

Regional Energy Integration In Africa

A Report of the World Energy Council

June 2005

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FOREWORD

This report is the first publication produced within the framework of WEC's Africa Regional Action Plan, as a part of the 2005-2007 overall Work Programme. One of my most important responsibilities as the Chairman of the WEC Programme Committee is to monitor regional activities that today practically cover the whole world and are focused on WEC's mission of achieving energy sustainability for all people.

I am particularly pleased that the first tangible output of the current Work Programme comes from Africa. Presently, over 80% of the total energy consumption in Africa is based on traditional biomass used mostly for cooking. This lack of access to modern energy is holding back economic and social development for 1.6 billion people around the world. The situation is particularly grave in sub-Saharan Africa where over 80% of the population lives in rural areas and the average electrification rate is less than 5%.

At least 50 million new connections are needed to provide electricity to supply the non-connected areas in Africa. The over 700 million potential customers represented by these new connections provide a major business opportunity. It is now widely recognised that development assistance, bilateral aid, multilateral financing institutions, a multitude of international aid agencies, NGOs and others have failed to make a significant difference. A new approach is required, otherwise the number of people without access to electricity will continue to grow, and none of the Millennium Development Goals set by the United Nations will be achieved.

I would like to thank all contributors to this report, including WEC's members in Africa, Vice Chair for Africa, Dr. Alioune Fall, members of the Study Steering Group and the Study Chair, Dr. Michel Lokolo, the Study Director, Dr. Ibrahim Gelil and the WEC London staff for their enthusiasm and hard work. Results of this work speak for themselves, and the message is clear. Regional integration holds a great potential for energy development in Africa and better cooperation and coordination. As the global energy industry organisation, WEC is ready to take on the leading role in coordinating the international effort "on the ground" through its membership network and its Centres of Excellence for Sustainable Energy, and Africa is certainly the region where this effort is needed most urgently.



Ronald R. Wood
Chairman
WEC Programme Committee

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We wish to thank all World Energy Council (WEC) African members for their efforts and dedication in supporting the goal of greater energy cooperation in Africa, without their support this work would not have been possible.

One of the main conclusions of the 19th World Energy Congress in Sydney in September 2004 is that regional integration of energy supply systems can boost energy access and energy supply security. Recent research and analysis underlying this report confirms that energy cooperation can significantly contribute to increasing energy access in Africa.

There is increasing understanding of the critical role of energy for achieving the United Nation's Millennium Development Goals (MDG). This is manifested by the emphasis placed on Africa and the environment on the agenda of the 2005 G8 meeting. We hope that our work will contribute to the momentum being created around Africa's problems and will support the New Partnership for Africa's Development (NEPAD), Africa's governments and regional, multilateral and bilateral development agencies and institutions in implementing the NEPAD projects that promote affordable and environmentally sound energy supplies.

Our thanks also go to:

- The Steering Committee of the Study for sharing their views, experience and guidance. This has been invaluable in ensuring that the Study was completed to the expectations set out in the Terms of Reference whilst also building on the preliminary work carried out for the discussion document: *The Potential for Regionally Integrated Energy Development in Africa* published in 2003.
- Dr Ibrahim Abdel Gelil, the Study Director, for his excellent work in producing this report.
- Mr Rachid Abdoun, of Sonatrach and the Algerian Member Committee of WEC for providing detailed information and guidance on the Algerian interconnection projects.
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Dr Alioune Fall
WEC Vice-Chair for Africa &
Chair, WEC Senegal Member Committee

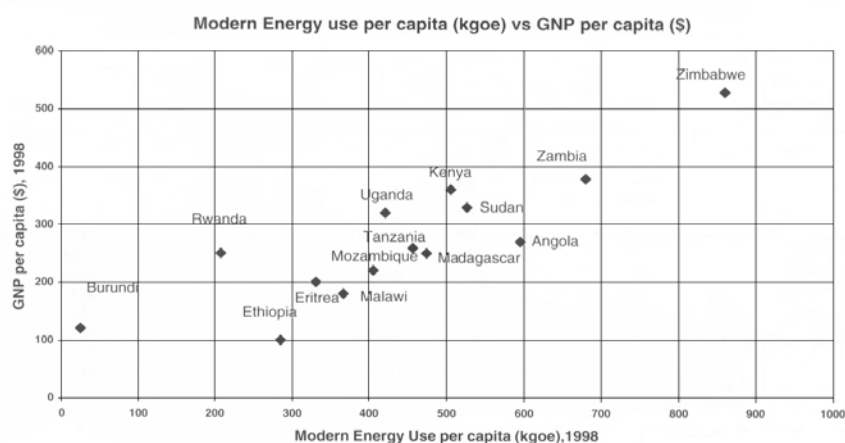
Dr Michel Lokolo
Chairman of the Steering Committee
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Chapter 1: Potential for Regionally Integrated Energy Development in Africa

