ECONOMIC CONSULTING ASSOCIATES

The Potential of Regional Power Sector Integration

South African Power Pool (SAPP) | Transmission & Trading Case Study

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Economic Consulting Associates

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Economic Consulting Associates Limited
41 Lonsdale Road, London NW6 6RA, UK
tel: +44 20 7604 4545, fax: +44 20 7604 4547
email: peter.robinson@eca-uk.com

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Abbreviations and acronyms

AAR	Alkaline Aggregate Reaction
ABOM	Agreement Between Operating Members of SAPP
AC	Alternating Current
AFUR	African Forum for Utility Regulation
ANC	African National Congress of South Africa
BLNS	Botswana, Lesotho, Namibia and Swaziland
BPC	Botswana Power Corporation
CAPCO	Central African Power Corporation
CDM	Clean Development Mechanism
CEC	Copperbelt Electricity Corporation
CFL	Compact Florescent Lamp
CNELEC	Conselho Nacional de Electricidade (Mozambican electricity regulator)
CTC	Central Transmission Corridor
DAM	Day-Ahead Market
DANIDA	Danish International Development Agency
DBSA	Development Bank of Southern Africa
DC	Direct Current
DFID	United Kingdom Department for International Development
DRC	Democratic Republic of the Congo
ECB	Electricity Control Board of Namibia
ECOWAS	Economic Community of West African States
EDM	Electricidade de Moçambique (Mozambique electricity utility)
EIA	Environmental Impact Assessment
ENE	Empresa Nacional de Electricidade (Angola's electricity utility)
EPC	Engineering, Procurement and Construction (form of contract)
ERB	Energy Regulation Board of Zambia
ESCOM	Electricity Supply Commission of Malawi (but formerly also the Electricity Supply Commission of South Africa)
Eskom	South African electricity utility (formerly called ESCOM)
EU	European Union
EWURA	Energy & Water Utilities Regulatory Authority of Tanzania
FIFA	Fédération Internationale de Football Association
GPZ	Gabinete do Plano de Zambese (Zambezi Planning Office)

GWh	Gigawatt-hour (measure of electrical energy = 10^9 watt-hours)
HCB	Hidroeléctrica de Cahora Bassa (company operating the Cahora Bassa complex)
HTP	Hidro-Tecnica Portuguesa (engineering consultant firm based in Portugal)
HVAC	High-Voltage Alternating Current
HVDC	High-Voltage Direct Current (transmission lines)
IDC	Industrial Development Corporation of South Africa
IGA	Inter-Government Agreement
IGMOU	Inter-Government Memorandum of Understanding
IRSE	Institute for Electricity Regulation of Angola
IUMOU	Inter-Utility Memorandum of Understanding
kWh	kilowatt-hour (basic unit of electrical energy = 10^3 watt-hours)
LEA	Lesotho Electricity Authority
LEC	Lesotho Electricity Corporation
LRMC	Long-Run Marginal Cost
MFPZ	*Missão do Fomento e Povoamento do Zambesi* (Agency for the Promotion and Settlement of the Zambezi),
MO	Market Operator
MOTRACO	Joint venture Moçambique Transmission Company supplying power from South Africa via Swaziland to MOZAL and EDM in Moçambique and to the Swaziland Electricity Board
MOU	Memorandum of Understanding
MOZAL	Alumina smelting company located close to Maputo
MW	Megawatt (unit of electrical power = 10^6 watts)
NamPower	Namibian electricity utility
NECO	National Electricity Council of Malawi
NERSA	National Energy Regulator of South Africa
OG	Operating Guidelines for SAPP's operating members
PPA	Power Purchase Agreement
PCB	Polychlorinated Biphenyl
PCP	Power Conservation Programme
PJC	Permanent Joint Commission for Cahora Bassa (governments of Mozambique, Portugal and South Africa)
PPA	Power Purchase Agreement
RERA	Regional Electricity Regulators Association of Southern Africa
SADC	Southern Africa Development Community
SADCC	Southern Africa Development Coordination Conference

SAPP	Southern African Power Pool
SEB	Swaziland Electricity Board
SIDA	Swedish International Development Agency
SIEPAC	Sistema de Interconexion Electrica para America Central
SNEL	Societe Nationale d'Electricite (electricity utility of the DRC)
SO	Systems Operator
SPV	Special-Purpose Vehicle
STEM	SAPP's Short-Term Energy Market
Tanesco	Tanzania Electricity Supply Company Ltd
UCPTE	Union for the Co-ordination of the Production and Transmission of Electricity (in Europe)
UDI	Universal Declaration of Independence (by minority government in Southern Rhodesia in 1965)
VSAT	Very Small Aperture Terminal
WAPP	West Africa Power Pool
WESTCOR	Western Corridor Transmission Company
ZERC	Zimbabwe Electricity Regulatory Commission
ZESA	Zimbabwe Electricity Supply Authority (now ZESA Holdings)
ZESCO	Zambia Electricity Supply Company (later registered under the Companies' Act as ZESCO Limited)
ZRA	Zambezi River Authority

Preface

This case study is part of an Energy Sector Management Assistance Program (ESMAP) project on Regional Power System Integration (RPSI). The objective of the project is to facilitate and accelerate RPSI projects in developing countries around the world. The project will draw on international experience and theoretical analysis in this area to provide a framework to assess:

- the economic, financial and environmental benefits that can accrue to regional power trading;
- the institutional and regulatory arrangements needed to sustain and optimize regional projects; and
- the ways in which obstacles to integration have been successfully overcome.

The final output of the project will be an umbrella report, *Regional Power Sector Integration – Lessons from Global Case Studies and a Literature Review*. This review will summarize the 12 case studies and literature review undertaken and analyze common themes on barriers to RPSI and solutions to overcome them.

Economic Consulting Associates was contracted to execute the project. In doing so, we are working closely with ESMAP and World Bank staff, as well as government officials, utility, power pool, and regional economic community personnel, and others directly involved in implementing regional power schemes.

This and other 11 Case Studies are prepared as clear, factual presentations of the selected projects. The intent is to provide a direct, easily digestible description of each of the selected projects without imposing an analytic framework or making judgments about the degree of success. Such analysis will be undertaken at the global level, considering the entirety of experiences from the Case Studies, in the aforementioned umbrella report.

All 12 Case Studies follow a uniform structure to facilitate ease of comparison and reference from one Study to the next. Some sections are longer than others, depending on the specifics of the Study. Additionally, there is some cross-referencing within each Study.

1 Executive summary

1.1 Motivations/objectives for trade

The focus of this case study is the Southern African Power Pool (SAPP). This was formed in the mid-1990s, but cooperation in the electricity sector in southern Africa goes back much further. The case study therefore covers a broader concept, tracking the development on the one hand of regional infrastructure (major generation plants and regional interconnectors) and on the other of the agreements, operating guidelines, rules and market structures to make it possible for the infrastructure to be used for trade in electricity. In fact, most of the generation and transmission infrastructure of SAPP predates the formation of the power pool and was developed to fulfil the power demands of the two major power markets in southern Africa: South Africa and the erstwhile Federation of Rhodesia and Nyasaland, together with the DR Congo copper belt.

South Africa, through its national electricity utility Eskom, is the overwhelmingly dominant electricity market in the region. The electricity systems of the small neighboring countries of Botswana, Lesotho, Namibia and Swaziland (BLNS countries) were all developed as offshoots of the South African network and historically have all been net importers of electricity from South Africa. Looking northwards, the underlying political and economic force behind the evolution of SAPP has been South Africa's desire to meet future increases in demand by importing low-cost hydropower from its northern neighbors. The Cahora Bassa hydroelectric scheme was the first of many such projects that South Africa expected to be developed to supply its market.

The Federal Power Board developed the Kariba hydroelectric scheme and the 330 kV grid supplying Zimbabwe and Zambia, while the Congolese national power utility developed the high-voltage direct current interconnector between the Inga hydroelectric scheme and the country's copper mines in the Katanga Province. An interconnection with the Zambian grid was made as a standby arrangement for emergencies.

During the apartheid era, there were interconnection projects that were developed to reduce the dependence of what were known as the frontline states on imports from South Africa. These interconnectors, between Zambia, Zimbabwe and Botswana, have become part of the backbone of the SAPP grid. Notwithstanding the political isolation of South Africa, Eskom was actively involved in resolving the 1991/92 drought-induced power crisis in Zimbabwe and Zambia that resulted in the building of the interconnectors between Zimbabwe and the Cahora Bassa hydroelectric scheme and from Zimbabwe through Botswana to the Matimba coal-fired plant in South Africa. Apart from the immediate market opportunity, Eskom's motivation was to initiate the realization of its long-term dream to create a regional power grid that would allow South Africa to access power from the hydroelectric potential of its northern neighbors.

SAPP itself was the culmination of efforts at coordinated energy development undertaken as part of the political goal of regional integration of the Southern African Coordination Conference (SADCC) created in 1980 and its successor, the Southern African Development Community (SADC) created in 1992. Given the dominant role of South Africa in the power market, it was not possible to make much progress as long as South Africa was not a member of SADC. The power utilities were, however, allowed to engage Eskom in the planning of the power pool. By 1994 when the first democratic government in South Africa was elected, most of the groundwork had been completed, and therefore it was possible to formally establish the power pool just a year later at the SADC Summit held in August 1995.

The founding agreements of SAPP were inspired by bilateral and multilateral agreements that were already in existence. The framework of each interconnection project or power purchase agreement comprised an intergovernmental memorandum of understanding (MOU) that authorized and guaranteed inter-utility contractual obligations. Accordingly SAPP developed a similar intergovernmental MOU authorizing and guaranteeing the inter-utility MOU and operating agreements.

1.2 The trade solution put in place (or attempted)

The SAPP member countries and the interconnected grid are shown in Figure 1. At present, SAPP comprises all 12 SADC member countries in the subcontinent (the other SADC members are the island states of Madagascar, Mauritius and Seychelles). Nine of these are operating members, that is countries which are part of the interconnected grid, which carries around 97% of the energy produced by SAPP countries.

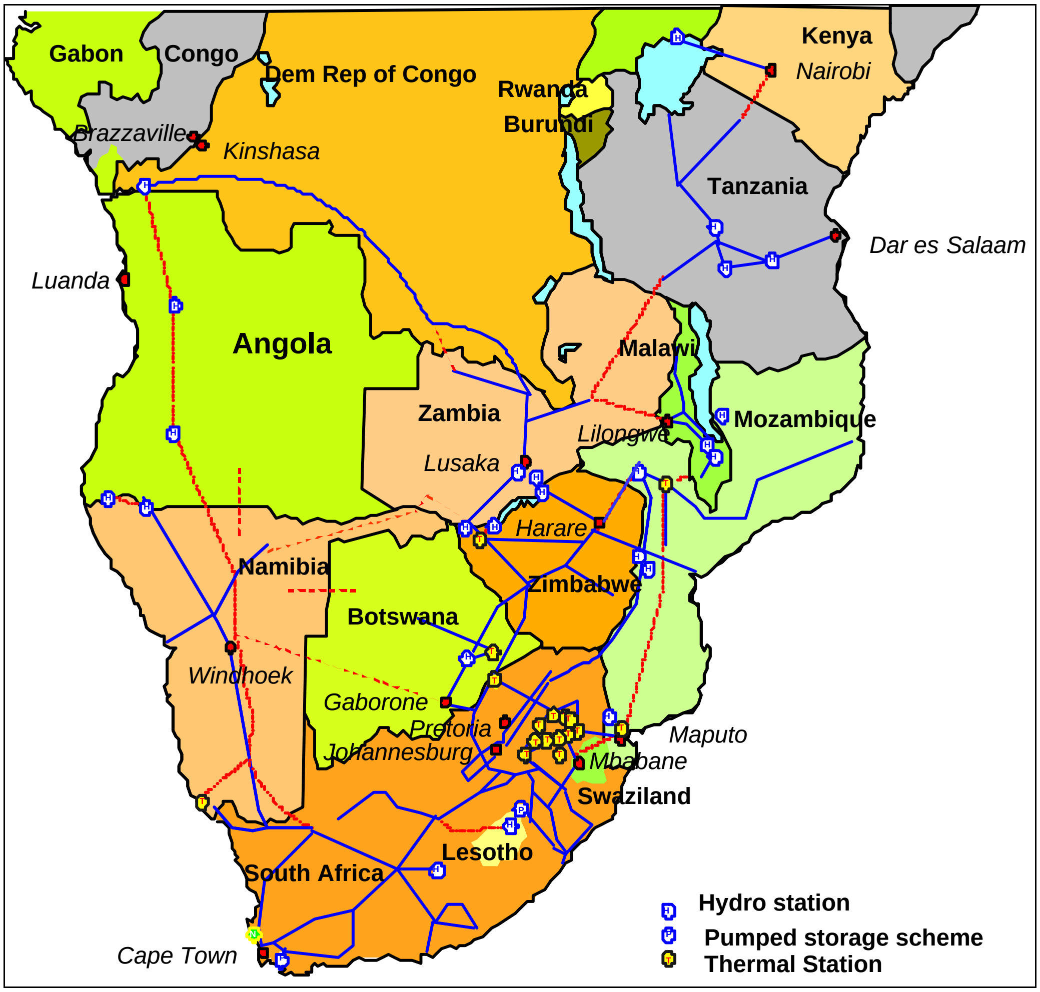
The bulk of the power is generated from coal, concentrated in South Africa's northern provinces, eastern Botswana, and western Zimbabwe. South Africa also has a nuclear power plant in the western Cape and hydro in the Drakensburg Mountains. The generation in the rest of the SADC countries is predominantly hydro-based, with power stations being located in the Zambezi Basin countries of Zambia, Zimbabwe, Mozambique and Malawi, at Inga in the Congo, in central Angola, Northern Namibia and also in Tanzania. The current operational statistics give the following generation mix for SAPP: 74.3% coal, 20.1% hydro, 4% nuclear and 1.6% diesel and gas.

