South Africa-locked.

According to the 2021 SAPP annual report, during the year 2020/2021 the total amount of energy traded was 8,205 GWh, of which 81.74% was traded through bilateral contracts and 18.26% on the Market Trading Platform.

1.2 The historical development of regional power trade

Trade between SAPP member countries initially took place under bilateral contracts of 1-5 year duration for peak, off-peak and standard times. These contracts were already in place before the creation of SAPP. Following the creation of SAPP, members were obliged to meet their accredited capacity obligations, have sufficient capacity to cover the forecast peak, being able to supply emergency energy for up to six hours, allow wheeling through its system when technically and economically feasible, submit maintenance schedules, and disclose information about generation costs. The goal was to move from bilateral contracts towards establishing an organised market.

In 2001, SAPP introduced the STEM platform to serve as an initial organised market (bid-based) as a transition towards a regional spot market. STEM was designed for energy contracts up to a month duration for daily and hourly transactions operated chiefly in off-periods (countries lacked generation capacity during peak hours to trade). Utilities sent their bids to the coordination centre that matched them and published the successful bids. The successful bids were then published on a bulletin board and members continued, in parallel, negotiating for bilateral trades. In 2002, STEM was supplemented with an Over-The-Counter (OTC) trading for short-term needs during emergency and planned outages (ad hoc).

In January 2004, SAPP started the development of a full-fledged organised electricity market. In 2006, the Nord Pool ASA signed a contract with SAPP to implement a day-ahead spot market.

2009 witnessed the delivery of an organised Day-Ahead Market (DAM) in which bids could be submitted up to 10 days ahead. In 2013, SAPP introduced the Post-Day Ahead Market to increase the number of matched bids. The Post-Day Ahead Market takes place after the DAM is concluded, and the price is published for the bids that were not accepted in the DAM. Until 2015, Nord Pool owned and operated the trading system. When NASDAQ OMX acquired the Nord Pool ASA in 2010, they increased maintenance and operation charges, which led SAPP to develop their own trading platform, SAPP Market Trading Platform (SAPPMTP), in 2015. This development was particularly important for SAPP to be able to modify, develop and add new features to the trading system. Upon the launching of the MTP, SAPP immediately introduced three new markets: the Forward Physical Market-Weekly/Monthly (FPM-W/M) and the Intra-Day Market (IDM).

Since 2019, SAPP has been working on developing a balancing market in collaboration with the government of Norway and the SIDA fund and intends to establish a financial market to facilitate trade in the physical markets.

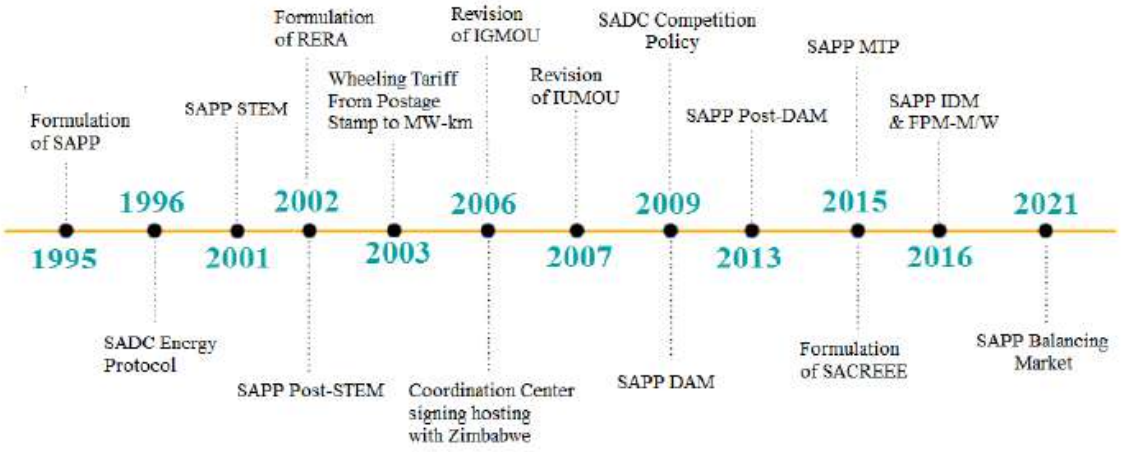


Figure 5. SAPP development timeline.

Figure 4 shows the development timeline of SAPP. Several factors were important in this development, some of which are:

1. The establishment of the SADC.
2. The presence of sufficient regional infrastructure (interconnections and generation) to support significant power trade.
3. The uneven distribution of natural energy endowments in the region (e.g., thermal generation in South Africa and hydropower in the northern countries), which created the need for interdependence and the incentive for trading among countries.
4. The presence of South Africa as a regional champion for pushing regional trade agendas in SADC.
5. The technical and financial support received from international institutions.

2. The Western African Power Pool – WAPP

The Western African Power Pool (WAPP) is the second oldest power pool and the largest in terms of the number of participating countries. Following the promotion of trade liberalization and regional integration among the Economic Community of West African States (ECOWAS) member states, WAPP was created by Decision A/DEC.5/12/99 of the 22nd summit of 1999 in Lome, Togo. However, it wasn't until the 29th summit in 2006 that ECOWAS member states signed the Articles of Agreement for WAPP organization and functions under Decision A/DEC.18/01/06. Since then, WAPP was accorded a special institution of ECOWAS by the other approval of Decision A/DEC.20/01/06. WAPP includes all members of ECOWAS except for the unconnected island of Cape Verde. Hence, it includes 14 members: Benin, Burkina Faso, Cote d' Ivoire, the Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Sierra Leone, Senegal, and Togo.

Of the eight elements to establish a regional market, WAPP implemented the following five:

1. Establish legal documents and agreements permitting trade: the WAPP Articles of Agreement.
2. Establish a regional regulator for trade: the ECOWAS Regional Electricity Regulatory Authority (ERERA).
3. Establish commercial market rules for trade: the WAPP Market Rules and Procedures.
4. Admit IPPs participation.
5. Establish a regional grid development unit: the WAPP Project Unit, donors' coordination committee, and the Special Purpose Company/Vehicle.

2.1 The regional infrastructure

The regional infrastructure of WAPP only connects two-thirds of the members; the remaining five countries will become connected when the commissioning of the WAPP OMVG and CLSG transmission projects takes place, as shown in Figure 5. The operating transmission network has an interconnection capacity of 3,199.3 MW. Each country has at least two interconnections, except for Niger and Senegal, and the largest interconnection capacity is 777 MW between Nigeria and Benin. As of January 2018, the regional power grid suffers from synchronization problem on two interfaces, and because of this, the regional transmission network is divided into three synchronous blocks:

- Block A: Burkina Faso, Ghana, Cote d'Ivoire, part of Mali (up to Bamako) and part of Togo/Benin.
- Block B: Senegal, Mauritania and part of Mali (up to Bamako).
- Block C: Nigeria, Niger and part of Togo/Benin.

Major stability issues have been detected at the interfaces between the existing synchronous blocks; in particular, the interface between Block C and B is not secure and requires a Special Protection Scheme and a minimum set of reinforcements[3].