1.1 Introduction

Access to modern energy services is critical for socio-economic development. Fig. (1.1) demonstrates that there is a strong and positive correlation between gross national product (GNP) per capita and modern energy use per capita. Energy underpins the provision of clean water, health services, education and communication. It is obvious that efficient and clean energy supplies are needed to fuel Africa's development and fight against poverty. Yet the proportion of its people still dependent on traditional, inefficient and polluting energy sources is higher than on any other continent.

Fig. (1.1):



Source: IEA, *World Energy Outlook*

Through their Regional Programme, WEC's members in Africa conducted this study with the support of British Petroleum (BP) Southern Africa, and concluded that the traditional approach of limiting energy planning and service provision to the nation states contributes negatively to the energy access issue in Africa.

The nation-based planning is sub-optimal in several respects:

- The geography of energy supply options does not necessarily correspond to political boundaries, the cleanest and cheapest energy source may lie across national borders;
- National energy markets are often too small to justify the investments needed in particular energy supply options;
- Cross-border energy supply often provides diversification of energy source – a key component in energy security.

Although there is strong evidence¹ that Africa is beginning to reap the benefits of regionally integrated energy development, there is still a long way to go. The development of energy markets on a regional basis offers significant benefits, as the linking of national petroleum and electricity industries can help mobilise private and domestic investments by expanding market size. Whilst interconnections create export

¹ WEC, *The Potential for Regionally Integrated Energy Development in Africa – Phase I*, 2003

opportunities for countries with comparative advantage, in terms of resource or energy supply, secondary benefits such as increased and cheaper energy supply options, will be available to smaller markets and countries.

The study confirms four major benefits associated with regional energy integrations: improved security of supply, better economic efficiency, enhanced environmental quality and a wider deployment of renewable energy resources.

WEC's African members have worked hard to increase understanding of this subject. In this second phase of the Study, a more detailed, analytical assessment has been made of existing and planned energy projects in Africa.

1.2 The Energy Situation in Africa: Overview

The most significant challenge facing the African energy sector today is energy access. However, Africa's energy resources are more than adequate to meet its short and medium-term requirements, taking into account the main drivers such as population growth and economic development.

1.2.1 Regional Diversity

Oil and gas reserves are concentrated in North and West Africa, hydroelectric potential in Central and Eastern Africa and coal in Southern Africa. Many of these resources are monetised through their trade with external markets. North Africa, with its gas pipelines to Europe, is an example of more advanced forms of regional cooperation, but it also demonstrates that market availability is the ultimate driving force of energy cooperation and integration.

Reliance on traditional biomass, as the main source of energy, is particularly high in sub-Saharan Africa, where biomass accounts in some countries for 70-90% of primary energy supply and up to 95% of total consumption². The pattern of commercial energy consumption in Africa mirrors energy resource availability and per capita income. Commercial energy consumption, particularly the oil and gas sectors, is highly concentrated in the northern and southern parts of the continent.

Electricity consumption in most African countries is very low and demand is mostly confined to the energy-intensive industries, commercial enterprises and load centres in urban locations³. The electricity sector is often characterised by high technical losses, managerial weaknesses, illegal electricity connections and political interference. However there is growing evidence that the unbundling of previously vertically integrated utilities is bringing benefits, in terms of service reliability and lower 'real' electricity prices.

Joint energy projects are usually based on both domestic and international market demand. This demand is driven by the ability to pay and thus allows investors to hedge risk exposure with future revenue. However, at the local level, the provision of energy services through regional integration and cooperation faces certain challenges. Energy is a significant part of the total infrastructure that allows rural and urban poor

² Stephen Karekezi, Energy Policy, Renewables in Africa: Improving Modern Energy Services for the Poor, 2002

³ M R Bhagavan, Reforming the Power Sector in Africa, 1999

to grow beyond subsistence activity, to generate individual savings and increase their demand for modern energy services.

1.2.2 Renewable Energy Options

At present, the majority of the poor in Africa spend a significant proportion of their income on energy and rely mainly on biomass. Since most of Africa's poor live in remote rural communities, there are no clear economic incentives for grid-extensions or for supplying modern hydrocarbon fuels, such as kerosene and liquefied petroleum gas (LPG).