The trading arrangements between members have continued to operate predominantly under the pre-SAPP–type bilateral and multilateral contracts. SAPP's focus has thus been:

- to improve the reliability and security of the existing regional grid;
- to facilitate the expansion of the grid to connect nonoperating members;
- to introduce a short-term energy market (STEM) to facilitate the trading of surplus energy not committed under existing contracts.

The SAPP Coordination Centre, which is located in Harare, Zimbabwe, was created in 2000 as an arm of the Operating Subcommittee to take charge of these immediate operational tasks.

Figure 1 SAPP Interconnected Grid



Source: Southern African Power Pool (2008)

Although the initial SAPP trading activities were based on excess generation capacity that was available for various historical reasons, it was recognized from the outset that the major benefits would come from coordinated investment in new generation and transmission facilities. The Planning Subcommittee was given the responsibility of developing a coordinated development plan, known as the SAPP Pool Plan, to serve as a tool for investment promotion. It is important to note that the SAPP Pool Plan was regarded as being for indicative purposes only and was not intended to be binding on member states. In the event, no new capacity expansion project of any significant size was implemented anywhere in SADC in the first 10 years of SAPP's existence. With the resulting emergence since 2007 of an overall supply shortage in the SAPP region, there is now considerable urgency in implementing investment projects. Net capacity additions of 1,700 MW were made in 2007, 1,442 MW in 2008 and 2,266 MW was planned for 2009. Demand side management measures have also been put in place.

Cooperation within the SAPP framework has resulted in benefits in the area of auxiliary services. For example, the decision to share spinning reserve resulted in a reduction on a national basis of reserve requirements from 20% to 15% of peak demand, giving rise to considerable savings. From 2007, regional power shortages have forced utilities to operate at reduced reserve margins, and many countries were forced into load shedding in late 2007 and 2008. In April 2009, the available capacity in the region was 48,649 MW (46, 772 MW for the interconnected grid) and the peak demand was 43,267 MW (41,645 MW for the interconnected grid), which indicates a reserve margin which is a little over the minimum level of 10.2%. This slight improvement is due to load reduction arising from the effects of the global economic downturn, coupled with successful demand management initiatives.

To date, SAPP has made creditable strides in establishing mechanisms to encourage short-term trade. The short-term energy market (STEM) that was developed and used over the period 2001–2007 is a notable achievement, even though the amounts involved were always a small proportion of the region's total annual energy consumption, which is about 300,000 GWh in the interconnected grid. The reduction in STEM trading activities in 2007 and 2008 was due to power shortages and transmission constraints. STEM is currently being replaced by a fully competitive day-ahead market (DAM), but most of the electricity trade in the region will continue to be via long-term bilateral contracts. The introduction of DAM has been delayed by the need to ensure that all members fully understand the way the market operates and how it will affect the long-term contracts.

1.3 Current status and future plans

For the foreseeable future, the primary challenge for the region is going to be the expansion of generation, transmission and distribution capacity in order to improve the security and reliability of supply as well as to cater to growth. According to the current SAPP Pool Plan, the medium- to long-term projects (to 2025) are expected to require US$83 billion for an additional 57,000 MW that will more than double the present regional generating capacity. At least US$5 billion is required to eliminate the current deficit by 2013. The recommended option assumes that South Africa postpones plans for a nuclear development program as a major component of its long-term expansion plan. A further US$6 billion will be required for regional transmission investments.

The Pool Plan targets are also predicated on the assumption that the factors that have inhibited greater regional development in the past will be overcome. In this regard, consideration is being given to new mechanisms for implementing regional electricity projects, including the possible establishment of a Project Acceleration Unit to be housed in the SAPP Coordination Centre.

In addition to vigorous implementation of the new Pool Plan, SAPP's other priorities going forward are:

- extension of the interconnected grid so that all member utilities become operating members of SAPP;
- promotion of small cross-border distribution projects to increase access to electricity in parallel with the large regional generation and transmission schemes;

- greater harmonization of rules, regulations and codes and further development of competitive electricity markets, a crucial starting point being to allow big customers to be market participants.

Greater attention needs to be paid to making regional electricity projects bankable. In this regard, SAPP and RERA (the Regional Electricity Regulators Association of Southern Africa) have important ongoing roles to play in assisting in the harmonization of sector policies and regulatory approaches and in sensitizing governments to the benefits of regional approaches and the importance of higher electricity tariffs.

2 Context for trade

2.1 Economic and political context

Although SAPP is the product of the Southern African Development Community (SADC), which is one of the regional economic communities of Africa, its roots are in the region's colonial history. The countries that form SAPP are former British colonies and protectorates (Botswana, Lesotho, Malawi, South Africa, Swaziland, Zambia and Zimbabwe), former German colonies taken over by the British (Namibia and Tanzania), former Portuguese colonies (Angola and Mozambique) and a former Belgian colony (Democratic Republic of the Congo).

The colonial powers either directly or indirectly influenced the development of most of the major power generating and transmission facilities within their territories. The backbone of the SAPP grid was developed in the countries where there was significant mining and industrial activity, such as South Africa, Zambia, Zimbabwe and DRC. Later power developments in Botswana, Mozambique and Namibia benefited from extension of South African mining activities and the country's quest for cheaper and cleaner sources of power.

The region also kept abreast with technology developments, with nuclear power in South Africa, and with high-voltage direct current (HVDC) transmission to transport power over the long distances from the Congo River to the Katanga Copperbelt and from the Zambezi River to South Africa.

2.1.1 Socioeconomic conditions

In 2007 the 12 SADC countries that comprise SAPP had a combined population of 226 million and GDP of US$330 billion. The dominance of South Africa in economic development and energy consumption is evident in the socioeconomic data in Table 1, which is ordered by per capita electricity consumption (last column). Excluding South Africa, and accounting for distortions due to energy-intensive industries in some of the countries, the region's socioeconomic conditions are typical of sub-Saharan Africa—endemic poverty, low life expectancy, high infant mortality rates, low electrification and low electricity consumption per capita rates. It is noteworthy that countries with the higher electrification rates have higher GDP per capita, lower inflation and higher literacy and school enrollment.

Some resource-rich countries such as Zimbabwe and DRC have experienced negative growth rates in recent years due to politically motivated internal strife. Zimbabwe's GDP has collapsed from a high of over US$10 billion in 1997 to about US$3 billion 10 years later. Zimbabwe experienced the world's highest inflation rates, which resulted in the total collapse of its currency in the fourth quarter of 2008; hence the table suppresses the inflation statistics for the country. The IMF figure for Zimbabwe inflation in 2007 is 10,453%, while for the first nine months of 2008 the IMF's estimate is 5.6*10^10%.

The relatively high per capita electricity consumption for South Africa, Namibia, Botswana, Zambia and Zimbabwe are due to energy-intensive mining, mineral smelting and similarly energy-intensive industrial operations.

Table 1 SAPP Countries Basic Socioeconomic Data 2007

Country	Population (millions)	Surface Area (km²)	GDP (US$ Billions)	GDP Per Capita (PPP	GDP Growth % (1990 - 2005)	Inflatio (CPI annual %)	Exports (% of GDP)
South Africa	47.9	1,221,037	240	11,110	0.6	3.4	27.0
Namibia	2.0	825,418	6	7,586	1.4	2.3	46.0
Botswana	1.8	600,370	10	12,387	4.8	8.6	51.0
Zimbabwe	13.1	390,757	3	2,038	-	..	43.0
Swaziland	1.1	17,364	3	4,824	2.1/0.2	4.8	88.0
Zambia	11.5	752,618	7	1,023	-	18.3	16.0
Mozambique	20.5	801,590	7	1,242	0.3/4.3	7.2	33.0
Angola	16.1	1,246,700	33	2,335	1.5	23.0	74.0
Lesotho	2.0	30,355	2	3,335	2.3	3.4	48.0
Malawi	13.2	118,484	2	667	1.0	15.4	27.0
Congo (Democratic Republic)	58.7	2,344,858	7	714	-	21.3	32.0
Tanzania (United Republic)	38.5	945,203	12	744	5.2/1.7	8.6	17.0
Total/weighted average	226.4	9,294,754	332	3,368	-	6.5	33.1
Total/wt av (excl. S.A.)	178.5	8,073,717	92	1,290	0.4	14.6	49.1
					0.7		

Country	Human Development Index	Life Expect-ancy at Birth (years	Mortality Rate under 5 (per 1,000)	Adult Literacy Rate (%)	School Enroll-ment (%	Electrification Rate (%	Electricity Consumption Per Capita (KWh pa)
South Africa	0.674	51	68	82	77	70	4,818
Namibia	0.650	52	62	85	65	34	1,488
Botswana	0.654	48	120	81	70	39	1,435
Zimbabwe	0.513	41	132	89	52	34	924
Swaziland	0.547	41	160	80	60	*20*	775
Zambia	0.434	41	182	68	61	19	721
Mozambique	0.384	43	145	39	53	6	545
Angola	0.446	42	260	67	26	15	220
Lesotho	0.549	43	132	82	66	11	177
Malawi	0.437	46	125	64	63	7	100
Congo (Democratic Republic)	0.411	46	205	67	34	6	92
Tanzania (United Republic)	0.467	51	122	69	50	11	69
Total/weighted average	0.491	47	148	70	52	24	1,246
Total/wt av (excl. S.A.)	0.442	46	169	66	45	12	287

Sources: UNDP Human Development Report (2008), World Bank data, SAPP Annual Report 2008.
Swaziland elec. rate estimated; excluding Mozal, Mozambique consumption is 64 kWh/capita p.a.
Inflation and exports weighted by GDP, others by population.

2.1.2 Political and security concerns

One of the unique features of SAPP is the history of successful electricity trading despite political and security concerns. The exception is the sabotage of the Cahora Bassa HVDC link to South Africa that interrupted supply for 17 years.

The political isolation of apartheid South Africa and Southern Rhodesia during the decolonization period (1960 to 1990) influenced these countries' drive for self-sufficiency through developing internal generation and their neighbors' drive for reduced power sector dependency. Most of Zambia's hydroelectric capacity, which is at Kafue and Kariba North, was rapidly developed soon after its 1964 independence, thereby removing its inherited vulnerability to dependence on power supplies from Kariba South Power Station located in

Southern Rhodesia. The latter, lacking any major hydroelectric capacity on its internal rivers, was forced to embark on the development of the coal-fired Hwange Power station, which was then completed after Zimbabwe's 1980 independence.

The formation of SADCC in 1980 influenced the development of stronger transmission interconnections between Botswana, Zambia, Zimbabwe and Mozambique, whose objective was to reduce the dependency of the frontline states on South Africa. These were funded by grants or concessionary loans from sympathetic donors. One particular interconnector, the 220 kV line between Botswana and Zimbabwe, was meant to provide Botswana with an alternative to the existing 132 kV line to South Africa. This objective was never fulfilled because the 132 kV link to South Africa continued to provide more reliable and cheaper power for Botswana than could be provided by its northern neighbors.

Politically motivated sabotage of the HVDC line to South Africa reinforced the view that security of supply is derived from internal self-sufficiency. This view is surprisingly strong even in countries like Zimbabwe, where imports have historically provided more secure supplies than internal generation. Notwithstanding the political hostility between Southern Rhodesia and Zambia following the former's unilateral declaration of independence in 1965, reliable power supplies from Zambia continued uninterrupted.

The first government elected on the basis of universal adult suffrage in South Africa inherited significant surplus generating capacity developed during the apartheid years. This provided the basis for a major electrification drive to connect the previously disadvantaged poor sections of the society. By the mid-2000s, without any new major investments being made, the surplus capacity had been used up. South Africa has had to curtail its power exports and resort to load shedding while embarking on an urgent investment program that includes expensive gas turbines to meet peak demand. Countries that had been dependent on South Africa for their power now face significantly increased prices, which are much higher than the cost of their internal generation options.

This checkered history is a major barrier to the development of the significant hydro resources in the northern areas of the SAPP region. The 17-year shut-down of the Cahora Bassa project due to sabotage of the transmission lines remains a vivid warning of security risks. A number of important projects with regional potential are located in countries which have either been at war or have had, and often still have, weak administrations, poor security arrangements and very high risk profiles from the viewpoint of any outside investor (including SAPP utilities considering developing projects jointly in neighboring countries). This applies in particular to the development of projects in the Zambezi Basin involving Zambia, Zimbabwe and Mozambique, and the Inga site on the Congo River in the Democratic Republic of Congo, which with 40,000 MW of hydropower potential is a prime focus for future electricity supplies for the region.

While projects in the countries with large hydropower resources may be least cost in the absence of these factors, the increase in the cost of capital brought about by local instability can be sufficient to turn project economics away from regional trade in favor of self-sufficiency. In the current environment of shortages of power in South Africa, a major thermal project in a stable, well-managed economy (the Mmamabula project in Botswana) is likely to look more attractive as a reliable source of supply than a low-cost hydropower plant in a country which has lived through decades of instability (the Inga project in the DRC) and which also requires a much longer transmission network.[1]

2.2 Supply options

2.2.1 Energy resources

The current generation mix in SAPP is 74.3% coal, 20.1% hydro, 4% nuclear and 1.6% diesel and gas. The coal generation is predominantly in the south (South Africa, Botswana and Zimbabwe) and the hydropower in the north in the Zambezi Basin (Zambia, Zimbabwe, Mozambique and Malawi), Congo and Cunene (Angola and Namibia). The nuclear power station is in the Western Cape, which is far from the coal-fired power plants in the northern and eastern provinces. Most of the diesel power plants are for small isolated rural networks.