[3] See WAPP (2018), Update of the ECOWAS revised master plan for the development of power generation and transmission of electrical energy - Volume 4: Generation and Transmission Master Plan.

The generation profile of WAPP, shown in Figure 6, consists mainly of 72% fossil fuels (primarily natural gas), 24% hydro, and 3% solar installed capacity. The installed capacity of Nigeria is 11.7 GW, which accounts for 47% of the total installed capacity in the region. The second-largest installed capacity is 5.3 GW (22%) found in Ghana. The two countries also have the largest hydropower generation capacity in the region, 36% and 27%, respectively. The third largest producer in the region is Cote d'Ivoire with an installed capacity of 2.2 GW. The five unconnected members; Liberia, Guinea, Guinea Bissau, Sierra Leon, and the Gambia; have a total peak demand of just 488.5 MW and a generation capacity of only 1,156 MW.

The energy trade in WAPP, shown in Figure 7, is rather simple when considering the countries' natural endowments. There are only three exporting countries; these are the same countries with significant hydro generation: Nigeria, Ghana, and Cote d'Ivoire. Naturally, Nigeria, with the largest installed capacity, is responsible for 27.9% of the trade and does not import from any country.

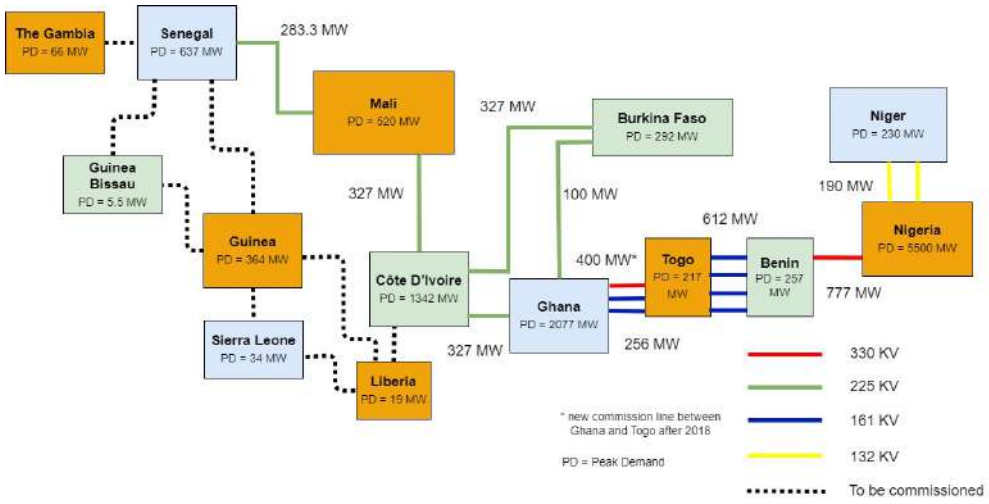
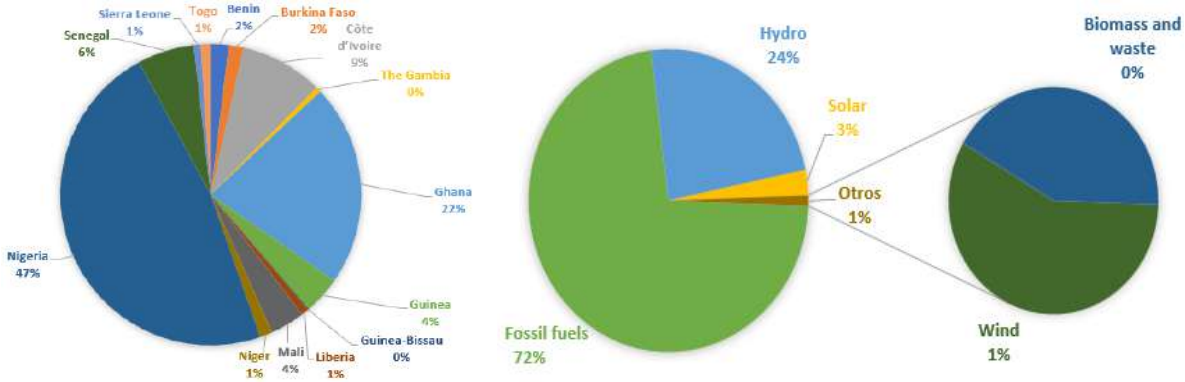


Figure 6. Peak demand and transmission capacity of WAPP regional power grid[4].



(a) WAPP generation capacity share % per country in 2021.

(b) WAPP installed capacity share % by resources in 2021.

Figure 7. WAPP generation portfolio in 2021. Data source: EIA, 2023.

[4] Composed by the author from various secondary data sources: WAPP (2018), Update of the ECOWAS revised master plan for the development of power generation and transmission of electrical energy - Volume 4 & 5 and projects documentations from the World Bank.

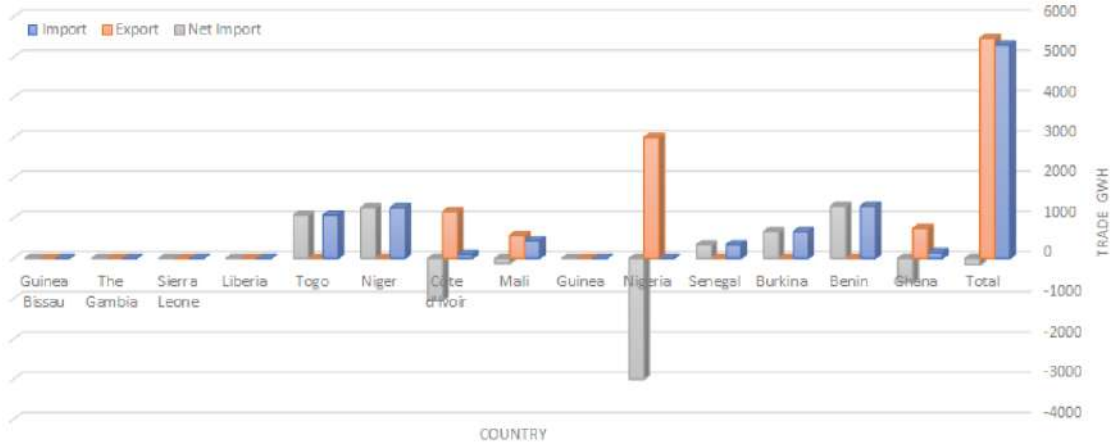


Figure 8. WAPP export and import (GWh) in 2018. Data source: EIA, 2021.

The small countries in the region rely heavily on imports to fulfil their consumption. In particular, Benin and Togo import 108.8% and 86% of their consumption from Nigeria, respectively. Interestingly, the interconnection between Togo and Benin is only used for wheeling electricity either from Nigeria to Togo or from Ghana to Benin, as both countries had zero export in 2018.