There is an enormous potential for hydropower development in Africa,⁴ and yet to date only 7.0% of that potential has been harnessed. Traditionally, hydro-based electricity generation was the basis for the expansion of electricity networks in many African countries.

In these conditions, the deployment of other renewable energy technologies should play an important complementary role; however it would need to be aided by the following⁵:

- Implementation of long-term renewable energy policy programmes;
- Initiation of long-term renewable energy training and capacity building programmes;
- Introduction of flexible financing mechanisms.

These factors are also valid for the development of the conventional energy sector in Africa. Energy cooperation and integration are often based on conventional and centralised energy systems. These require huge capital investments, both from foreign and domestic sources and thus add to heavy debt burdens. Moreover, Africa is in competition for investments with the emerging economies of Latin America, Asia and Eastern Europe, and energy project development will not happen, unless Africa's energy resources are monetised through market.

Renewable energy can therefore provide a solution to the energy needs of dispersed rural populations and complement energy services provision to more centralised energy demand centres.

1.3. The Need for Regional Energy Integration

Regional integration is increasingly being seen as a way for individual countries suffering from structural and economic weaknesses to join the global economy. Today, intra-Africa trade remains low and the lack of macro-economic policy convergence and insufficient infrastructure negatively affect cooperation and integration.

However, ongoing work to assess the rate at which economies in Africa are being linked together in eight key sectors - trade, transport, communications, energy, agriculture, manufacturing, finance, human development and labour markets – show

⁴ WEC, Survey of Energy Resources, 2004

⁵ Stephen Karekezi, Energy Policy. Renewables in Africa – Meeting the Energy Needs of the Poor, 2002

mixed results⁶. Some regional economic communities have done a great deal to liberalise trade with their neighbours, by permitting the free movement of people and building external infrastructural links. While Africa's network of transportation infrastructure and services is still "disjointed", the energy sector is showing signs of greater integration, particularly in North and Southern Africa.

A number of problems have reduced the ability of the energy sector to drive inter and intra-African trade. These include: high system losses in transmission and distribution; unsustainable tariffs; environmental factors; poor technical, managerial, and financial performance; and government interventionism.

In the hydrocarbons sector, many oil and gas exporting countries are benefiting from massive trade gains. However, the income derived from oil exports has been used neither to finance the necessary structural diversification of the economy nor to place these countries on a sustainable growth path.

1.3.1 Security of Supply

Security of supply is one of the primary drivers in developing power interconnections between countries and regions. In more advanced economies, security of supply in the short-term involves ensuring the immediate uninterrupted daily operation of the national power and fuel supply systems, whilst coping with short-term supply problems such as international price fluctuations, environmental concerns or industrial action. In the long-term, security of supply is correlated to the depletion of national, regional or global energy resources and the need to diversify energy supply options.

In the African context, security of supply can be viewed in both senses, depending on location. The sharing of operational reserves and installed capacity through interconnections provides an alternative source of supply and can help reduce investments in domestic generation. A World Bank study has indicated that an estimated saving of US\$1.6 billion over 10 years⁷ could be realised through the optimal use of the regional electricity resources and installations in Southern Africa, such quantifiable benefits are driving other regions to diversify their energy supply base. The West Africa Gas Pipeline (WAGP) is an example.

The World Bank estimates that Benin, Togo and Ghana can save nearly US\$500 million in energy costs over a 20-year period, as WAGP-supplied gas replaces more expensive fuels in power generation. Ghana estimates that it will save between 15,000-20,000 barrels of crude oil per day by using gas from the WAGP to run its power plants.⁸ Nigeria benefits by monetising previously flared gas and exploiting its comparative advantage to meet the energy demand of its neighbours, whilst delivering clear environmental benefits.

1.3.2 Increasing Economic Efficiency

There is a greater awareness of energy's role for socio-economic development at all levels of productivity. No country has been able to raise per capita income from low levels without increasing its use of commercial energy. The transition from traditional to modern energy sources carries the greatest hope for the 1.6 billion people in developing countries without access to electricity and modern fuels⁹.

⁶ ECA, Accelerating Regional Integration in Africa, 2004

⁷ World Bank, Promoting Regional Power Trade - the Southern African Power Pool", 2000

⁸ US DOE, Energy Information Administration Country Analysis Brief, 2003

⁹ UNDP/UNDESA/WEC, World Energy Assessment: Energy and the Challenge of Sustainability, 2000

However, modern energy forms are sometimes seen as economic “bads”, when the environmental implications of their use are taken into account. It is the negative environmental “externalities” associated with energy supply and use and not energy itself that can lead to economic failures. On the other hand, the provision of affordable modern energy in developing countries to meet the growing demand will have a knock-on effect on productivity and macro-economic growth.