Coal-fired plant makes up the bulk of the 42,000 MW of Eskom's installed capacity, and the problems of air pollution and water demand have grown enormously, sophisticated abatement and dry-cooled thermal technologies notwithstanding. South Africa accounts for more than 80% of the total generation in SAPP, and hence coal accounts for three-quarters of the total SAPP generation. Outside South Africa the dominant energy resource is hydropower. The DRC has more than 400 TWh/year of economically exploitable hydropower. Further south, the Zambezi, Cunene and Kwanza river basins have another 100 TWh/year potential.

The currently developed coal and hydropower resources account for 95% of SAPP generation. The remainder of the power generation is based on nuclear and oil and gas, with Angola having some of the continent's largest proven oil resources. The recommended SAPP Pool Plan has an increased role for oil and gas plants for peaking and reserve capacity, hence the projected generation mix for the year 2025 is 56% coal, 26% hydro, 2% nuclear and 22% diesel and gas.

As previously mentioned, one of the main underlying driving forces in SAPP is the concept of supplying future growth in demand in South Africa with environmentally clean hydropower generated in the northern part of the SAPP region. The prime target for hydro development is a unique site on the Congo River, called Inga. This has 40,000 MW of hydro potential in a setting where virtually no civil engineering works would be required and where the environmental impact would be minimal. At present, only 2,468 MW have been installed. There are also significant sites on the Zambezi river, as shown in Table 2.

For the potential hydropower exporters—DRC, Zambia, Zimbabwe and Mozambique—exploiting their electricity potential offers the opportunity to diversify their exports. The once-in-a-century drought in the region in 1991/92 provided a warning that hydropower is

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[1] The capital costs estimated by SAPP are: Mmamabula US$8.0 billion for 2,400 MW, Inga 3 US$3.6 billion for 4,300 MW, WESTCOR US$3.5 billion for 3,500 MW. To deliver power to South Africa, the capital costs of Inga plus WESTCOR are thus US$840 + 1,000 = US$1,840 per kW, as compared with US$3,300 per kW from Mmamabula. In fact, only part of the WESTCOR costs should be counted in such a calculation and in addition, the operations and maintenance (O&M) costs of the hydropower option will be very small, whereas coal-fired Mmamabula will have significant O&M costs.

subject to climatic risks, and countries could expect greater security of supply with shared power resources. This was part of what drove the construction of the 400 kV transmission lines between Zimbabwe and the Matimba power station in South Africa and Cahora Bassa in Mozambique. The Matimba link synchronized the northern power systems with the large Eskom system. The Cahora Bassa link was initially operated at 330 kV, with plans to operate at the designed voltage level when there is need to wheel higher levels of energy, for example, when the north bank power station is built at Cahora Bassa.

Table 2 Significant Hydropower Sites on Congo and Zambezi Rivers

River Basin	Site	Potential (MW)	Installed (MW)
Congo	Inga	40,000	2,468
Zambezi	Batoka Gorge	1,600	
(Zambia/Zimbabwe)	Devil's Gorge	1,240	
	Kariba	2130	1,470
	Mupata	1,200	
	Kafue Gorge	1740	990
	Itezhi tezhi	120	
Zambezi (Mozambique)	Cahora Bassa	3,275	2,075
	Mepanda Uncua	1,780	
	Lupata	654	
	Boroma	444	
Total		54,183	7,003

The intergovernmental and inter-utility agreements behind these developments provided the context of the founding agreements for the Southern African Power Pool, which was created in August 1995.

2.2.2 Current electricity supply

The members of SAPP and their basic operating data are summarized in Table 3. Figures for the year ending March 2007 provide a less distorted picture of the regional power supply situation as subsequent years have been characterized by load shedding in several countries arising from supply constraints due to underinvestment in new capacity.

The statistics show the extent to which the interconnected system is dominated by South Africa, which has around 84% of the installed capacity, maximum demand and energy consumption.

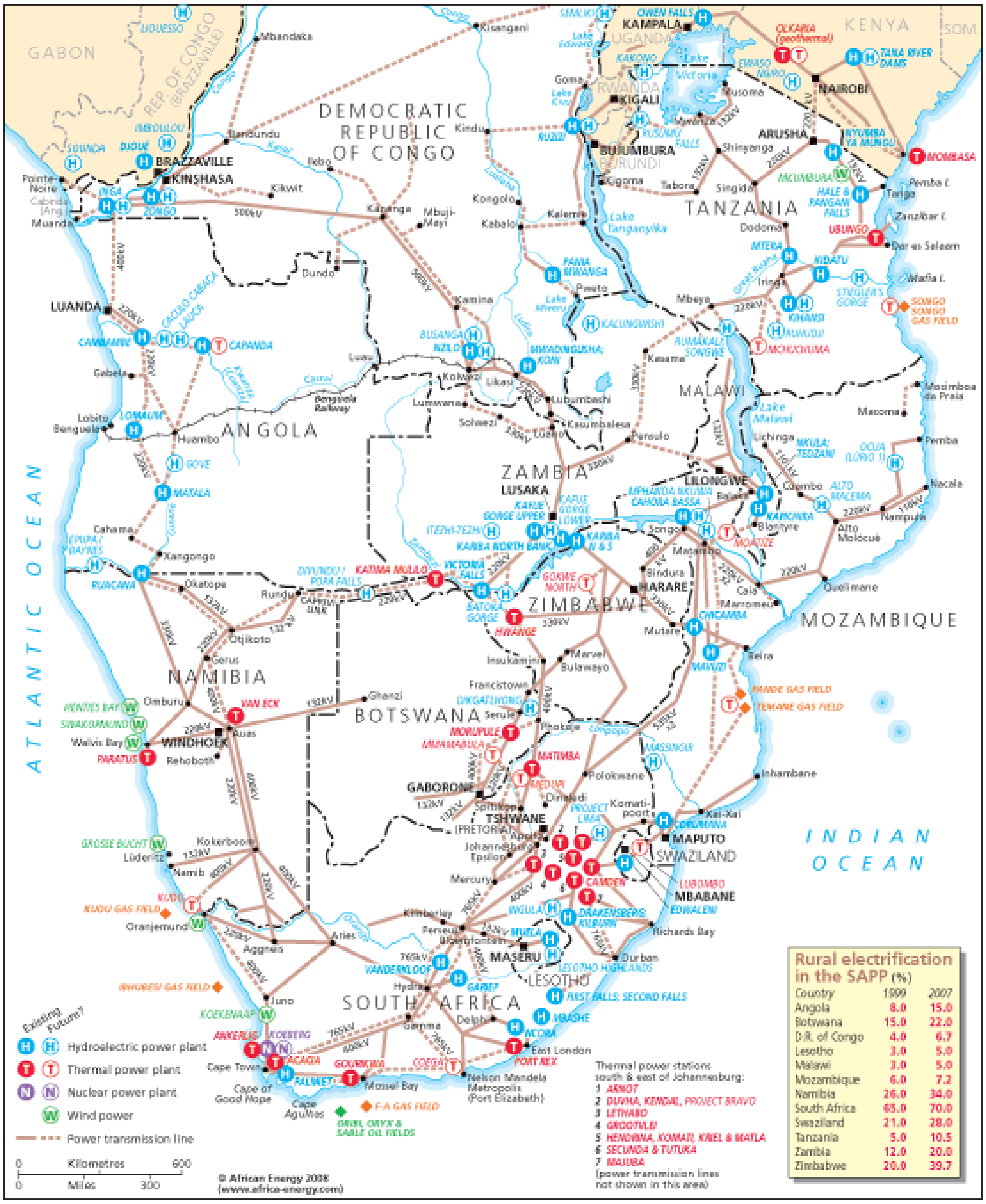
Table 3 Summary of SAPP Members (Year to March 2007)

Country	Utility	Membership Status	Installed Capacity (MW)	Net Capacity (MW)	Max Demand (MW)	Energy Sent Out (GWh)
South Africa	Eskom	operating	42,011	36,398	34,807	221,985
DRC	SNEL	operating	2,442	1,170	1,027	7,214
Mozambique	HCB	IPP	2,075	2,075		15,847
Zimbabwe	ZESA	operating	1,990	1,825	1,904	7,781
Zambia	ZESCO	operating	1,632	1,630	1,393	9,480
Namibia	NamPower	operating	393	390	490	1,606
Mozambique	EDM	operating	233	137	320	222
Botswana	BPC	operating	132	120	434	977
Lesotho	LEC	operating	72	70	101	466
Swaziland	SEB	operating	51	52	188	126
Tanzania	TANESCO	non-operating	897	680	563	3,674
Angola	ENE	non-operating	742	590	476	2,982
Malawi	Escom	non-operating	305	253	251	1,177
Total interconnected			51,031	43,867	40,664	265,704
Total SAPP			52,975	45,390	41,954	273,537
Interconnected % SAPP			96%	97%	97%	97%
S Africa % interconnected			82%	83%	86%	84%

Source: SAPP Coordination Centre. Mozambique demand figure excludes MOZAL. See the Cahora Bassa case study project for further details of the HCB IPP.

The location of generation plant and the national and regional transmission systems are illustrated in Figure 2.

Figure 2 Electricity Generation and Transmission in Southern Africa



SAPP has three control areas, where the nominated system operators (SOs) are Eskom, ZESA and ZESCO. The Eskom control area includes Botswana, Lesotho, Southern Mozambique, Namibia, South Africa, and Swaziland. The ZESA area includes Zimbabwe and Northern Mozambique, and the ZESCO area includes Zambia and DRC. The SOs are responsible for maintaining spinning reserve, frequency control, and system stability in their designated areas. Since the major interconnector between ZESA and Eskom (300 MW) was commissioned in 1995, and the initial system stability problems were overcome, the system has been synchronous.[2] The South African system, due to its size, dominates SAPP and essentially imposes its operational characteristics on the other systems. A sophisticated, dedicated VSAT telecommunications system has recently been installed, but hitherto the SOs have communicated via telephones and the Internet.

2.3 Demand

Power demand in SAPP is dominated by the mining and manufacturing sectors in South Africa and the BLNS countries as well as in DRC, Zambia and Zimbabwe. A renewed focus on significantly increasing household electricity access is also driving electricity demand in the region.

Table 4 provides the most up-to-date and projected maximum demand statistics for SAPP member states. The forecasts for 2015 and 2025 are those used for the current recommended SAPP Pool Plan. The corresponding energy generation and demand figures for SADC as a whole are in the last two rows of the table (in terawatt-hours, that is, thousands of gigawatt-hours).

Table 4 SAPP Demand Projections and Current Capacity

Country	Power Utility	Installed Capacity (April 2009) (MW)	Available Capacity (April 2009) (MW)	Peak Demand (MW)			Average Annual Growth (%)
				2008	2015 Fore-cast	2025 Fore-cast	
Angola	ENE	1,187	930	668	1,657	2,871	9.0
Botswana	BPC	132	90	503	928	1,272	5.6
DRC	SNEL	2,442	1,170	1,028	1,865	2,723	5.9
Lesotho	LEC	72	70	108	165	215	4.1
Malawi	ESCOM	287	267	260	430	629	5.3
Mozam-bique	EDM	233	174	416	793	1,208	6.5
	HCB	2,075	2,075	-	-	-	-
Namibia	NamPower	393	360	430	549	758	3.4
South Africa	Eskom	44,170	40,483	35,959	51,204	75,919	4.5
Swaziland	SEB	71	70	200	271	323	2.9

[2] There had been significant synchronization problems in 1990 when a low-capacity link had been installed between Botswana and Zimbabwe. The higher capacity Matimba link locked in the synchronism.

Country	Power Utility	Installed Capacity (April 2009) (MW)	Available Capacity (April 2009) (MW)	Peak Demand (MW)			Average Annual Growth (%)
				2008	2015 Fore-cast	2025 Fore-cast	
Tanzania	TANESCO	1,008	680	694	1,037	1,566	4.9
Zambia	ZESCO	1,812	1,200	1,604	1,970	2,407	2.4
Zimbabwe	ZESA	2,045	1,080	1,397	2,643	3,674	5.9
SAPP Total Capacity (MW)		55,927	48,649	43,267	63,530	93,565	4.6
Interconnected Grid (MW)		53,445	46,772	41,645	63,530	93,565	4.9
SAPP Generation (TWh)				310	407	599	3.9
SAPP Energy Demand (TWh)				306	403	587	3.9

The base case scenario of the Pool Plan is an aggregation of the individual national plans. The Recommended Pool Plan is one which is designed to meet the same demand as the base case but using a generation and transmission expansion program that is optimized on a regional rather than national basis. The impact of regional cooperation is then evident from the differences in cost between the two scenarios. Alternative scenarios were also developed using lower load forecasts, or introducing constraints such as carbon dioxide emission reductions or compulsory use of defined technologies such as nuclear power generation.

Central to the realization of the recommended Pool Plan is the increased transmission investments required to facilitate large power transfers from areas of low-cost generation in the north to areas of high demand in the south. This involves the acceleration of the interconnection of non-operating members and the strengthening of the central transmission corridor between DRC, through Zambia, Zimbabwe, Mozambique and Botswana to South Africa. Increased voltage levels of 765 kV are recommended for high-voltage alternating current.

Table 5 with information extracted from the Pool Plan shows the level of imports and exports as planned by the individual countries (the base case scenario) and the level of imports and exports that would result from adopting the Pool Plan as the investment program. There are interesting observations in comparing the national and regional plans.