2.2 The historical development of the regional market

Electricity trade in the region can be traced back to the 1970s. Since 1972, Ghana's Volta River Authority (VRA) has been exporting electricity from its Akosombo hydroelectric dam to Togo and Benin under the bi-national utility CEB. However, the infrastructure was highly underdeveloped and trade was controlled through ad hoc arrangements between parties that relied on voice telephone communication between adjacent systems and had no protection systems against fault propagation[5]. Bilateral trade was developed similarly between neighbouring countries and mostly around hydropower projects. In 1972, the Organisation pour la Mise en Valeur du fleuve Sénégal (OMVS) (the Senegal River Basin Development Organisation) was established between the three riparian countries Mali, Mauritania, and Senegal for coordinated exploitation of the Senegal River basin resources, initially for irrigation but later for building and trading electricity from hydro projects. Other power exchanges happened between Nigeria and Niger since the 1970s, and between Cote d'Ivoire and Ghana since the mid-1990s. These contracts, however, were not standardised and suffered from issues with billing collection and wheeling tariffs.

Since the official establishment of WAPP in 1999, the vision was set to integrate the national power systems into a unified regional electricity market. This includes devising a market creation plan and improving the existing trade by standardising the bilateral contracts. WAPP implementation roadmap for market development was divided into three phases: Phase 1 was dedicated to the regional infrastructure development until approximately 2015 by appointing a market operator and approving the market rules (by the regional regulator); Phase 2 is dedicated to market formalisation and will end by establishing a day-ahead market; and Phase 3 is dedicated to the long-term vision of enhancing liquidity and competition. To this date, WAPP is yet to finish Phase 1 to start the organised market.

[5] See Economic Commission for Africa, UN. (2003), Assessment of power pooling arrangements in Africa. UN. ECA Ad Hoc Expert Group on Assessment of Power Pooling Arrangements in Africa Meeting (2003, Jun. 24 - 26: Addis Ababa, Ethiopia.). Addis Ababa.

As of November 2021, WAPP has 39 members including one observer, the National Office for Electricity and Drinking Water (ONEE) of Morocco.

Figure 8 shows the development timeline of WAPP. The following factors were important in this development:

1. The establishment of the ECOWAS.
2. The uneven distribution of natural energy endowments in the region. Having countries with limited sizes and resources created interdependence and a need for trade among countries.
3. The presence of the ECOWAS Commission as a regional institution for promoting regional integration, foreign investments, and cooperation in the energy sector.
4. The financial support received from international institutions.

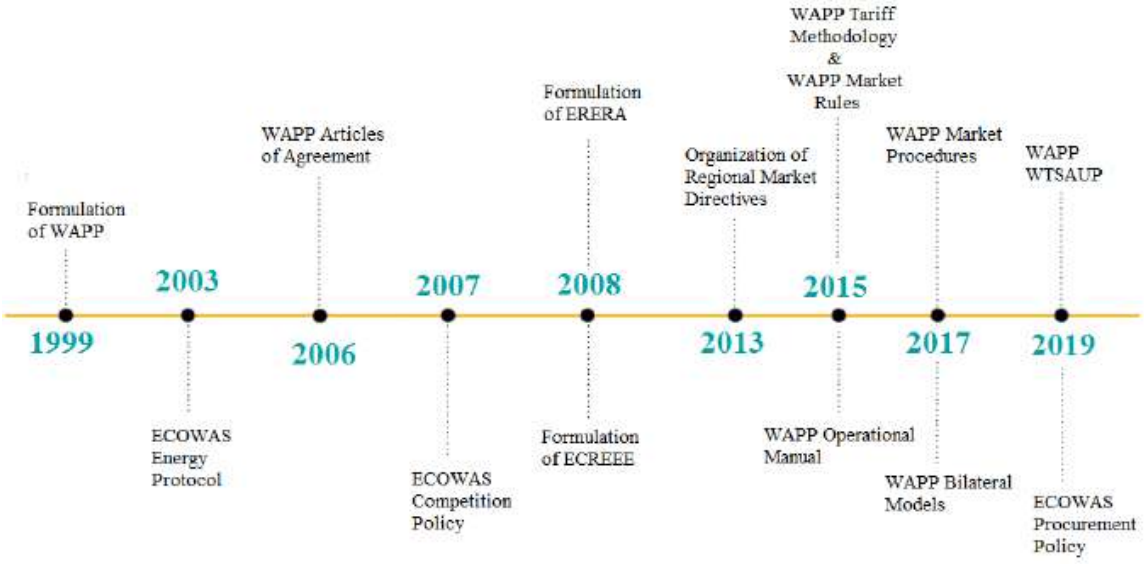


Figure 9. WAPP development timeline.

3. The Eastern African Power Pool – EAPP

The Eastern African Power Pool (EAPP) is the youngest power pool in Africa and the largest in terms of coverage area and inhabitants. It was founded in 2005 by seven Eastern African countries, namely: Burundi, DRC, Egypt, Ethiopia, Kenya, Rwanda, and Sudan. The member countries signed an IGMOU with the prime aim of fostering power system interconnectivity. In 2006, EAPP was adopted as a special institution of the Common Market for Eastern and Southern Africa (COMESA) during its 11th summit in Djibouti. By 2012, EAPP included the seven founding members plus Djibouti, Tanzania, Libya, and Uganda. Thus far, the development of EAPP has been very limited to only establishing legal documents and agreements permitting regional trade, an IGMOU and an IUMOU.

3.1 The regional infrastructure

The regional infrastructure of EAPP is fragmented and covers all the members within three isolated blocks as shown in Figure 9. The total capacity of the transmission network is 1,440 MW. Four countries have only one interconnection and the other seven countries each have two interconnections, with the largest interconnection capacity of 371 MW between Ethiopia and Sudan. The total installed capacity of the eleven countries is 83,818.4 MW with a peak demand of 48,570 MW.

Figure 10 shows the generation portfolio of EAPP, which consists of 77% fossil fuels (mostly natural gas), 16% hydro, 3% wind, 2% solar, and 1% geothermal plus biomass and waste. The largest country in terms of installed generation capacity is Egypt, with 56.1 GW installed capacity (accounts for 67% of the total regional capacity). The second-largest installed capacity is Libya with 32.11 GW, making 12% of the total. Then 10% of the capacity is installed in both Ethiopia and Sudan. Egypt and Libya are the two largest contributors to fossil fuel generation, with 78.8% and 15%, respectively.

EAPP is rich in hydropower generation, thanks to the Nile River that flows through most countries in the three different sub-networks. The largest hydro producer is Ethiopia, with a share of 23.1% of total hydropower, followed by Egypt at 22.9%, Sudan at 17.1%, DRC at 18.7%, and Uganda at 6.4%. The only country with geothermal generation is Kenya, with an installed capacity of 663 MW.

Figure 11 shows the energy traded in EAPP in 2021. Trading is scarce and the amount of annual trade was only 2.9 TWh. Due to the quite even distribution of hydro, countries have a similar energy mix and only export when they have a surplus of electricity. Ethiopia is the largest exporter in the region, with 62.1% of the total exported electricity. Burundi and Sudan are the biggest import-dependents, with 29.5% and 7.1% of their electricity consumption imported. The other two largest exporters are Egypt, with 18.9% and Uganda, with 14.2% of the total energy traded. Interestingly, at first glance at the third isolated network between Burundi-Rwanda-DRC, all three countries appear to be net importers despite being isolated; this is because the three countries established a public company called SINELAC which operates two hydropower plants, Ruzizi I (29.8 MW) and Ruzizi II (43.8 MW), on the shared border of the Ruzizi River. Thus, the three countries import electricity from SINELAC.