1.3.3 Macro productivity

A regional approach to energy markets offers significant benefits. The interconnection of national petroleum and power markets can help leverage private investment through expanded market size, allowing investors to reduce commercial and political risks. In the longer-term, these interconnections lower supply costs by reducing investments in redundant supply facilities, whilst increasing supply options. This has a very important implication for the debt burden of many Africa economies.

The West African Power Pool project, which brings together 14 countries, is now modelling the trading of electricity across borders, in order to optimise investment response to forecast electricity demand and population growth¹⁰.

Of the region’s 234 million potential consumers, about 30% have no access to electricity. Moreover, demand in the region is expected to grow by at least 6% annually over the next 20 years. Based on existing capacity of 10,000 MW, the region needs to increase capacity to about 17,000 MW to match demand.

A regional approach to meeting the demand makes economic sense – the estimated savings amount to approximately US\$3-5 billion over 20 years, if this approach to power generation and transmission development is adopted¹¹.

The technical and managerial performance of many centralised power systems in Africa has often been sub-standard¹². However, interconnections and regional trading can contribute to the economic efficiency of power systems.

¹⁰ Daniel Plunkett, West African Electricity Sector Integration, 2004

¹¹ USAID/WARP West Africa Power Pool Programme 2004

¹² MR Bhagavan, Reforming the Power Sector in Africa, 1999

Chapter 2: Energy Situation in Africa

2.1. Energy and Development

Generally, any reliable statistics on Africa are scarce and therefore, even the most commonly used figures are often estimates. Africa's population was estimated to be 832 million in 2002¹³, 641.1 million thereof in sub-Saharan Africa - over 80% of the continent's total.

According to the World Bank, in 1998, about half of Africa's population had average incomes of less than one dollar per day. Poverty in sub-Saharan Africa is particularly acute in rural areas, where about 70% of all Africans live and where poverty ranges from over 50% to 77% of the population¹⁴.

The estimated gross national income in Africa was US\$643million in 2002, the lowest in the world¹⁵. At the same time, national income levels in sub-Saharan Africa are significantly lower than in North Africa and South Africa. When North African countries are excluded, GNP per capita estimates drop from US\$677 to US\$492 (in 1999). If South Africa is excluded, the GNP per capita drops to US\$306¹⁶. This level of capita income usually indicates lower levels of human development. 27 of the countries at the bottom of the 2002 UN Human Development Index are in Africa¹⁷.

The levels of poverty in sub-Saharan Africa are reflected in the low consumption of modern energy, which is particularly striking. In 2002, the average per capita energy consumption in Africa was 0.65 toe, which corresponds to about 39% of the world average¹⁸. In terms of electricity consumption per capita, the average for sub-Saharan Africa is 447 kWh p.a, but if South Africa is excluded, the figure drops to 126 kWh¹⁹.

In sub-Saharan Africa, where the rural population accounts for about 70% of the total, traditional energy use, mainly unprocessed biomass, dominates the energy sector. The low consumption of commercial energy and the high dependence on traditional fuels is a measure of poverty in sub-Saharan Africa.

2.2. Energy Resources

While Africa's known energy resources are not predominant on a world-scale, in 2001 they accounted for 5.1% of the world primary energy supply, which is more than adequate to meet the short and even medium-term needs on the continent. These resources still remain largely under-exploited, mainly due to the lack of investment and the socio-economic environment, which does not encourage Foreign Direct Investment (FDI).

While in absolute terms, Africa's energy resources are adequate; the geographical distribution of the different resources across the continent is uneven. North Africa is