Table 5 National Power Development Plans vs. Optimized Pool Plan

Country	National Plans (Base Case Scenario)			Pool Plan (Recommended Scenario)		
	2006–2025			2006--2025		
	Imports (GWh)	Exports (GWh)	Net Imports	Imports (GWh)	Exports (GWh)	Net Imports
Angola	0	0	0	93,558	0	93,558
Botswana	80,543	5,460	75,083	70,271	10,673	59,598
DRC	2,254	24,517	-22,263	0	191,864	-191,864
Lesotho	2,002	403	1,599	4,279	0	4,279
Malawi	2,142	2,,351	-209	3,200	21,615	-18,415
Mozambique	0	91,421	-91,421	0	222,941	-222,941
Namibia	10,178	12,799	-2,621	25,582	11,061	14,521
South Africa	40,063	62,527	-22,464	277,436	207,813	69,623
Swaziland	26,517	0	26,517	26,515	0	26,515
Tanzania	20,496	0	20,496	38,634	0	38,634
Zambia	16,477	40,079	-23,602	36,318	38,289	-1,971
Zimbabwe	47,593	17,880	29,713	111,334	14,852	96,482
SAPP Total	**248,264**	**257,437**	**-9,173**	**687,125**	**719,108**	**-31,983**
Average per year	12,413	12,872	-459	34,356	35,955	-1,599

Since one country's exports is another country's imports, total SAPP exports should be equal to total imports. The differences are due to system losses expected based on the dispatch assumed for the plan.

Angola's plan does not appear to see any role for SAPP, and yet it is potentially the second-biggest importer. Zimbabwe is shown as potentially the biggest net importer, significantly surpassing Botswana, which is the biggest net importer according to the national plans. Some countries such as Namibia and South Africa see themselves as net exporters when the plan shows them as potentially significant net importers. Zambia plans to be a major net exporter but the plan shows them in a more or less break-even position. Some of the countries that see themselves as major exporters, notably Mozambique and DRC, are shown as grossly underestimating their export potential.

The Pool Plan is an indicative study that is not binding on the member states. It is also limited as an investment tool because of the limitations in the data and assumptions used. The plan is very sensitive to variations in the demand projections and capital and operating costs. The recommended plan is based on load forecasts provided by the individual utilities, which vary widely over the planning horizon from 2.4% to 9% per annum, this variation being due to assumptions about load growth which are evidently not consistent across the countries. Information on different generation options is also of questionable quality—some projects have had full feasibility studies, while many only have pre-feasibility or educated guesses as the basis of feasibility and cost. Some generation options are even based on speculative energy resources such as coal-bed methane.

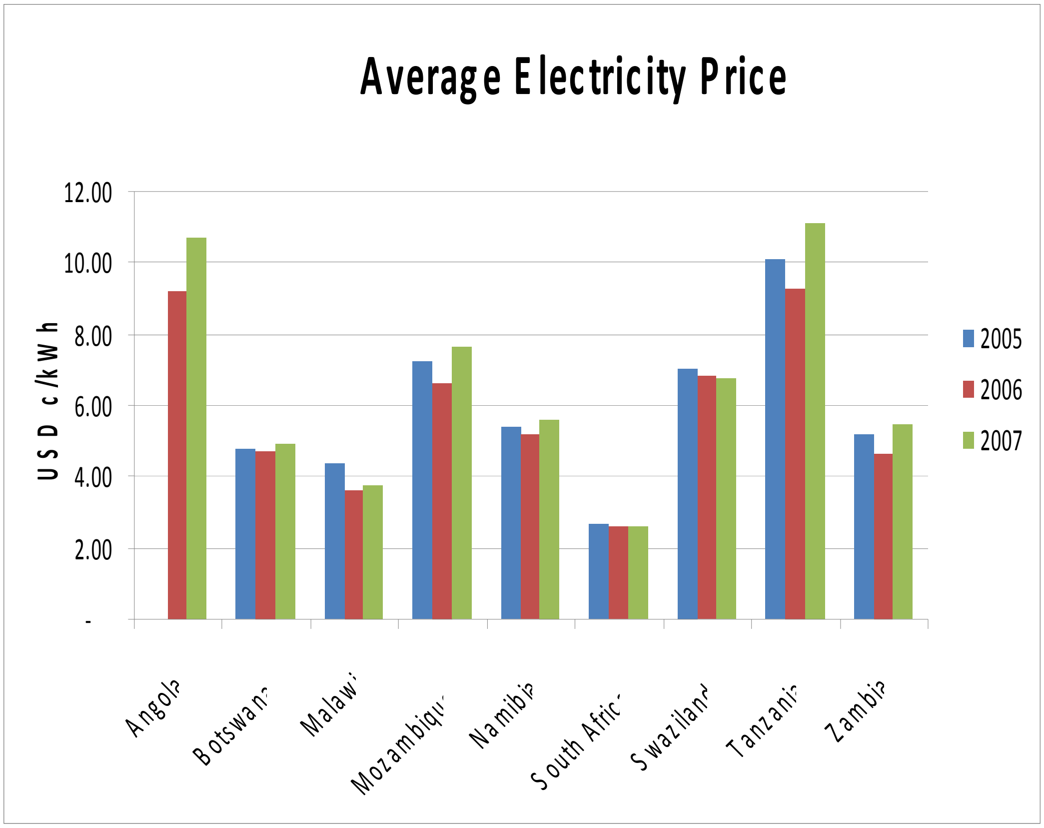
However, SAPP recognizes that the Pool Plan can be a very important document if used in an iterative process to guide the review of national plans, which in turn will provide more reliable data for a review of the Pool Plan. The plan will therefore be used as a tool to educate the energy ministers and other policymakers on the benefits of regional cooperation. Countries are then expected to review the degree of self-sufficiency and other national policies in order to realize the full benefits predicted by the Pool Plan. Through this process some national projects that are already on the list being presented to investors can be deferred. If not, at least the countries will be aware of the premium they will be imposing on their electricity consumers for the degree of self-sufficiency that is chosen.

2.4 Energy tariffs

Historically the interconnected SAPP member countries have enjoyed low average electricity prices by world standards. This is due to the fact that the capital costs of the main SAPP grid infrastructure have largely been paid for. A recent study by the Regional Electricity Regulators Association show average tariffs ranging from less than 4 USc/kWh (South Africa and Malawi), to between 4 and 7 USc/kWh (Botswana, Mozambique, Namibia, Swaziland and Zambia), and above 8 USc/kWh (Angola and Tanzania) (see Figure 3). The highest prices are those in two of the countries not yet interconnected to the grid.

Zimbabwe was not included in the study since the hyperinflationary conditions at the time of the study effectively meant that electricity was being provided free in US dollar terms. Since the country abandoned the Zimbabwe dollar and adopted stable currencies, its electricity prices have been set at an average of 7 USc/kWh.

Figure 3 SAPP Electricity Prices 2005–2007



A general weakness in the historical cost-based pricing structure in the region has been to discourage new investments. Most of the new coal and hydro in the recommended Pool Plan are estimated to average 7.5 to 8 USc/kWh. Gas turbine plants for peaking purposes average 22 USc/kWh. In contrast, in 2008 Eskom's average cost of electricity sold was 2.27 USc/kWh and its average selling price was 2.33 USc/kWh. Sales of electricity to neighboring countries were at an even lower average price of 1.70 USc/kWh.[3] This is the reason why potential regional projects oriented to supplying South Africa have so far not been able to compete with Eskom's extremely low cost structure.

With large investments now being planned, Eskom's costs and tariffs must rise significantly in the future in real terms. As a quasi-public enterprise, Eskom's cost of capital will be low, while other countries will have to look to foreign private investors to provide capital for major investment projects. This can result in a distorted cost of capital in favor of domestic projects in the south rather than potential export-oriented hydro plants in the north. This situation provides a strong argument for using long-run marginal costs (LRMC) as an energy policy instrument in all countries belonging to a power pool.

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[3] Calculated from rand data in the Eskom Holdings Limited Annual Report 2008, page 220. The report notes that the South Africa "government wanted to bring independent power producers into the market. Eskom's low prices, however, dissuaded independent power producers from investing in the power generation sector" (page 46).

In addition to charging long-run marginal cost–based pricing, it is also important that the historic poor financial performance of the utilities is addressed in order to attract private-sector investment. SAPP reports of financial performance of its members show low or negative rates of return and poor revenue collection performance for most of the utilities. Tariff studies by SAPP and RERA show that most of the utilities have hitherto survived as ongoing concerns only on the basis of direct and indirect subsidies from the taxpayer.

3 History of scheme

3.1 Overview including timeline/chronology

The roots of SAPP extend back to the pre-independence period, when the former colonial powers in the different countries developed significant generation and transmission projects that are now the backbone of the regional grid. Table 6 highlights some of the significant historical events that contributed to the creation and development of the power pool.

Table 6 Chronology of Regional Power Integration in Southern Africa

Year	Event
1906	Victoria Falls Company is set up with intention to supply power to South Africa.
1910	Union of South Africa established as a self-governing dominion within the British Commonwealth; beginning of South Africa's development as the regional economic power.
1953	Federation of Rhodesia and Nyasaland established with a plan to create a new self-governing dominion of Central Africa.
1955	Federal Power Board launches Kariba hydroelectric project.
1956	220 kV line constructed between Northern Rhodesia and Katanga province in Congo.
1959	Kariba Dam wall is completed (construction started in 1955).
1960	Kariba South Power Station (666 MW) feeds 330 kV CAPCO grid for Northern & Southern Rhodesia.
1963	Federal Power Board reconstituted as Central African Power Corporation jointly owned by Northern and Southern Rhodesia (Zambia and Zimbabwe).
1964	Zambia and Malawi independence
1965	Rhodesia unilateral declaration of independence
1971	First unit at Kafue Gorge (Zambia); by 1973, 600 MW (later increased to 900 MW)
1975	Mozambique independence and completion of Cahora Bassa dam
1977–1978	Commissioning of the Hidroeléctrica de Cahora Bassa (HCB) turbines
1977	Kariba North power station completed (Zambia side of Kariba).
1980	Zimbabwe independence; SADCC formed.
1981	Cahora Bassa HVDC transmission lines put out of operation by sabotage during the civil war in Mozambique.

Year	Event
1987	CAPCO reconstituted as ZRA; joint electricity infrastructure taken over by ZESCO and ZESA.
1990	SADCC Electricity Subcommittee established; Namibia independence.
1991/2	Regional drought of once-in-a-century severity; tripartite agreement for wheeling of power from DRC to Zimbabwe through Zambia.
1992	SADCC reconstituted as SADC.
1994	First democratically elected government in South Africa
1995	Formation of the Southern African Power Pool (SAPP); initial focus on trading of excess generation capacity available in the region based on ongoing transmission projects
1996	Completion of 400 kV line between Matimba and ZESA; significant exports of Eskom power to Zimbabwe commences.
1997	Completion of 400 kV line between HCB and ZESA; export of Cahora Bassa power to Zimbabwe commences, wheeling the power through EDM power line in Mozambique.
1998	New HCB-Eskom tariff agreement and resumption of electricity exports to South Africa
1998	400 kV interconnector is built between South Africa, Swaziland and Mozambique (MOTRACO, primarily to supply MOZAL aluminium smelter at Maputo).
2000	SAPP Coordination Centre is established in Harare.
2001	Short Term Energy Market (STEM) commences operation.
2002	Regional Electricity Regulatory Association of Southern Africa (RERA) is established (Secretariat is located in Namibia).
2007	Emergence of regional shortage of generation capacity
2008	Emergency plans launched to deal with regional shortage.
2009	Day-Ahead Market (DAM) due to commence operations.

The idea of power trade within southern Africa stretches back as far as 1906 when the Victoria Falls Power Company was registered in Southern Rhodesia “to harness the Victoria Falls and supply electricity to the mining industry on the Witwatersrand" in South Africa. This was a vision that could not be realized at the time because the technology to transmit power over the long distances from the Zambezi to the South African mines did not exist. The transmission of power from the Zambezi to the Witwatersrand had to wait until the 1970s, when Cahora Bassa was built.

The demand of the mining industry in Southern Africa, and the subsequent industrial development around the industry, explain the significantly higher level of power generation and transmission development in this part of the world compared to the rest of sub-Saharan

Africa. The abundant coal resources in South Africa provided power to the mines in the Witwatersrand. In the Federation of Rhodesia and Nyasaland, the Kariba hydroelectric scheme was developed to supply the Northern Rhodesian (Zambian) Copperbelt and the mines and industry in Southern Rhodesia (Zimbabwe).

The Kariba scheme was the first significant grid interconnection involving the construction of the Kariba Dam and 666 MW power station complex on the south bank (1955–1959) and the installation of 330 kV power lines providing a high-voltage backbone to the electricity systems of the two countries sharing the Zambezi River border on which the dam was built. Following the break-up of the Federation of Rhodesia and Nyasaland in 1963 and Zambia's independence in 1964, the 900 MW Kafue Gorge power station and the 600 MW Kariba North power station were developed with support from the World Bank and friendly countries that supported Zambia's desire for self-sufficiency. By the late 1970s it was Rhodesia that now depended on its northern neighbor for power imports.

In the Belgian Congo, the Inga hydroelectric scheme on the Congo River supplied the Katanga Copperbelt via an HVDC line. Through a 220 kV interconnection built in 1956 with its southern neighbor, Zambia, the Inga line also served as a back-up for the Zambian Copperbelt. Subsequently this link provided a backup for the Zimbabwe and SAPP grids through the first tripartite agreement to allow third-party transmission access. Zimbabwe and Congo negotiated the power purchase agreement and Zambia agreed to wheel the power for a fee. The experience with this arrangement provided useful lessons for the power transmission and wheeling studies.

Further south, the grids of Botswana, Lesotho, Swaziland and Namibia were developed as offshoots of the South African grid.

In the late 1960s, the Portuguese colonial regime in Mozambique began investigations into the development of a major power complex downstream of Kariba, at Cahora Bassa on the Zambezi. The only market large enough for the proposed 2,075 MW station was South Africa. Eskom and other South African companies were heavily involved in the planning and execution of the project, which was completed over the period 1969 to 1978. By the time that the last turbines were commissioned, Mozambique was embroiled in a civil war and the 1,360 km HVDC power line was put out of operation by sabotage attacks in 1981. The line was only restored to full operation 17 years later in 1998.