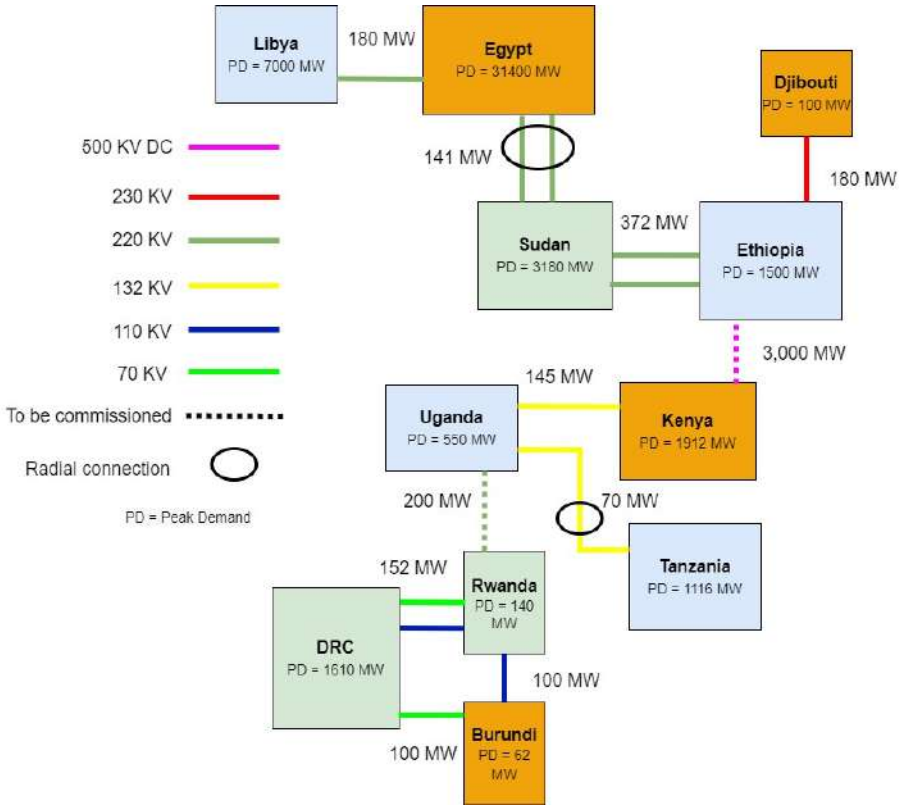
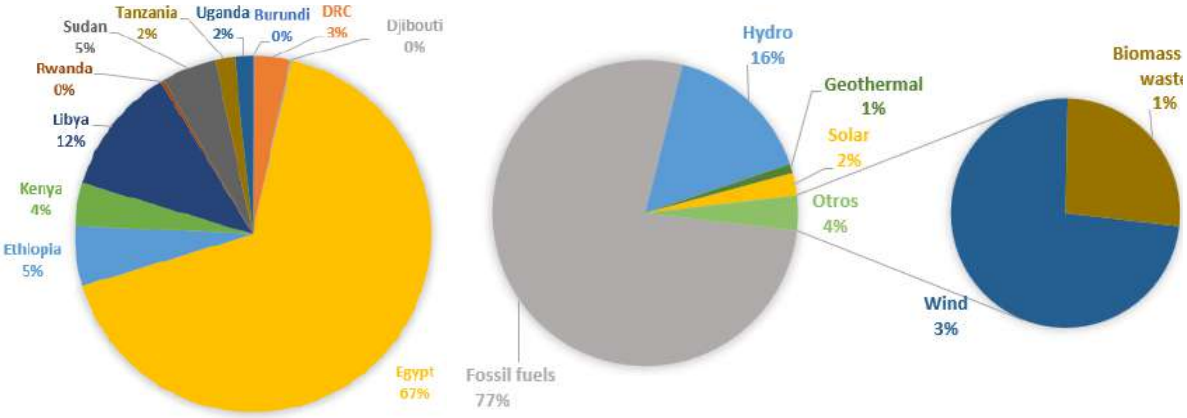


Figure 10. Peak demand and transmission capacity of EAPP regional power grid[6].



(a) EAPP generation capacity share % per country in 2021.

(b) EAPP installed capacity share % by resources in 2021.

Figure 11. EAPP generation portfolio in 2021. Data source: EIA, 2023.

[6] Composed by the author from various secondary data sources: EAPP, "Development of Regional Power Trade in East Africa," 2014; [18] EAPP, Ea Energy Analyses, and Energinet, "EAPP Regional Power System Master Plan Volume I: Main Report," 2014; SNC Lavalin International Inc and Brinckerhoff Parsons, "Regional Power System Master Plan and Grid Code Study," Eastern Africa Power Pool (EAPP) and East African Community (EAC), Final Master Plan Report, chapter Volume I., 2011; and projects documentations from the World Bank.

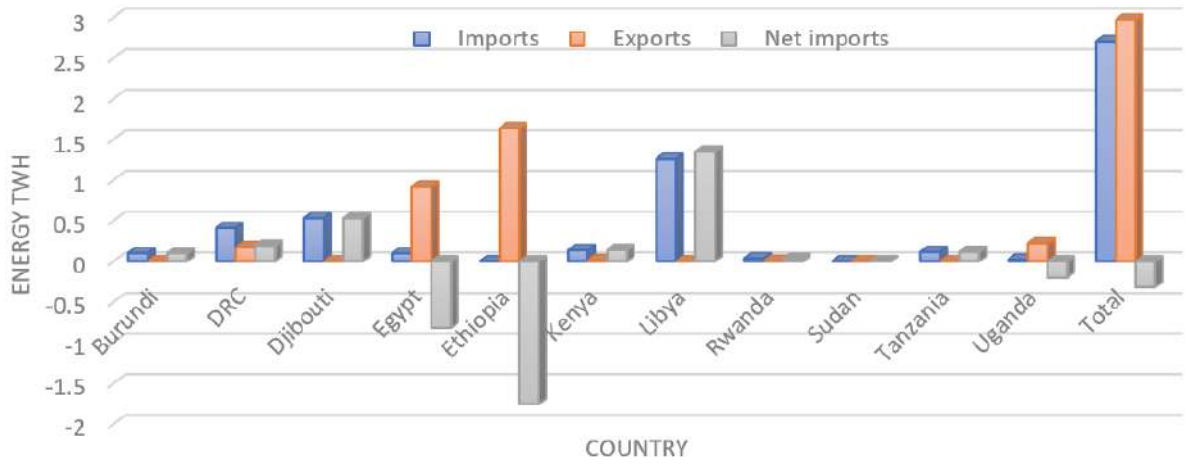


Figure 12. EAPP export and import (TWh) in 2021. Data source: EIA, 2023.