¹³ IEA, Key World Energy Statistics, 2004

¹⁴ Stephen Karekezi, Poverty and Energy in Africa – A Brief Review, 2002

¹⁵ Ref.15

¹⁶ Ref.16

¹⁷ UNDP, Human Development Report, 2003

¹⁸ Ref. 15

¹⁹ Ref. 16

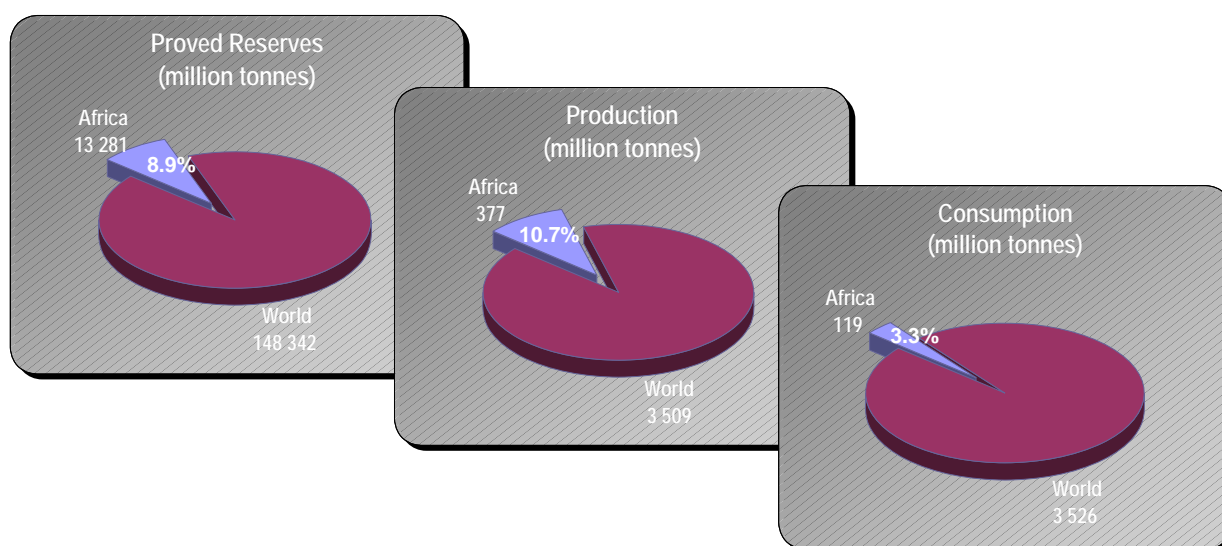
rich in oil and gas; South Africa has huge coal reserves and the sub-Saharan Africa is largely reliant on biomass.

2.2.1 Oil

Africa's oil reserves in 2002 amounted to 13,200 million tonnes²⁰, whereof the largest are 4688 million tonnes in Libya followed by Nigeria (4252 million tonnes), Algeria (1568 million tonnes) and Angola (at 1201 million tonnes).

Fig. (2.1) shows 377 million tonnes of crude oil were produced on the continent in 2002, which accounted for 10.7% of the total global oil output. Nigeria with 96.2 million tonnes in 2002, is the leading oil producer in Africa, followed by Algeria, Libya, Angola and Egypt. Nigeria ranked sixth among the world oil exporters in 2002.

Fig. (2.1): Africa's Oil Reserves, Production and Consumption, 2002



Source: WEC Survey of Energy Resources, 2004

Africa's total oil consumption in the same year reached only about 119 million tonnes, although it is expected to grow rapidly in the future. Some estimates project a doubling of Africa's oil consumption by 2010²¹.

2.2.2 Gas

Total natural gas reserves in Africa in 2002 amounted to 1,3010 billion cubic meters (bcm)²², most gas reserves are in North Africa (Algeria, Libya and Egypt) and West Africa (Nigeria). In 2002, North Africa accounted for about 63.3% of Africa's total gas reserves. Nigeria has the largest gas reserves in Africa estimated at 5,055 bcm. Algeria comes second with 4,000 bcm, followed by Egypt with 1,657 bcm and Libya with 1,314 bcm.

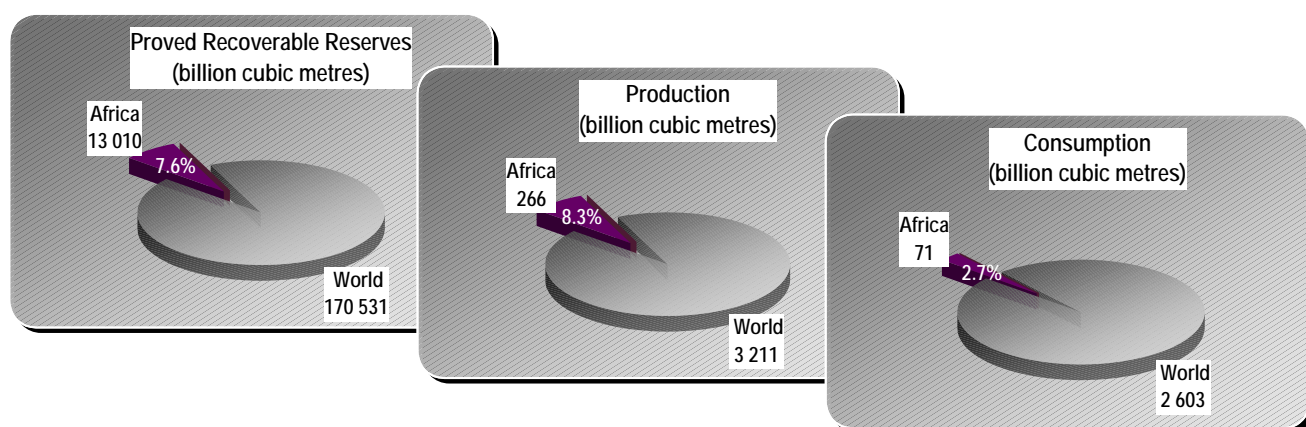
²⁰ WEC, Survey of Energy Resources, 2004