Having survived the liberation struggle that put Zambia and Rhodesia on different sides, the joint company that was set up in the 1950s to manage the Kariba complex, the Central African Power Corporation (CAPCO), was dissolved in 1987 and re-constituted as the Zambezi River Authority (ZRA), which is focused on the maintenance of the Kariba Dam complex and regulation of the shared water resources of the Zambezi. CAPCO's generation and transmission functions in the respective countries were taken over by the national power utilities, ZESA in Zimbabwe and ZESCO in Zambia.

The formal process of establishing a power pool started with the establishment of the Southern African Development Coordination Conference (SADCC) in 1980. Angola was given the responsibility of spearheading the integration of the region's energy sector. A Technical and Administrative Unit (TAU) based in Luanda assisted the government of Angola with this responsibility. The TAU organized regular meetings of SADC energy ministers and officials, out of which resolutions and action plans for facilitating regional energy integration were agreed upon. One of these resolutions was the creation of an electricity subcommittee which first met at the SADC energy ministers meeting held in Harare in 1990. The subcommittee comprised the national utilities of the member countries and acted as technical advisers to the energy officials and ministers on issues relating to enhancing cooperation in the electricity sector.

The utilities embraced the opportunity and resolved to fund their own meetings so that they could meet as frequently as they wished, without the constraints of donor funding. Consequently the utilities organized another meeting later that year in Windhoek in the newly independent republic of Namibia, at which Eskom was invited to participate. All the utilities realized at the outset that no significant progress in developing a regional power pool could be made without involving the largest power market in southern Africa, on which several of the SADC members were already dependent. While South Africa was still not eligible to formally participate in SADC meetings, the technical nature of the Electricity Subcommittee provided a convenient loophole to allow the participation of its national utility.

The drive toward greater regional cooperation in southern Africa received an unlikely boost from the extreme drought in 1991–1992, which severely affected hydropower production in the Zambezi basin, leading to economically and socially disruptive load shedding in Zimbabwe and Zambia. This is the event that led to the first tripartite agreement between Zimbabwe, Zambia and the Democratic Republic of the Congo (DRC) to source power from DRC for supply to Zimbabwe.

The drought also expedited plans for the interconnection projects to connect Zimbabwe to the South African grid and to the Cahora Bassa power station. The interconnections allowed the drought-resistant coal-fired capacity of South Africa to provide backup for this and future droughts. These projects had been conceived in the late 1980s following the realization by ZESA that it would have to build interconnectors to import electricity to tide it over while it tried to resuscitate Zimbabwe's long-delayed domestic generation projects.

The dismantling of apartheid in South Africa was another fortuitous event that removed the political constraints on South Africa's participation in regional activities. The SADCC was therefore transformed to the SADC in 1992, as one of the original objectives of lessening dependency on South Africa became redundant. This allowed formal tripartite intergovernmental and inter-utility agreements to be signed between Mozambique, South Africa, and Zimbabwe for the Cahora Bassa interconnector and between Botswana, South Africa, and Zimbabwe for the Matimba interconnector. On the basis of these agreements, funding was rapidly arranged to build the 400 kV transmission lines from the Zimbabwe system to South Africa via Botswana (commissioned in 1996) and to Cahora Bassa (commissioned in 1997).

One year later, a 400 kV interconnector between South Africa, Swaziland and Mozambique was constructed to provide power to the aluminium smelter project MOZAL (1998). A special-purpose transmission company, called MOTRACO, was established for this. With all of the raw material being imported, the MOZAL project involves toll refining. What is being exported is the cheap electricity which South Africa and Mozambique are able to supply. At the time the MOZAL project was commissioned, the SAPP region had excess electricity generation capacity. That slack has since been taken up by growth in demand, and the region is now beset by shortages.

The explorative work of the national electricity utilities through the Electricity Subcommittee took advantage of these various intergovernmental and inter-utility agreements to create similar documents as the founding agreements for the power pool. This paved the way for SAPP to be formed within a year of South Africa's first democratic elections, which took place in 1994. SAPP itself was created in August 1995.

The formal establishment of SAPP was not expected to lead to an immediate increase in trading among members. It was appreciated that this was only an institutional framework to begin the serious work of translating the vision of regional cooperation into reality. STEM was only introduced in 2001 because there was need for member countries to complete studies on wheeling charges. The more sophisticated DAM market was only being introduced in 2009 because members needed to thoroughly understand the financial, operational and other impacts of moving from cooperative to competitive transactions.

3.2 Project concept, objectives, and development

As a creation of SADC, SAPP's principal purpose was the practical realization of the region's political agenda of regional economic integration. Consistent with this political commitment to regional cooperation, and following the adoption of the SADC Protocol on Energy in August 1996, SAPP has enunciated the following vision and objectives:

Vision

The Southern African Power Pool will:

- Facilitate the development of a competitive electricity market in the SADC region.
- Give the end user a choice of electricity supplier.
- Ensure that the southern African region is the region of choice for investment by energy intensive users.
- Ensure sustainable energy developments through sound economic, environmental and social practices.

Objectives

The Southern African Power Pool aims to:

- Provide a forum for the development of a world class, robust, safe, efficient, reliable and stable interconnected electrical system in the southern African region.
- Co-ordinate and enforce common regional standards of Quality of Supply; measurement and monitoring of systems performance.
- Harmonize relationships between member utilities.

- o Facilitate the development of regional expertise through training programs and research.
- o Increase power accessibility in rural communities.
- o Implement strategies in support of sustainable development priorities.

It is significant that the immediate objectives are cooperative in character, while the longer term vision contains more challenging goals, in particular the creation of a competitive regional electricity market. This is mirrored by the fact that the founders launched SAPP as a “cooperative pool” by which they intended that the members would be willing to share information on costs and benefits for the purpose of establishing prices. The price at which trade would take place would, in the simplest case, mean the midpoint between the marginal or average cost of the exporter and the avoided cost of the importer. These were the principles embedded in the bilateral and multilateral agreements already in existence.

Recognizing that there was a worldwide trend toward the restructuring of the electricity supply industry, moving from state-owned vertically integrated monopolies to an unbundled industry designed to allow greater private sector participation, the SAPP founders decided that in due course the organization would have to move to a “competitive pool” where prices would be determined on the basis of a free market. In such a market only the prices would be known, and those requiring power would purchase from the supplier with the lowest prices.

While the SAPP objectives include increasing electricity access for rural communities, SAPP has so far been focused on extra-high voltage transmission interconnections. This should not preclude emulating other regional power organizations such as the West African Power Pool (WAPP), which actively promotes cross-border distribution interconnections that directly benefit rural communities.

3.3 Feasibility studies done

There was no formal feasibility study done to determine whether to establish the power pool and if so what form it would take. Once the member states decided that there would be greater regional cooperation in the energy sector they created specialized subcommittees of technical experts from each country to work out the practical details. That is how the Electricity Subcommittee of the SADCC energy sector came to be constituted in 1990 from the national utilities.

The necessary studies and investigations for establishing the Power Pool were undertaken by the utilities. These comprised a desk study of existing bilateral and multilateral electricity interconnection agreements and study visits to North America and Europe to learn from the established power pools. Once established, SAPP identified priority areas where various studies came to be commissioned, with financial support being provided by a number of donors. The details are given in Section 4.4.

Because the initial focus was to facilitate the sharing of the excess generation capacity that was then available when SAPP was created in 1995, the priority was to establish a synchronous grid from South Africa to DRC. Danish support for a study to solve the initial teething problems encountered in synchronizing the grid was critical to the success of this endeavor.

The next early problem was to facilitate the creation of a short-term energy market (STEM) through generally agreed wheeling charges. Once the wheeling study was completed and approved, the market was launched in 2001. The system adopted was based on the amount of power and distance of the buyer from the supplier—the MW-km method. The wheeling study anticipated the need for a review of this simple system to facilitate more competitive trading. This is what has now been done in planning for the Day-Ahead Market (DAM), which is replacing STEM.

Although it was intuitively known that optimizing the generation and transmission expansion planning on a regional basis would be less costly than uncoordinated national plans, there was no formal study to quantify the benefits until the USAID-funded research project carried out by SAPP with assistance from Purdue University over the period 1997–2002. Short-term and long-term models of the interconnected system in southern Africa were developed, and scenarios were developed of different ways of meeting projected energy demand. These ranged from noncooperative solutions to full regional integration with a single market and a single system operator. Intermediate solutions were obtained by introducing "autonomy factor" constraints (either on the extent to which energy needs had to be met domestically—a more demanding requirement—or on the proportion of peak demand which had to be backed by domestic capacity).

As power pool theory predicts, the results showed that there were gains from trade in the short run, but much larger gains to be obtained in the long run from co-ordinating electricity investments (on the order of US$100 million per annum from short-run optimization of regional opportunities to US$1.5 billion in net present value of investment savings). The summary of the revised Pool Plan by Nexant given in Sections 2.3 and 3.4 provides updated figures of savings of US$48 billion (US$8.7 billion in present value terms) for the recommended regional plan. The fact that the investments in the 2001 SAPP Pool Plan were not made in time has led to a situation where utilities are now scrambling to fill the gap in the electricity generation requirements. In such circumstances, projects which are not least cost from a regional viewpoint are being advanced, thereby negating the large net benefits that regional power sector integration was slated to deliver.

3.4 Assets built and planned resulting (directly and indirectly) from scheme itself

SAPP's role in the planning and building of assets has largely been advisory. The SAPP Pool Plan provides the framework for regional investments, but the final decision of the assets to be built is made by the member states. Since the emergence of the current power generation shortfalls, SAPP's advice on investment has been taken more seriously than before. At a meeting in Botswana in February 2008 a SADC Energy Ministerial Task Force established to address the power generation emergency adopted the following initiatives proposed by the SAPP Executive Committee and RERA:

- Formulation and implementation of a SADC program for power conservation and energy efficiency;

- Fast tracking the rehabilitation projects for existing power stations;
- Creation of enabling environment to improve the financial viability of the power utilities so that they could be able to undertake projects for expansion of interconnections and addition of new generation plants.

Tables 7 and 8 list the generation projects commissioned in 2008 (1,442 MW) and those intended to be completed during 2009 (2,266 MW).

Table 7 SAPP Generation Projects Commissioned in 2008

Country	Utility	Plant Name	Type	Capacity (MW)	Comment
South Africa	Eskom	Camden	Coal	380	Demothball
		Grootvlei	Coal	380	Demothball
		Komati	Coal	202	Demothball
Swaziland	SEB	Maguga	Hydro	20	
Tanzania	TANESCO	Ubungo	Gas	100	
Zambia	ZESCO	Kafue Gorge	Hydro	60	Uprating
Zimbabwe	ZESA	Hwange	Coal	300	Rehabilitate
TOTAL				**1,442**	

Table 8 SAPP Generation Projects to Be Commissioned in 2009

Country	Utility	Plant Name	Type	Capacity (MW)	Comment
Angola	ENE	Lobito	Oil	83	
DRC	SNEL	Inga 1	Hydro	85	Rehabilitate
		Inga 2	Hydro	160	Rehabilitate
Malawi	ESCOM	Kapichira	Hydro	64	Rehabilitate
South Africa	Eskom	OCGT	Gas	1,050	New
		Grootvlei	Coal	565	Demothball
		Komati	Coal	114	Demothball

Tanzania	TANESCO	Tegeta	Gas	45	
Zambia	ZESCO	Kariba North	Hydro	30	Uprating
Zimbabwe	ZESA	Hwange	Coal	100	Rehabilitate
TOTAL				**2,266**	

On the transmission side, the most significant transmission project to be initiated and completed as a result of the cooperation opportunities identified through SAPP is the Zambia-Namibia 220 kV interconnector commissioned in March 2008. It is a 231 km line built for US$39 million which links Victoria Falls Power Station in Zambia and Katima Mlilo in Namibia.

Another line, rated at 400 kV, is codenamed ZIZABONA and will link Zimbabwe, Zambia, Botswana and Namibia. A significant development is the appointment of SAPP as project coordinator for ZIZABONA. This project follows another successful collaboration between NamPower and Zesa in which the former provided US$40 million funding for the rehabilitation of Hwange Power Station in return for having a power purchase agreement for 150 MW of firm power for at least five years. The framework provided by SAPP facilitated the negotiation of this agreement.

Priority transmission projects that have been planned for a long time but which have not yet been implemented are:

- Mozambique–Malawi 220 kV interconnector, to link Malawi to SAPP;
- Zambia-Tanzania-Kenya, 330 kV to link Tanzania to SAPP; this would also link SAPP to EAPP (East African Power Pool);
- Western Corridor transmission project—WESTCOR—comprises 3,000 km of transmission lines to wheel 3,500 MW of power from Inga on the Congo River through Angola and right down into South Africa. WESTCOR is also targeted at the hydropower potential of the Kuanza basin in Angola (6,700 MW).

The revised Pool Plan is the most significant SAPP study to identify the generation and transmission assets that need to be developed to facilitate least-cost regional system development. The recommended scenario for the Pool Plan is one involving adding a total of 57,000 MW of generation capacity at an estimated total cost of US$83 billion by 2025 (in undiscounted terms). This is $48 billion less than the alternative scenario where each country pursues its own power development plan, with Eskom having a strong commitment to nuclear power generation (18,700 MW of nuclear by 2025).[4]

The corresponding transmission projects to realize the Pool benefits would cost around US$6 billion, comprising interconnection of the non-operating countries of Angola, Malawi

[4] The recommended case in Nexant (2009) is the Revised Alternative ScenarioA1 with CO_2 price at zero. The reference scenario referred to is the Updated Base Case B1.

and Tanzania and the strengthening of the central transmission corridor (CTC). A special-purpose company is already being set up to fund and implement the central transmission corridor projects.