3.2 The historical development of the regional market

The first cross-border interconnection in Africa was the 132 kV transmission line linking Uganda and Kenya for bulk power supply to the capital of Kenya, Nairobi, in 1958. A contract was signed in 1955 whereby the Uganda Electricity Board (UEB) was supposed to supply 30 MW of electricity to Kenya Power Company (KPC) for five years. In 1993, UEB also signed a supplying contract with the national utility of Tanzania (TANESCO), which provided 9 MW of electric power to Bukoba for 30 years. The trade between these countries was further promoted by the creation of the East African Community (EAC) and the development of a regional master plan supported by the World Bank. The exploitation of Uganda's hydroelectric potential was the main driving force.

The same trend followed in the lower Nile basin. Burundi, DRC, and Rwanda formed a tri-lateral partnership for developing hydropower stations along the shared resources of the Ruzizi River. Jointly in 1958. the Ruzizi I hydroelectric dam was built within the territory of DRC and was followed by Ruzizi II in 1989. The early agreement enabled Rwanda to import 3.5 MW from Ruzizi I, while Burundi imports electricity from Ruzizi I based on its owed debts. On the other hand, the six countries had isolated electricity exchange on their borders through common medium voltage networks. Uganda supplied electricity to isolated centres in Tanzania and Rwanda, while Rwanda also supplied electricity to the isolated district of Kisoroin in Uganda.

In contrast to the lower part of the Nile basin (the Nile Equatorial Lakes region), the upper easter region (Egypt, Ethiopia, and Sudan) did not witness similar historical development. It was only in 1999 that the Nile Basin Initiative (NBI) was launched to foster regional partnerships. With the support of the World Bank, the NBI conducted several studies and master plans for developing power trade which was used by EAPP.

EAPP conducted a consultancy project with Mercados for the regional market design and rules. The deliverables included market guidelines, rules, and procedures, along with an excel-based mini-application named the African Day-Ahead Market (ADAM). A pilot project was performed with ENERGINET-DK (the Twinning consultant) for testing the ADAM through shadow trading in two locations Sudan-Ethiopia and Uganda-Kenya, over a six-month period in 2014-15. The exercise yielded virtually a $20 million economic gain from the short-term trade, which is huge

considering the limited transmission capacity. According to the Twinning consultant, the ADAM is fit for live trading, and there is no need for a new market platform to start trading on existing interconnectors[7]. However, trading went back to bilateral contracts upon finalizing the project, and currently, there is no organised market nor a market committee.

Figure 12 shows the development timeline of EAPP. An important factor in the establishment and development of EAPP is the support from international institutions and the facilitation of funds through COMESA.

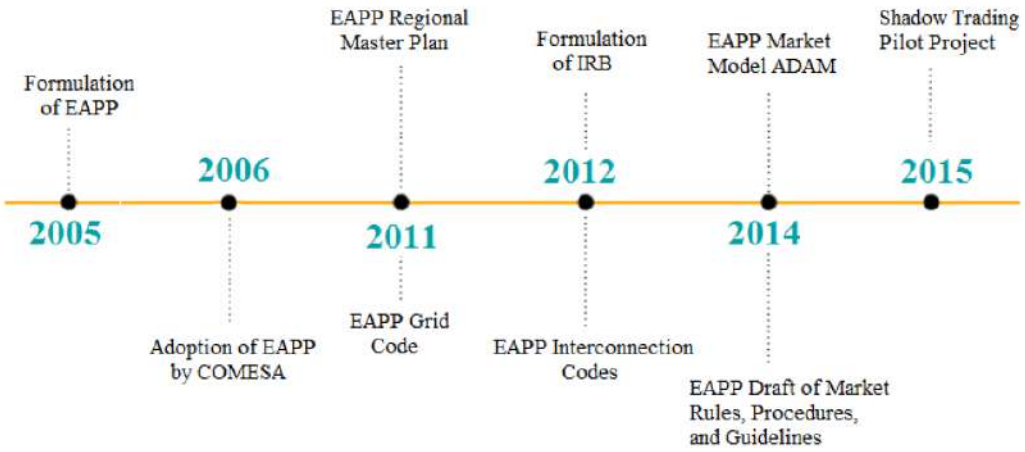


Figure 13. EAPP development timeline.

4. The Northern Africa Power Pool – NAPP[8]

The Maghreb Electricity Committee (COMELEC) was created in 1974 by the decision of the public electricity companies of the three countries Algeria (SONELGAZ), Tunisia (STEG), and Morocco (ONEE), and to create the Maghreb Electricity Commission (COMELEC). It was joined by SONELEC (Mauritania) in 1975 and GECOL (Libya) in 1989. The establishment of COMELEC was based on mutual aid and securing energy between neighbouring countries. It was responsible for developing interconnections that would allow countries to exchange power in times of need in good faith. Net flows were enumerated annually, and deficits and surpluses were settled the following year, typically as a balance of MWhs rather than money. Following the establishment of the Arab Maghreb Union (AMU) in 1987 as an official regional economic community, that includes the five countries, COMELEC was designated as a special institute of AMU in 1990.

4.1 The governance structure

The governance structure of COMELEC consists of two bodies: The steering committee and the general secretariat. That steering committee defines the strategic development of COMELEC and ensures its implementation. Its decisions are taken unanimously, considering existing international standards. The general secretariat, located in Algeria, is the Headquarters of COMELEC and encompasses six working committees/commissions. It is responsible for preparing the work of the committees, disseminating its decisions and recommendations, representing COMELEC in international

[7] See Norda and KPMG, "Joint Review of Swedish/Norwegian Support to the Southern African Power Pool and the Eastern African Power Pool ," Norwegian Agency for Development Cooperation, Norad Collected Reviews, 2019.

[8] The formal institutional name of NAPP is the Comité Maghrébin de l'Electricité (Maghreb Electricity Committee), we use the term NAPP in the title as an alias in conjugation with the other power pools' names.

organisations and ensuring the implementation of the work programmes. The General Secretariat also organises the ordinary and extraordinary sessions of COMELEC in liaison with the host organisations. Figure 1 shows the governance of COMELEC.

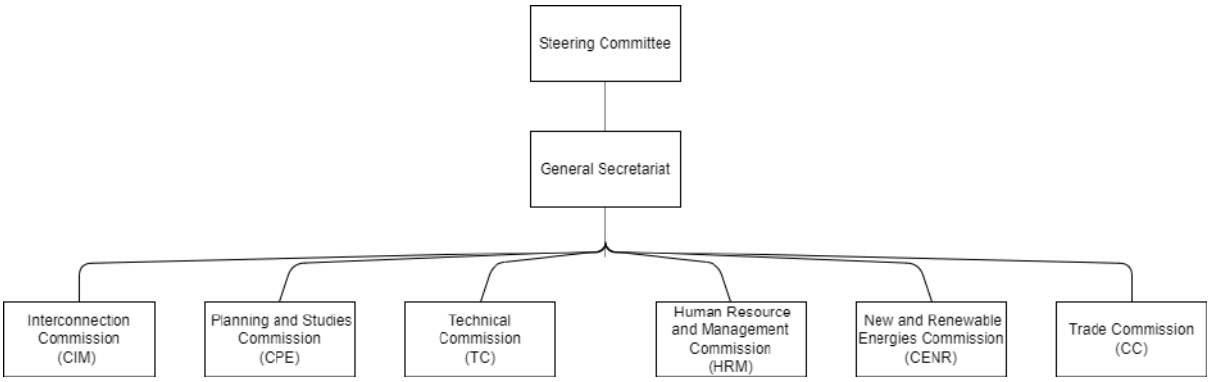


Figure 14: The governance structure of COMELEC. Source: Updated Regional Power Status in Africa Power Pools, ICA, 2016.

4.2 The regional infrastructure

COMELEC countries are interconnected with each other except for Mauritania, as shown in Figure 2. Two major studies have been conducted for the development of interconnection projects between North African countries, the ELTAM Study (Egypt-Libya-Tunisia-Algeria-Morocco), and between Mediterranean countries, MEDRING Study (Mediterranean Ring). The regional grid has a total of twelve cross-border interconnections with a total capacity of 3,660 MW. The power pool is also connected to the Middle East via the Egypt-Jordan interconnection and to Southern Europe via the Morocco-Spain interconnection across the Strait of Gibraltar.

In 2003, a Memorandum of Understanding was signed in Rome by Algeria, Morocco and Tunisia with the European Union for establishing the Euro-Maghreb Electricity Market. It aims at progressively integrating the electricity market of Algeria, Morocco and Tunisia into the European Union's internal electricity market. Currently, the Moroccan power system is synchronised with Europe and the interconnection between Morocco-Algeria-Tunisia is also operated under synchronous mode with the European grid since its first operation in 1997. The national utility, ONEE, participates in the Spanish electricity market and is responsible for managing exports and imports.

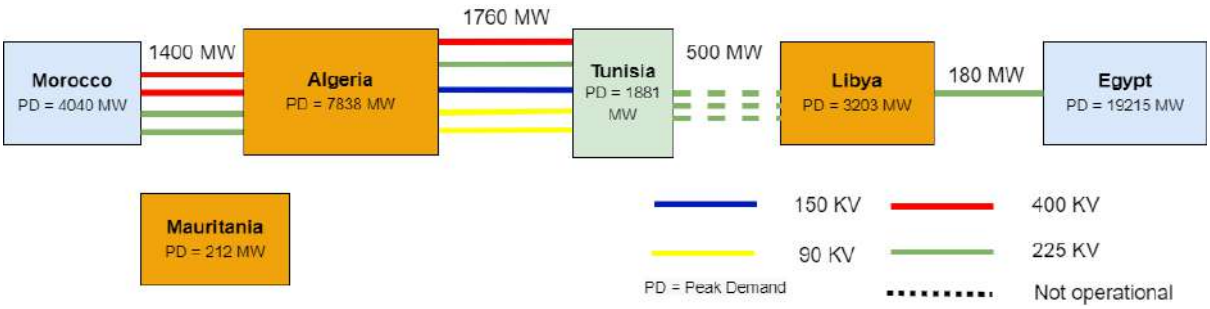
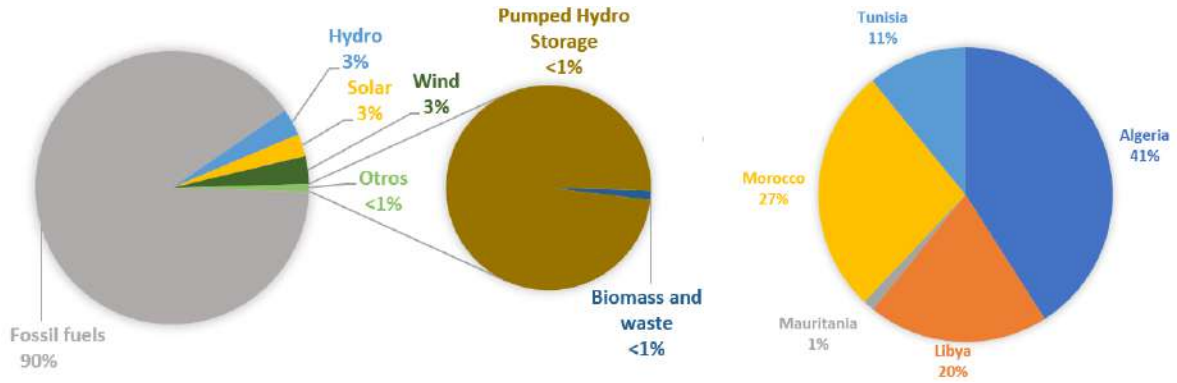


Figure 15: Peak demand and transmission capacity of NAPP regional power grid.

The region has a total installed capacity of 53 GW, and the generation portfolio, shown in Figure 3, is predominantly fossil fuel-based, with 90% of the total installed capacity. Renewables share only 9% of the total installed capacity, with Morocco having the only pumped hydro station with a capacity of 465 MW. Unlike the other power pools, hydropower does not make up a considerable share of the generation mix (only 3%). Figure 3 also shows the distribution of the installed capacity among countries. Algeria has the largest generation capacity, which counts for 41% of the total, followed by Morocco with 27%. Compared to the other four countries of COMELEC, Mauritania has a minuscule generation capacity (and consumption). The country is also the only one that does not provide universal electricity access (47% access rate).



(a) NAPP Installed Capacity by Sources in 2021

(b) NAPP Generation Capacity Share % per Country in 2021

Figure 16: NAPP generation portfolio in 2021. Data source: EIA, 2023.

Figure 4 shows the power exchange of the five countries in 2021. Power is exchanged mainly between the three countries of Algeria, Morocco, and Tunisia. The rest of the countries, Libya and Mauritania, import power from outside the power pool as they are not connected effectively. The three trading countries all export and import during the year, with Tunisia and Algeria being net exporters in 2021. Part of Moroccan import and export belongs to Algeria as the latter sells power to Spain through it. Considering the interconnection capacity (and compared with the other power pools), the amount of regional trade is insignificant and is only 1.7% of the regional consumption, and countries mainly trade during crises. One reason for trade paucity is believed to be the political tension between Morocco and Algeria.

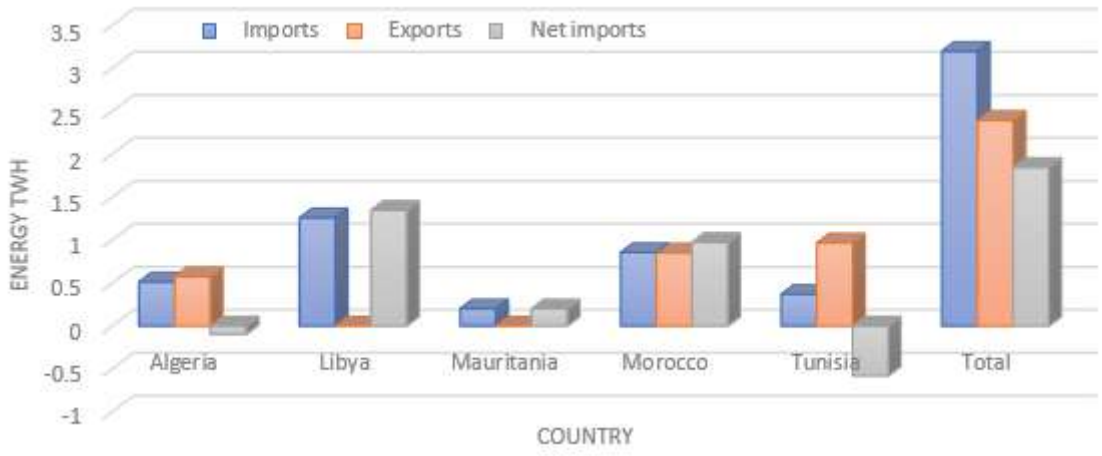


Figure 17: NAPP export and import (TWh) in 2021. Data source: EIA, 2023.