3.5 Interconnections and electricity trade

3.5.1 Electricity trade data

Electricity trade in SAPP has always been dominated by bilateral contracts, which amount to around 15,000 to 20,000 GWh per year. The short-term energy market, STEM, introduced in April 2001, and which operated to 2007, accounted for only 5% to 10% of energy traded.

The data for 2005 in Table 9 indicate a typical year's trading when STEM was operational. The table shows that 99% of the energy traded was via bilateral contracts. It also shows that in 2005 trade was itself a very small portion of total energy sent out (7%). Annual demand in the STEM market rose from 766 GWh in 2001 to 4,222 GWh in 2004, while supply was around 2,550 GWh and lower than this in 2005 when some utilities withdrew from STEM. Energy actually traded was far lower, however, with a peak of 842 GWh in 2002, which dropped to 178 GWh in 2005, 226 GWh in 2006, and 68 GWh in 2007. Average prices ranged from about 0.4 USc/kWh in the early years, rising to just under 1.6 USc/kWh by 2006 before dropping off to about 1 USc/kWh in 2007 when the emergence of a regional power deficit effectively killed STEM .

Table 9 SAPP Electricity Trade in 2005

Country	Utility	Bilateral Contracts (MW)	Energy Traded 2005 (GWh)
South Africa	Eskom	1,706	10,417
Mozambique	HCB	1,620	4,515
DRC	SNEL	260	1,470
Zambia	ZESCO	80	280
STEM	5 utilities		178
Trade		3,666	16,860
Total on inter-connected system		39,341	255,910
Trade % total		9%	7%
STEM % total trade			1%

Maximum STEM trade 842 GWh in 2002 at an average price of around 0.4 USc/kWh. Price rose to 1.2 USc/kWh in 2005

3.5.2 Electricity market development

The Short-Term Energy Market (STEM) was introduced in 2001 and operated until 2007. Operated by the SADC Coordination Centre, STEM was introduced to provide a market for the surplus power not covered by bilateral contracts. It was restricted to power utilities only and was designed as a precursor to full competition. Buyers and traders were matched and traded at the sellers' offer prices.

Bids and offers were made via an Internet platform. The Coordination Centre checked capacity on the interconnected transmission lines, matched demands and offers, and confirmed the successful contracts. It also published (within four hours of the initial 10:30 a.m. cutoff) a "bulletin board" giving details of all the demands and offers made. This resulted in trade being expanded on a bilateral basis in a "post-STEM" market which typically accounted for 30% of the short-term energy traded.

When considering bids, precedence was given to established bilateral contracts. Irrespective of actual power flows in the system, which may in practice have involved "swap" arrangements, wheeling charges in STEM contracts were designed to encourage trading using lines designed for domestic purposes. This involved a simple addition of a rental charge and compensation for incremental losses for wheeling over the distance between the contractual source and destination, whereas in practice swap arrangements would mean that power flows would often much traverse smaller distances. The STEM wheeling formula thus would often overestimate actual wheeling charges. In the STEM system, these costs were shared equally among the countries lying on the assumed wheeling path.

A fundamental problem was that the market was not sufficiently competitive. Demand almost always outstripped supply in the STEM market because trading was biased against the suppliers. A buyer could offer a price higher than that offered by the seller but the sellers did not benefit as trading was established at the seller's price. Another reason was reduced flexibility due to bilateral agreements, which took precedence notwithstanding opportunities for more efficient system dispatch.

From 2003, SAPP began investigating the introduction of a more competitive market in the form of a Day-Ahead Market (DAM). Five years later, the DAM trading platform had been installed and was ready to go live by the end of 2009. This is an auction market that is open to utilities, independent power producers, transmitters and distributors, in line with the opening up of membership beyond the founding vertically integrated utilities.

The DAM is expected to start off with the same 5 to 10% of the market as was the case with STEM. The dominance of long-term bilateral contracts is a characteristic of all electricity markets where there is a need to develop infrastructure. Bilateral contracts provide the predictable cash flows that allow projects to be funded. The bilateral contracts do not eliminate market competitiveness altogether if the market is operated for maximum efficiency, and separate arrangements are entered into between market participants to deal with differences between specific market conditions and bilateral contracts. This is the philosophy behind the introduction of the DAM.

Unlike in STEM, where individual buyers and sellers were matched, in the DAM trading is with a market operator, the SAPP Coordination Centre in this case, which matches total bids and offers to establish a market-clearing price that is used to settle transactions. This is a simplified model of the pool pricing used in the UK and Nordic markets. This means that the generators are all paid the same pool price determined by the marginal cost of the last plant dispatched to meet demand in each hour or half hour. Forward bidding for up to 10 days will be allowed.

As part of the development of the DAM, comprehensive studies have been undertaken to introduce a more appropriate transmission pricing system than the simple MW-km approach used for STEM. In the MW-km method the buyer pays a wheeling charge that is dependent on the contractual distance from the supplier. The further a buyer is from the source, the more expensive the wheeling charge. This restricts trade to those closer to the generation sources and does not address congestion problems. The new approach is a zonal or nodal investment cost-related pricing system which is nondiscriminatory for all users in the zone. Instead of point-to-point charges, there are entry and exit network charges and wheeling loss charges based on nodal loss factors. A single system-wide transmission charge is used when there is no congestion, but local area or zone prices are used if the market has to be split to avoid transmission congestion. Relating charges to investment costs sends the appropriate market signals to promote new transmission capacity development when needed to relieve persistent congestion.[5]

Successful DAM trials have been held and 32 traders have been trained. The DAM platform is very demanding of data from the participating utilities, and improvements in the speed with which data can be exchanged via the Internet or by e-mail have to be made before the system can go live. An independent Market Surveillance Committee for market oversight and audit, including dispute resolution, also needs to be in place. Relevant governance documents need to be signed by all members. An important requirement is that only the market operator and participants know their individual bids and offers, but everyone else only knows the market-clearing prices after they have been published.

The DAM trading system will continue on a trial basis until full operation commences, which was expected before the end of 2009. Thereafter, the SAPP Coordination Centre will publish monthly summaries of market performance results. With time, it is expected that DAM prices will be used as a reference for negotiating bilateral contract prices.

Once the DAM is established, the market operator will also need an Ancillary Services Market and a Balancing Market in order to ensure reliable system operation. These services can be provided by sellers or buyers. Examples of ancillary services are frequency and voltage control, black start or emergency support for continuity of supply. The Balancing Market provides services to re-dispatch the system to deal with network constraints and losses. The costs for these services are recovered from all market participants.

3.5.3 Importance of electricity trade for individual countries

The comparison of the national plans and the recommended Pool Plan in Table 5 (Section 2.3) provides an indication of the relative importance that individual countries attach to electricity trading. Some countries such as Botswana, Lesotho, Swaziland, Tanzania and Zimbabwe plan to be net importers. DRC, Malawi, Mozambique, Namibia, South Africa, and Zambia plan to be net exporters. Given the SAPP priority plan to interconnect non-operating members, it is not clear why Angola's national plan did not provide for any

[5] The two transmission charging schemes are described in more detail in Section 5.3.

trading with other countries. There is a discernible bias at the national level toward self-sufficiency, or better still toward being a net exporter.

For importing countries, the gains would be rather modest when it is a question of buying electricity more cheaply from STEM or DAM than producing it from existing domestic generation capacity. The economic gains would typically be very significant when it is a question of importing to avoid brownouts or blackouts. This is because the cost of unserved energy is always many multiples of the tariff. Eskom, for example, in its 10th Integrated Strategic Electricity Plan estimated the cost of unserved energy at around 300 US cents/kWh. From this viewpoint, besides South Africa's access to cheap Cahora Bassa power, the largest beneficiary of regional electricity trade has been Zimbabwe, which has been a significant importer of electricity since pre-SAPP days. The pool plan sees Zimbabwe continuing to be the biggest power importer for the foreseeable future, partly due to its strategic position at the center of the SAPP grid, and partly due to its internal political crisis that is likely to make it difficult to attract funding for new major power generation investments.

Until 1997, Zimbabwe had an excellent payment record for imports and for all its external obligations in general. This created a win-win situation where exporters were competing to provide favorable prices in exchange for the predictable revenue from a creditworthy customer. For ZESCO and SNEL, ZESA was their most valuable customer because collection of revenue from their major domestic customers on the Copperbelt suffered from political interference. Since the country's self-inflicted economic crisis, which began around the year 2000, Zimbabwe has had increasing difficulty in making payments to its suppliers for electricity imports, while its own internal electricity production has collapsed due to flight of skills and lack of resources for maintenance of plant.

Punitive prices have in some cases been imposed by Zimbabwe's suppliers, influencing a more inward-looking national plan with net imports that are less than a third of what the regional plan recommends. However, it is notable that despite periods of nonpayment, the external suppliers have continued to provide electricity, this being remarkable testimony to the security of regional arrangements. Reduction in external electricity supplies to Zimbabwe has largely been due to the generation constraints by the supplying countries rather than due to Zimbabwe's poor payment record.

Countries which have a longer history than Zimbabwe of being electricity importers are the BLNS states. This is shown by the data in Table 3 in Section 2.2, which shows the BLNS countries (as well as Zimbabwe) did not have sufficient internal capacity to meet maximum demand. As of 2005, a large portion of the shortfall was supplied by firm energy exports by Eskom. Since the emergence of the regional shortfall, Eskom has declined to renew firm energy contracts when they come up for renewal. This has forced the countries which in the past have relied on South African electricity to rapidly diversify their sources of supply. Namibia particularly stands out as a country which has successfully done this, in part through the interconnections to Zambia and the innovative arrangement with ZESA, involving payment for rehabilitation work at Hwange in return for a favorable firm power contract (mentioned previously in Section 3.4).[6]

[6] It is somewhat ironic to reflect on NamPower's recent investment in Zimbabwe in that an earlier proposal had been made in the 1990s by NamPower to have ZESA participate in the Kudu gas project, an idea that was

Mozambique is another country for which trade in electricity and wheeling of power through neighboring countries is crucial. In Mozambique, the generation capacity of the national utility, Electricidade de Moçambique (EDM), is not sufficient to meet internal demand, but EDM purchases power to meet the country's needs from HCB. This is delivered both via direct 220 kV links to central and northern Mozambique and in southern Mozambique (Maputo) via a buy-back arrangement with Eskom, which receives the bulk of HCB power via the HVDC transmission lines which terminate at a substation just outside of Pretoria. Electricity is also supplied by Eskom via MOTRACO to the aluminium smelter MOZAL. The annual volume is approximately 6,600 GWh. This is more than twice the energy supplied to the rest of the country (2,880 GWh in 2008).

3.6 Environmental and social issues

3.6.1 SAPP Environment Committee

SAPP started off with two subcommittees, Operating and Planning. The environment subcommittee was the next to be created when it was recognized that mitigation of adverse environmental and social impacts was integral to successful implementation of plans. The Environment subcommittee has undertaken a number of different activities, ranging from defining terms of reference and evaluating environmental impact assessment (EIA) studies of regional generation and transmission projects, to carrying out research on issues that SAPP members need to be fully informed about, such as sustainable development and the impact of climate change on the electricity supply industry.

The following environmental guidelines have been published and are available on the SAPP website:

- Guidelines for Environmental Impact Assessment for Thermal Power Plants
- Environmental Impact Assessment Guidelines for Transmission Lines
- Guidelines on the Management of Oil Spills
- Guidelines for the Safe Control, Processing, Storing, Removing and Handling of Asbestos-Containing Material
- Guidelines for Management and Control of Electricity Infrastructure with regard to Animal Interaction

Some of the current projects include mitigation, compensation and resettlement plans for proposed regional and national generation and transmission projects and a project on the

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rejected by Zimbabwe at the time. Had Zimbabwe been a joint venture partner in Kudu, both as an investor and as an importer of electricity via a long-term PPA, the country would have had additional options for obtaining electricity in the post-2000 period. The Kudu gas generation project (800 MW) remains a project that is yet to be developed, the target date for commissioning presently being 2015.

phase-out of PCBs and the safe handling of CFLs.[7] Several of the SAPP Environment Subcommittee reports have been approved by the national environmental protection agencies in the affected countries.

The Environment Subcommittee is also involved in the cross-cutting demand-side management initiatives of SAPP, where it collaborates with SAPP's Demand Side Management Working Group. The subcommittee has created its own working groups on capacity building, sustainable development, climate change and clean development mechanism (CDM).

3.6.2 Carbon dioxide emissions

The importance of climate change is recognized in the Pool Plan where the impact of CO_2 emissions, especially related to coal-fired plants, has been taken into account in the scenarios studied. The scenario recommended for the Pool Plan has total CO_2 emissions over the 20-year planning horizon of 6,392 million tonnes. This is 7% higher than the reference baseline scenario which includes significant nuclear capacity.

The Pool Plan scenarios are very sensitive to assumed CO_2 costs. At costs below US$22 to US$23 per tonne, there is no need to have nuclear power plants during the planning horizon. Above $30/tonne, there is no new coal-fired plant recommended as the increased fuel cost makes these more expensive than nuclear, hydropower and gas power plants.

Pollution as well as global warming effects associated with coal-fired electricity production are major issues in South Africa, so much so that the huge nuclear power investments are being contemplated despite the much higher electricity costs that this would entail (see discussion in Section 3.4). South Africa has one of the most carbon-emission–intensive economies in the world, with CO_2 emissions per capita higher than those of more developed economies in Europe. Much of this is attributed to the use of coal, particularly for electricity production. Total CO_2 emissions in South Africa are on the order of 415 million tonnes per annum, with Eskom power stations accounting for 224 million tonnes (54%).