4.3 The current progress

The system operators of COMELEC are part of MedTSO (except for Mauritania) and they also partnered with MEDELEC, associated with the Arab League, the AMU, and partially with NELSAP, so some interconnections focusing on future export opportunities into other grids, like EAPP. There have been some efforts between Algeria, Morocco, and Tunisia in the last decade to harmonise regulations and competition with the EU through the Algerian Declaration of 2010. The Algerian electricity regulator, CREG, has made a statement about COMELEC's intention to expand cross-border trade beyond transmission system operators to include corporate off-takers and independent power producers. However, nothing concrete has been proposed or taken, and there is no regional grid code.

Currently, COMELEC does not operate in any competitive markets and trade happens through bilateral agreements. Over the years, there have been waves of interest in launching competitive markets, but none have progressed significantly. Generally speaking, as an institution, COMELEC has generally been idle and its members seem uninterested in further operationalising the legal union into a competitive regional market. Nevertheless, this seems to be changing with the current initiative of the African Union to develop a continental master plan. Earlier in 2021, the president of COMELEC announced that a study on the establishment of a joint electricity market and possibly for jointly developed renewable power projects would be launched alongside an independent evaluation of the governance structure of the power pool. The study aims to prepare the joint market for a 2025 launch, which could be feasible given that there are very few physical infrastructure constraints and electrification rates are much higher, but political barriers could also hinder it.

5. The Central Africa Power Pool – CAPP[9]

The Economic Community for Central African States (ECCAS), established in 1983, comprises ten member states: Angola, Burundi, Cameroon, Chad, Congo, Gabon, Equatorial Guinea, Central African Republic (CAR), Democratic Republic of Congo (DRC) and Sao Tomé. Although the Central Africa Power Pool (CAPP)was created in 2003 through the signing of an inter-governmental memorandum of understanding (signed by ministers responsible for electricity in ECCAS) and an inter-utility memorandum of understanding (signed by CEOs of the national utilities), it became a specialised agency of ECCAS formally in 2004. As a specialised agency of the ECCAS, the role of the CAPP as stipulated in its founding texts is to contribute to building a regional electricity market able to meet the electricity needs of both industry and the people. The CAPP is thereby responsible for expanding regional infrastructure and for defining the commercial, legal and technical conditions necessary to encourage investment and power pooling amongst all Central African countries.

5.1 The governance structure

The governance structure of CAPP consists of four levels. At the top of the hierarchy is the council of ministers, which includes all ECCAS energy ministers. Under the council of ministers is the executive committee that has the power pool executive power and is responsible for all CAPP activities. The executive committee supervises the steering committee and a special body called the regulatory agency[10]. Under the steering committee, there are the two working committees and the permeant secretariat, which is located in Brazzaville, Congo, and manages three sub-committee. CAPP has also envisaged a coordination centre that encompasses the national system operators and is likely to be the regional market operator. Figure 5 shows the governance structure of CAPP. Currently, only the

[9] Also known by PEAC for its French name: Le Pool Energétique de l'Afrique Centrale.
[10] The role and formulation of this body is unclear

permanent secretariat and the planning sub-committee are operational, the rest of the committees and sub-committees are yet to be staffed and operationalised.

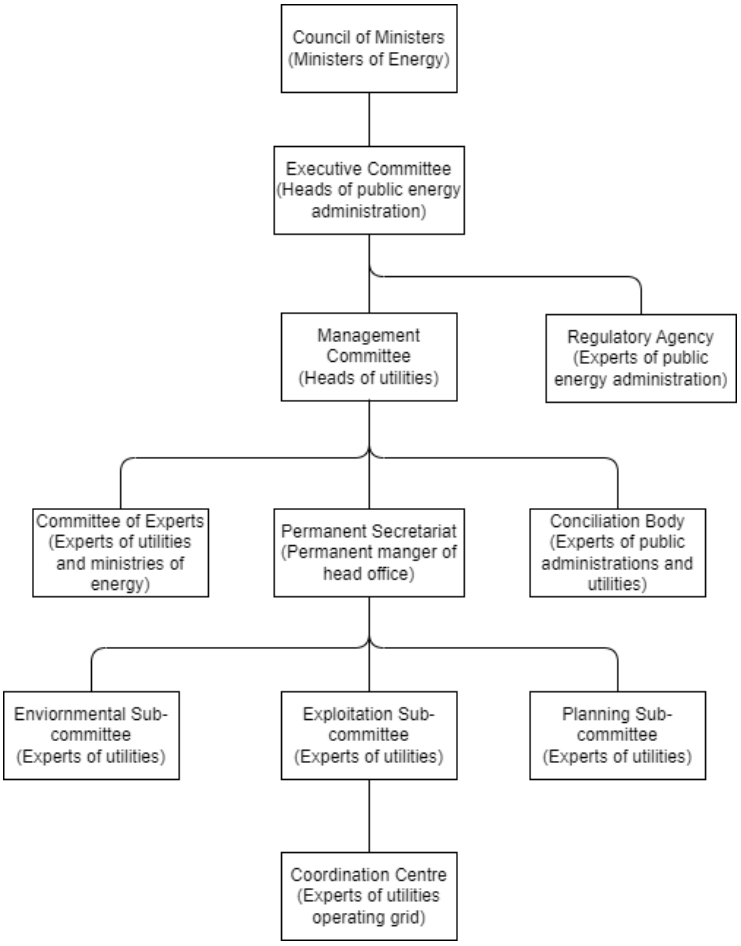


Figure 18: The governance structure of CAPP. Source: CAPP official website.

5.2 The regional infrastructure

The regional transmission network of CAPP is heavily underdeveloped. Not only is there a lack of sufficient interconnections between countries, but within the countries, national grids are not interconnected into a single grid. All of the big three countries in the region (Angola, Republic of Congo, and DRC) have their national grids segmented into three isolated grids. The only operating transmission lines interconnection are between DRC and Burundi, and DRC and the Republic of Congo, both having operating capacity of less than 100 MW. Other than these two interconnections, rural electrification also exists between countries (e.g., Gabon and Equatorial Guinea). Figure 6 shows CAPP region with its existing transmission lines.