Research has been conducted on the extent to which climate change will affect the hydropower potential of the Congo and Zambezi Rivers. Temperatures are expected to rise and rainfall patterns to become more erratic, resulting in increased evaporation, reduced runoff, increased risk of flooding and increased siltation. All of these effects are expected to be more severe in the Zambezi as compared with the Congo basins, with increased evaporation and siltation being the most pronounced.[8] As far as can be ascertained, no studies have been done of the countervailing influence of greenhouse gases produced from the decay of organic material in the lakes associated with hydropower plants (the largest being Lake Kariba and Lake Cahora Bassa).

[7] Polychlorinated biphenyls (PCBs) are a class of organic compounds, commonly used in the past as dielectric fluids in transformers, capacitors and additives in flexible PVC coatings of electrical wiring. PCB production was banned in the 1970s due to the high toxicity of most PCB congeners and mixtures. PCBs are classified as persistent organic pollutants which bioaccumulate in animals. Compact florescent lamps (CFLs) contain mercury and require careful disposal procedures.

[8] Mukheibir (2007)

3.6.3 Zambezi River Authority

The Zambezi River Authority (ZRA), responsible for management of the Kariba Dam complex and related hydrological and other installations on behalf of Zimbabwe and Zambia, has been addressing the historical and ongoing environment and social issues associated with the construction and operation of the hydroelectric scheme. This work also provides lessons to be taken into account in order to ensure that any additional dams to be built on the Zambezi River within the two countries will minimize the negative environmental and social impacts.

The Authority has identified the need for a belated compensation plan for the Tonga and Korekore people who were displaced by the Kariba Lake and lost their original habitat without any benefit from the project. These people used to be able to fish and grow crops twice in a year in areas that are now prohibited as they are now designated as national parks. Feasibility studies have shown that the compensation plan is a prerequisite before any new development, such as that planned for Batoka and Devil's Gorge, can be supported by the local people and other stakeholders. As a modest start to the compensation plan, ZRA charges ZESA and ZESCO a small levy that is being used for development projects for the displaced people.

Other threats and challenges being addressed by the ZRA include the following

- Control of water hyacinth, a fast-growing weed that can interfere with navigation, aquatic life and power generation by clogging water intakes. Reliance is placed on biological control mechanisms such as the introduction of a South American grasshopper that ate most of the weed, the use of small fish called kapenta, originally introduced from Lake Tanganyika, that reduce the nutrients in the lake to slow down weed growth, and using weevils that feed on the weed. Use of chemicals is restricted to situations where the growth overcomes the biological agents, such as happened following the great drought of 1991–1992.

- Control of water quality, by monitoring sources of pollution and getting the polluters to pay for mitigation measures. Pollution is mostly from urban settlements and mining activities along the lake and catchment areas and from lake transportation and tourist activities (oil spillage and waste from boats).

- Monitoring and managing dam safety, flooding and drought cycles. The ZRA maintains a network of hydrological measurement stations and dam safety monitoring equipment that provides early warning of potential catastrophic events. The concrete that was used to build the dam swells due to alkaline aggregate reaction (AAR), and this can distort the structure sufficiently to create problems with the opening of floodgates, for example.

  Observations seem to indicate that the AAR is burning out with time, but the ZRA has had to undertake modifications to the floodgates to ensure that they do not vibrate or jam when they need to be operated. Another potential threat to dam safety is the undermining of the toe of the dam wall when floodgates are opened. The plunge pool which has been created by successive gate openings is now 81 meters deep, and divers have to inspect the pool and define the underwater works needed to stabilize or reshape the pool.

ZRA has recommended the extension of its activities beyond Zambia and Zimbabwe through the establishment of a Zambezi basin-wide coordinating body. Such an organization would ensure the sharing of experiences and data and the coordination of disaster relief activities in case of emergencies. Various initiatives have been taken in this regard under the auspices of the SADC Water Division.[9]

[9] If a Zambezi-wide environment body were to be formed, it would also largely take over the environmental activities of HCB associated with the Cahora Bassa dam (details of these are available in the companion case study on Cahora Bassa).

4 Institutional arrangements

4.1 Governance structure

The structure of SAPP is shown in Figure 4. The top level is the SADC Directorate of Infrastructure and Services, under which energy lies in the regional organization. SADC government ministers and officials are responsible for overall policy matters relating to the electricity sector. These determine both the institutional structure and market conditions in each member state.

Figure 4 SAPP Governance Structure

The two main committees of SAPP itself are the Executive Committee and the Management Committee.

- ***Executive Committee:*** The chief executives of the various power utilities form the Executive Committee. The Executive Committee will refer matters such as requests for membership by non-SADC countries and major policy issues that may arise to the SADC energy ministers.

- ***Management Committee***: Officials from the member utilities form the Management Committee, the main function of which is to oversee the management of SAPP.

There are four subcommittees which report to the Management Committee:

- **Operating Subcommittee** membership consists of representatives from those power utilities that are already interconnected and which exchange power on a major scale. At the outset, these were the utilities of Botswana, South Africa, Zambia and Zimbabwe. The number has now increased to nine to include the DRC, Lesotho, Mozambique, Namibia and Swaziland.

- **Planning Subcommittee** consists of a maximum of two representatives per member who are of sufficient seniority in their own organization to make all relevant decisions. This seniority criterion applies to all three subcommittees.

- **Environment Subcommittee** consists of appointed representatives from each operating member. The duty of the subcommittee is to keep abreast of world and regional matters relating to air quality, water quality, land use and other environmental issues. Where governments of the member countries have in place related environmental organizations, the subcommittee has to liaise with them, so that they can assist one another on specific issues.

- **Markets Subcommittee:** This is a new body, provided for in the revised founding documents, and formed in September 2008.[10] The Markets Subcommittee is to be responsible for the governance and operation of the competitive market operations of SAPP, the present focus being on the full operationalization of the DAM.

Chairing of each of the committees is rotated between representatives of the member utilities.

While maintaining the rotating chair principle, in 2000 a permanent **SAPP Coordination Centre** was established in Harare. The functions of the SAPP Coordination Centre are to:

- Provide a focal point for SAPP activities;
- Facilitate the operation of the energy market;
- Monitor the operations of SAPP transactions between the members;
- Carry out technical studies on the power pool to evaluate the impact of future projects on the operation of the pool;
- Coordinate the training of members' staff to improve the region's knowledge of power pool operations; and
- Provide power pool statistics and maintain a pool database for planning and development.

[10] Aside from the formation of the Environment and Markets Subcommittees, and the separation of the Coordination Centre Board from the Operating Committee, the structure of SAPP has not changed since it was formed in 1995.

A website has been developed as a means for SAPP to inform people interested in SAPP's history and activities (www.sapp.co.zw). The Coordination Centre acts as a secretariat for the SAPP committees and subcommittees.

The members of SAPP fund the activities of the Coordination Centre through an annual subscription. The Coordination Centre prepares a budget, which is presented to the Coordination Centre Board for approval. Hitherto, the board has been made up of utility representatives of the Operating Subcommittee, but since 2008 the Coordination Centre Board has been an independent body.

The success of STEM, the completion of various studies whose recommendations have been approved and implemented, and the facilitation of meetings and dispute resolution among its members has helped to make the Coordination Centre a credible and respected organization. This is evident from the fact that the Coordination Centre is consulted on upcoming negotiations by new players (for example, providing capacity building to Malawi prior to Escom negotiating its first power purchase agreement with HCB) and being appointed project coordinator for the ZIZABONA interconnector. The Coordination Centre has assisted in the successful resolution of trading-related disputes between utilities and other pool participants, such as the dispute over reactive power between MOTRACO and Eskom.

4.2 Role of national governments and regional institutions

SAPP is a creation of the SADC governments and is managed through the SADC Secretariat, which is guided by policies from the SADC Energy Ministers and Officials. However the member utilities have considerable autonomy in managing the day-to-day operations of the pool. The ultimate decision to undertake and the financing of generation and transmission projects of regional significance have remained the responsibility of national governments rather than SAPP.

As an organization created by SADC, SAPP and its Coordination Centre have the same legal status as similar technical organs of the regional body. Its operations benefit from established procedures and precedents already agreed under the SADC Treaty and the related protocols. For example, in the area of dispute resolution, recourse for any unresolved matters is to the established SADC dispute resolution mechanisms.

With greater confidence in the abilities of SAPP, the restricted advisory role that it has had in terms of new investments is likely to change to a more active role of investment promotion. As a step toward this greater role, at the next SADC Energy Ministers meeting scheduled for the first half of 2010, SAPP, through the Infrastructure and Services Department of the SADC Secretariat, plans to formally launch the Power Pool and have it formally adopted as a reference plan to guide new generation and transmission investments.

4.3 Regulatory agencies

In southern Africa, as in most developing countries, formal infrastructure regulatory bodies only came to be formed in the 1990s. In South Africa, for example, the Electricity Control Board was replaced by the National Electricity Regulator in 1995, this being subsequently expanded into the National Energy Regulator of South Africa (NERSA) in 2005. Electricity or energy regulators in other SADC countries were generally only formed in the new millennium.

A regional regulatory body, known as the Regional Electricity Regulators Association of Southern Africa (RERA), was approved by the SADC Energy Ministers in Maseru in July 2002, and RERA was formally launched in September 2002 in Windhoek, Namibia. The eight current members of RERA are:

- Electricity Control Board (ECB) of Namibia
- Energy & Water Utilities Regulatory Authority (EWURA) of Tanzania
- Energy Regulation Board (ERB) of Zambia
- Institute for Electricity Regulation (IRSE) of Angola
- Lesotho Electricity Authority (LEA)
- National Electricity Council (NECO) of Malawi
- National Energy Regulator of South Africa (NERSA)
- Zimbabwe Electricity Regulatory Commission (ZERC)

RERA is not a regional regulator, in the sense of having authority and power in regulatory matters in the region, but is instead at this stage merely an association of national regulatory institutions. RERA currently has the following three strategic objectives:

- ***Capacity building and information sharing:*** Facilitate electricity regulatory capacity building among members at both national and regional levels through information sharing and skills training.
- ***Facilitation of electricity sector policy, legislation and regulations***: Facilitate harmonized electricity sector policy, legislation and regulations for cross-border trading, focusing on terms and conditions for access to transmission capacity and cross-border tariffs.
- ***Regional regulatory cooperation:*** Deliberate and make recommendations on issues that affect the economic efficiency of electricity interconnections and electricity trade among members that fall outside national jurisdiction, and exercise such powers as may be conferred on RERA through the SADC Energy Protocol.

A memorandum of understanding between SAPP and RERA on liaison and interaction between the two parties was entered into in April 2007. SAPP and RERA working together to assist in harmonizing regulatory policies, legislation, standards and practices is expected to increase the trade of electricity within the region. Cooperation is also oriented toward opening up opportunities for increased public and private investments in the generation of energy throughout the region.

Since the onset of electricity shortages in the region, there has been much greater willingness to raise electricity tariffs to cost recovery levels that allow for bankable projects. The ministers of energy have committed themselves to "cost reflective" tariffs, although what this means in practice remains to be seen. SAPP and RERA intend to benchmark SAPP utilities and publish an annual Electricity Tariff Review. This should be a useful means of raising debate about electricity tariff issues and may result in higher average tariffs being charged.

It is to be hoped that the benchmarking would include compiling and publishing credible estimates of long-run marginal costs in each system, thereby encouraging feasibility studies to be prepared in a framework of real economic costs. This would help build investment momentum and ensure the sustainability of the electricity supply industry in the region.

Like SAPP, RERA has started on a cooperative basis. As the member states see the need for the role of SAPP to become more competitive to maximize the benefits of cooperation, the role of RERA will similarly evolve, perhaps into a regional regulatory body such as that planned in the West African Power Pool. This is a natural evolution that occurs when the member states gain more confidence in the benefits to be derived from delegating greater responsibility to their regional institutions.

4.4 Role of outside agencies

SAPP has been the beneficiary of various types of outside assistance. In the early years before its establishment the government of Norway provided financial support for the operation of the SADC Energy Sector Technical and Administrative Unit that was based in Angola. The support included the funding for meetings of energy ministers and officials and the first meeting of the all-important Electricity Subcommittee in 1990. The utilities then decided that they would fund subsequent meetings from their own resources, seeking donor funding only for specialized studies, projects and programs.

The main donors and the types of assistance that have been provided are:

- **United States Agency for International Development (USAID):**
  - Over the period 1997–2002, USAID supported a research project which allowed SAPP, with support from Purdue University, to develop short- and long-term models of the interconnected grid; this was the initial Pool Plan that has subsequently been updated with World Bank funding.
  - During the period 1998–2006, USAID seconded an American expert, retired from the New York power pool, to help SAPP in all the steps of its creation and development. The assistance included support for the creation of the Coordination Centre, capacity building with visits to the United States for representatives of the three subcommittees, and implementation of the Operating Subcommittee.
  - Project just starting for the USAID Global Competitiveness Hub, based in Gaborone, Botswana, to provide technical assistance to RERA.

- **Danish International Development Agency (DANIDA)**:
  - Technical support to analyze and solve oscillation problems of the 420 kV inter-tie between Zimbabwe and South Africa.
- **United Kingdom Department for International Development (DFID)**:
  - Sponsored a study on system open up, third-party access, and wheeling charges, these forming the basis of the cooperative power pool which has been in place since then.
- **Development Bank of Southern Africa (DBSA):**
  - Sponsored a tariff study, examining cost-reflective tariffs and regulatory requirements.
- **World Bank**:
  - Trust fund grant for a telecommunication project for SAPP.
  - Trust fund grant for the updating of the 2001 SAPP Pool Plan.
- **Government of Norway**:
  - On-going, US$7.5 million project for the development of a competitive electricity market. Includes installation of the day-ahead market platform.
- **Swedish International Development Agency (SIDA)**:
  - Grant for study on long-term transmission pricing policy, implementation procedures and ancillary services market development for SAPP.
- **European Union (EU-ACP Energy Facility):**
  - Ongoing capacity-building project for SAPP.

Many of these agencies have also indirectly provided support for SAPP through their bilateral aid in member states. In the early- to mid-1990's the Nordic countries were particularly active in funding projects that have become key elements of the grid, such as the Cahora Bassa interconnector as well as the extension and the refurbishment of the Zimbabwe and Mozambique transmission networks.

5 Contractual, financial and pricing arrangements

5.1 Contracts

5.1.1 SAPP contractual documents

At the 1995 SADC summit, the member governments signed an **Inter-Governmental Memorandum of Understanding (IGMOU)** for the formation of a power pool in the region. Three other key documents which were agreed to and signed subsequently are:

- **Inter-Utility Memorandum of Understanding (IUMOU)**, which established SAPP's basic management and operating principles.
- **Agreement Between Operating Members (ABOM)**, which established the specific rules of operation and pricing.
- **Operating Guidelines (OG)**, which provide standards and operating procedures.

The function of the intergovernmental agreement was for each government to grant formal authority to its national utility to participate in SAPP activities and to guarantee the obligations of the utility. Through this agreement a utility that fails to discharge its obligations, such as paying for power delivered automatically, exposes its government to the liability. The supplying utility can also fall back on its government for support if it is prevented, for political reasons, from carrying out normal credit control measures such as switching off supply for nonpayment. That is why some utilities have been able to continue supplying when they have not been paid for several months.

The inter-utility agreements and operating guidelines address the technical and financial matters that facilitate the operation of the power pool.

The founding IGMOU was updated and a Revised SAPP Inter-Governmental Memorandum of Understanding was signed by the ministers of energy in February 2006. The IUMOU was then also revised and signed by the members during 2007, with revisions to ABOM and OG following after that. The need to revise the founding agreements was prompted by three factors:[11]

- The restructuring of the umbrella regional integration body, SADC. This created a department of Infrastructure and Services with an energy division to take over the functions of the former Energy Technical and Administrative Unit.
- Electricity sector reform in several SADC member countries, including the creation of electricity regulators and the intended unbundling of utilities. It was intended that the transmission companies or divisions would be the entities now actively involved in SAPP activities.

[11] *SAPP Annual Report 2006*, p. 5.

- o The expansion of SADC membership to include the DRC, which was not a member when the original power pool was created.
- o The need to expand SAPP participation beyond the national power utilities, to include commercial parties such as independent power producers and independent transmission companies.

New members which are not vertically integrated national utilities were to become full members of SAPP during 2009. These were expected to be HCB, MOTRACO, WESTCOR and Copperbelt Energy Corporation (CEC, a Zambian-based transmission company).

The redrafting exercise included the formulation of an agreement on dispute resolution that is specific to the electricity sector. SAPP had been able to do without such an agreement before because reference was made to the Dispute Resolution provisions in the 1992 SADC Treaty (Article 16-4).

5.1.2 Electricity trade contracts

As previously mentioned, the overwhelming bulk of electricity trade in SAPP is via bilateral contracts—see Table 9. Each of the bilateral arrangements operates under a framework of intergovernment and inter-utility agreements and operational rules, with the addition of wheeling agreements in cases where the power has to move through a third country.

Truly regional trade has been confined to STEM, which has allowed hourly, day-ahead, and longer-term contracts and has allowed secondary trading of contracts that have been cleared through the market. The operation of STEM has been governed by a framework laid out in its Book of Rules.

The Day-Ahead Market is being introduced in the context of an agreed methodology for trade and the setting of transmission prices on a nodal basis. The market specifications were developed initially at the subcommittee level, then went to the Management Committee for approval. The market is to be governed by the DAM Book of Rules and the Participation Agreements.

5.2 Ownership and finance

With respect to ownership, all of the generators and interconnectors in the SAPP region are in public ownership, with the assets being reflected in the books of the national utilities. In some cases, special-purpose vehicles (SPVs) have been formed to execute joint projects (such as MOTRACO, which is jointly owned by Eskom, SEB and EDM). Hidroeléctrica de Cahora Bassa is something of an exception because the ownership is directly by the governments involved (Mozambique and Portugal, Mozambique purchasing majority ownership in 2007). The only electricity asset of regional significance which is privately owned is the Copperbelt Energy Corporation transmission lines and power plant in Zambia.

Financing of SAPP is at two levels. Regional infrastructure investments are financed and undertaken by the utilities involved or by special-purpose companies set up to execute the projects (e.g., MOTRACO and WESTCOR). The financing requirements of SAPP as an organization are covering the costs of the SAPP Coordination Centre and the activities of the subcommittees, Management Committee and Executive Committee. Financing for the execution of various studies of common interest for the pool members is also channelled through SAPP.

Financing of projects is orders of magnitude larger than the financing of SAPP itself. The cost of the generation and transmission projects that are planned to be implemented from 2009 to 2013 are US$13.6 billion and US$4.7 billion, respectively, while the annual operational budget of the SAPP Coordination Centre is of the order of US$500,000, of which 50% is for salaries and wages. This budget is steadily increased by 10 to 20% per year as the scope of SAPP activities regularly increases. The financial management is sound.

The Coordination Centre costs are met from the following sources:

- ***Members' contributions***: This represents approximately 80% to 90% of the total income of SAPP. It includes a fixed portion of 20% and a variable portion calculated on the basis of the peak demand of each member.
- ***STEM/DAM participation fees:*** A levy is raised on the transactions made by the utilities using the short-term energy market and in future the day-ahead market.
- ***Donation and grants***: These sources of revenue were important during the phase in which SAPP was set up and the Coordination Centre established. Grants are now mainly used for studies and projects to further SAPP objectives, such as the competition project which has resulted in the establishment of DAM.

ZESA Holdings, the Zimbabwean national power utility, pays an additional "host country" contribution of 10% of the annual budget. This is to compensate for the advantages and savings to ZESA resulting from the SAPP Coordination Centre being located in Zimbabwe.

5.3 Pricing arrangements

National electricity tariffs were discussed in Section 2.4. This section reviews pricing arrangements in regional electricity trade.

Prices for bilateral contracts which are the dominant trading tool are negotiated on a willing seller and willing buyer basis. Prices are not necessarily related to domestic prices, unless the parties agree. Most contracts are subject to review on an agreed periodic basis to take account of changed circumstances, usually inflation or quantities supplied or demanded.

Pre-SAPP wheeling arrangements involved tripartite agreements in which the supplier negotiated a power purchase price with the customer and the customer negotiated a price for wheeling the power through a third party. As long as the third party was not a competing supplier, this arrangement worked well. However, to avoid competing suppliers with transmission facilities abusing their positions to prevent third-party access, the initial Agreement Between Operating Members provided an interim pricing arrangement to be used pending a more detailed and professional study. The interim charges were based on an agreed-upon percentage of the amount wheeled, the percentage reflecting the estimated incremental losses suffered by the wheeler.

The SAPP study on wheeling charges was undertaken in several phases and finally completed in 2001. The MW-km method was chosen, where charges were dependent on the amount of power traded and the distance between the buyer and seller. A simple load flow approach was used to identify specific transmission assets used for wheeling and to determine a set of wheeling charges for the defined wheeling routes. The level of charges was determined on the basis of the marginal cost of losses plus a rental charge calculated on an agreed-upon formula that took account of the replacement cost and depreciated value of the transmission assets. Except in the case of lines specifically built for wheeling purposes, in theory the members agreed to the principle that cost recovery for the assets was not an issue because the assets were developed for domestic use and hence already had separate cost recovery charges independent of wheeling. This approach was taken to ensure that the level of wheeling charges was not so prohibitive as to prevent trade and yet sufficient to provide an incentive for the wheeler to participate in the trading arrangement.

Notwithstanding this agreed-upon principle, the charges calculated ranged from US$1.4/kW/year to US$28/kW/year, depending on the amount of transmission assets used between the seller and buyer. In comparison, the published wheeling charges for England and Wales were US$1 to US$23/kW/year and for Brazil the wheeling charges were US$-2 to US$17/kW/year. The consultants observed that the SAPP charges were overlapping with ranges of charges based on full cost recovery, violating the agreed-upon principle of avoiding double recovery of costs already being charged to domestic users. The SAPP charges were, however, adopted simply because the members accepted them as fair, and this was considered a sufficient reason.

Although simple to use, the MW-km method was not suitable for a more competitive market with many transactions of varying size and duration. Consequently the introduction of a more competitive Day-Ahead Market has necessitated a review and a change to an investment cost–related pricing system with standard prices for defined zones or nodes. This allows power purchase prices to be set on the basis of bids and offers on the assumption of free transmission access for all eligible generators and their customers, who all pay separate prices for use of the transmission network. If there is no congestion, a standard transmission system price is used. If there is congestion, the system is split into different predefined bid areas and charges are related to the area that the market participants are in.

The new transmission pricing system addresses three aspects:

- *Network charges* to recover the costs for owning and operating the portion of the regional network that would be used for wheeling purposes. At a minimum these charges should recover the costs of wheeling. These would be entry or exit charges rather than point to point. Revenue received from network charges would be allocated by the market operator to the transmission system operators in proportion to their estimated costs of wheeling.

- *Losses* to recover the losses resulting from trade, either in making up the losses with energy, or through a financial payment. Losses would be the responsibility of each transmission system operator, and market participants would be charged for wheeling losses based on nodal loss factors and agreed prices. The transmission system operators would contract additional power to cover losses and be compensated by revenue from loss charges, which would be distributed in proportion to their estimated costs of losses.

- *Congestion management* to resolve congestion on transmission lines. SAPP has proposed the use of market splitting to address congestion on the interconnected grid. In the event of market splitting charges will be based on the specific areas rather than on a systemwide basis.

6 Future plans

The significant challenges for SAPP still lie ahead. The delicate act of balancing national and regional interests requires persistence, tact and diplomacy. There is a need to forge real political commitment to regional solutions to electricity supply and to promote competition in electricity markets. For a long time the region will need significant investment in new generation and transmission grid infrastructure. The huge investments that are needed must come not only from national and donor resources as in the past, but also fromprivate-sector financing.

Going forward, SAPP's priorities can be summarized as follows:

- **Investment projects:** Vigorous facilitation of the adoption and implementation of the new Pool Plan which maximizes benefits from regional cooperation by interconnecting non-operating members, deferring nuclear power plants in favor of hydropower and clean coal, and strengthening the central transmission grid in order to improve the link between the hydropower resources of the north and the main South African load centers. Critical to this exercise is to get the member states to maximize opportunities for regional trade in their national policies and plans.

- **Interconnected grid**: Reinforcement and extension of the interconnected area to include all SAPP members. This in time will involve TANESCO of Tanzania, Escom of Malawi and ENE of Angola becoming operating members of SAPP.

- **Electricity access:** Greater focus on all SAPP objectives, in particular increased access to electricity, including the promotion of small cross-border distribution projects in parallel with the large regional generation and transmission schemes.

- **Competitive markets:** Further development of competitive markets, with greater harmonization of rules, regulations and codes. In the long term, the region should move toward adopting international competitive best practice, whereby SAPP will be able to give freedom of choice of supplier to the end user. This will mean the delegation of greater responsibility and authority to the SAPP Coordination Centre and the independent regulatory agencies to direct the development and operation of the system on the basis of the best interests of the consumer, investor and the general public.

  In a region that requires significant investment, the financing of which will require long-term power purchase agreements (PPAs) to be in place, there will continue to be a domination of bilateral contracts in electricity trade. Allowing competition at the user end will be an important step in overcoming the constraints of long-term contracts and promoting market development.

For the foreseeable future, the primary challenge within the preceding list will be the expansion of generation, transmission and distribution capacity in order to improve security and reliability of supply as well as to cater to growth. According to the proposed SAPP Pool Plan, the medium- to long-term generation projects (to 2025) are expected to require US$83 billion for an additional 57,000 MW that will more than double the present regional generating capacity. At least US$5 billion is required to eliminate the current deficit by 2013.

The recommended option assumes that South Africa postpones plans for a nuclear development program as a major component of its long-term expansion plan. A further US$6 billion will be required for regional transmission investments.

In the wake of the regional capacity shortage which arose because of the lack of implementation of the 2001 Pool Plan, there is a high level of concern about ensuring that the current Pool Plan does not suffer the same fate. The Investors' Round Table Conference held in Livingstone, Zambia in July 2009 noted that arrangements in West Africa for regional power projects give greater authority to ECOWAS (the Economic Community of West African States) and WAPP (the West African Power Pool) to implement the regional investment plan. Even in the absence of corresponding authority being given to SADC and SAPP, the conference put forward a number of practical proposals for new project development mechanisms to be adopted in SAPP, including having regional project development teams at the national level and establishing a Project Acceleration Unit to be housed in SAPP. Whether this new role is given to SAPP remains to be seen.

In addition to improving the regulatory framework (including working toward a regional regulator with enforcement powers) and developing common grid codes, greater attention needs to be paid to making regional electricity projects bankable. The Investors' Round Table Conference recommendations on this are the raising of tariffs to cost-reflective levels, establishing a revolving risk capital bridging facility to allow utilities to make equity contributions to projects, and allowing bulk energy users to be parties in PPAs (i.e., moving to a hybrid version of the single-buyer model).

However, bankability goes beyond these specifics: what is needed at a high level is greater policy clarity and evidence of national and regional commitment to implementing those policies. In the present environment, high levels of country risk and factors such as inexperienced and politically dominated regulatory structures will continue to raise the costs of project financing and put pressure on the accuracy of demand forecasts and cost-recovery strategies. SAPP, together with RERA, have important ongoing roles to play in sensitizing member governments to the benefits of regional approaches and assisting in the harmonization of sector policies and regulatory approaches.

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