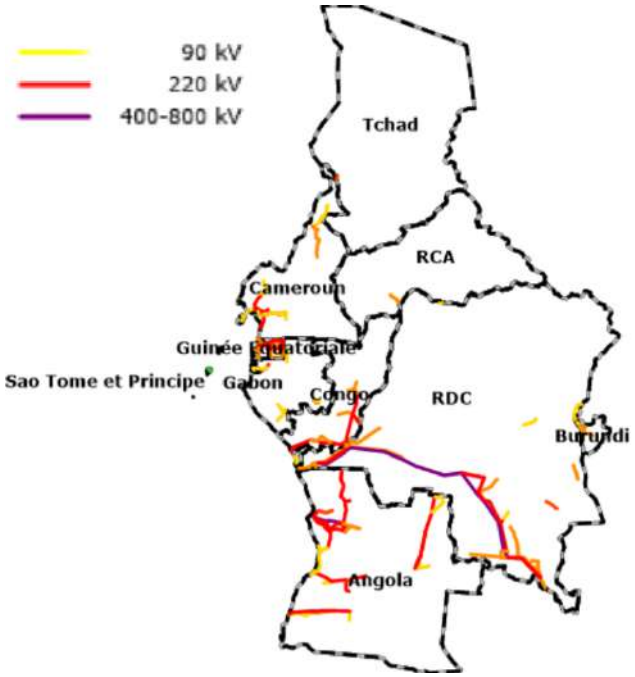
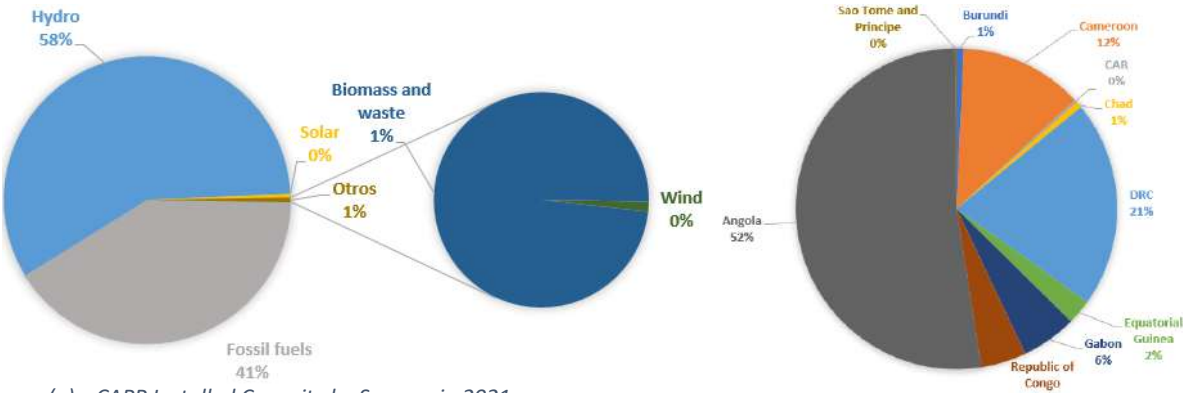


Figure 19: Transmission network of CAPP. Source: The official website of CAPP.

Figure 7 shows the generation mix of CAPP. The power pool is considered a hydro hub for the entire continent of Africa; 58% of its generation is from hydropower, still with huge potential to yet be exploited through the Grand Inga project in DRC. All countries in CAPP have hydropower generation, with the sole exception of Chad. The second large portion of the generation is fossil fuel-based, 41% of the total generation capacity. However, the CAPP has the lowest generation capacity among all of the power pools. The total installed capacity amounts to only 14 GW, with 52% of it located in Angola and 21% in DRC. The two countries also provide 81% of the hydro in the region.



(a) CAPP Installed Capacity by Sources in 2021

(b) CAPP Generation Capacity Share % per Country in 2021

Figure 20: CAPP generation portfolio in 2021. Data source: EIA, 2023.

Given the very limited capacity of interconnections and generation capacity in the region, the volume of power trade in CAPP is smallest among all power pools, as shown in Figure 7. All countries in the region are net importers and the only two exporters in the region are DRC and the Republic of Congo. The actual trade between CAPP members is even less than what is presented in the Figure 7 since a large portion of DRC's power exchange is with SAPP (through Zambia) and not CAPP members.

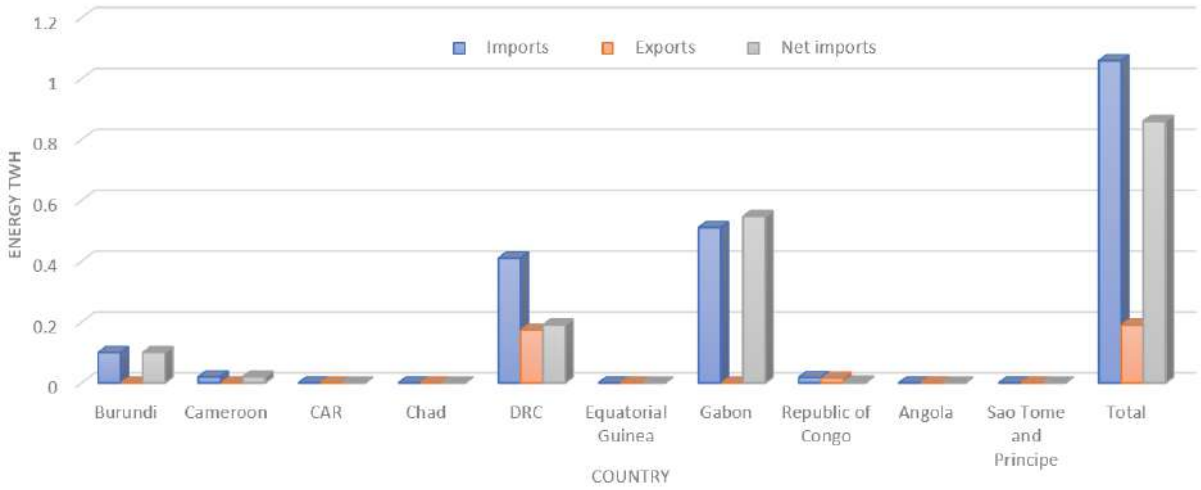


Figure 21: CAPP export and import (TWh) in 2021. Data source: EIA, 2023.

5.3 The current progress

The current reality of regional power supply in Central Africa is that there is no real trading of electricity. The power pool is still in the phase of acquiring expertise and operationalising its full organs. The current progress of CAPP is limited to capacity building and conducting studies and plans. Among these studies, CAPP developed its first CAPP regional power master plan in 2005 and followed it with a study on interconnection projects in 2010. The latter is coordinated by ECCAS with AfDB funding. It defines the overall development of interconnection schemes up to 2030. These priority projects consist of "the coastal backbone" linking Angola to Chad, including connection with DRC, Congo, Equatorial Guinea, Gabon and Cameroon and two other interconnections linking Cameroon to CAR and DRC to CAR.

In 2015, CAPP published its Regional Energy Policy Strategy Paper (REPSP) 2014-2030 to serve as a strategic framework for regional integration. The study was funded by European Commission as part of a technical assistance program. As part of this framework, CAPP developed an Electricity Market Code (regulatory framework) for promoting and securing power investments and regional trade. The Code was adopted in October 2009 by the heads of state and government at Kinshasa Conference (published in November 2010 by ECCAS gazette).