²¹ IEA, World Energy Outlook, 1995

²² WEC, Survey of Energy Resources, 2004

Africa's gross gas production in 2002 accounted for 8.3% of the world total, Fig. (2.2). Algeria is by far, the leading gas producer in Africa and the fifth largest gas producer in the world. Net of gas re-injected into oil fields, flared or lost, Algeria produced 79.3 billion cubic meters (bcm) in 2002 and ranked as the third largest gas exporter in the world²³. Egypt produced 26.7 bcm of gas in 2002 and Nigeria 14.2 bcm. Most of sub-Saharan Africa's gas is associated with oil and is simply flared on the continent's Western coastline, mainly due to the lack of energy conversion infrastructure. Several major gas development projects, both ongoing and planned, are expected to result in a significant increase in gas use for power generation in a number of West African countries.

Fig. (2.2): Africa's Gas Reserves, Production and Consumption, 2002



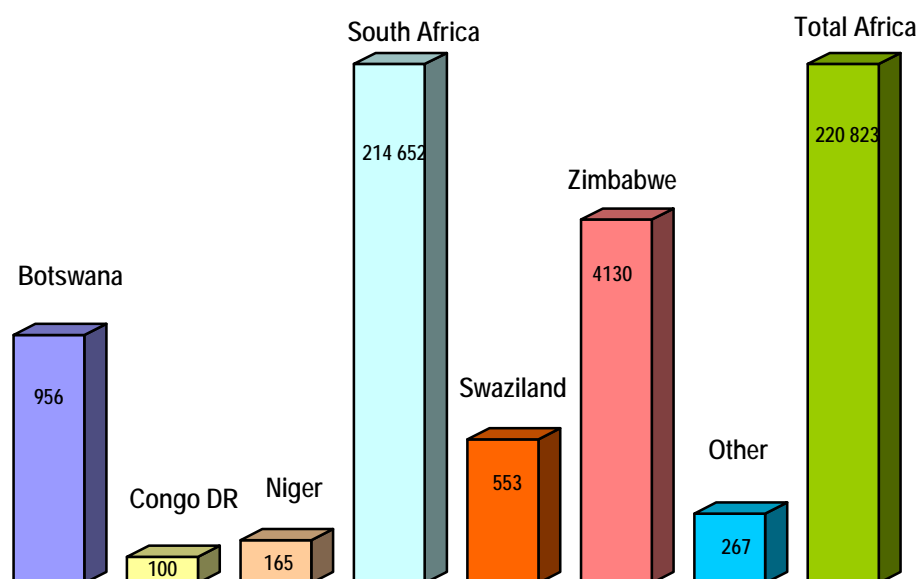
Source: WEC Survey of Energy Resources, 2004

2.2.3 Coal

Nearly all of Africa's coal reserves are in the South. The coal is overwhelmingly bituminous, and about 90% of total reserves are in South Africa, with proved recoverable reserves of 48,750 million tonnes in 2002. Most of the remaining coal deposits are located in the neighbouring countries: Botswana, Zimbabwe, Mozambique and Swaziland.

Africa's coal production in 2002 accounted for 6% of the world total. South Africa dominates coal production with 214,652 thousand tonnes, which makes it the fifth largest coal producer and the fourth largest coal exporter in the world. The second largest coal producer in Africa was Zimbabwe with 4,130 thousand tonnes, Fig. (2.3).

²³ IEA, Key World Energy Statistics, 2004

Fig. (2.3): Africa's Leading Coal Producers in 2002

Source: WEC Survey of Energy Resources, 2004

2.2.4 Uranium

Africa has significant uranium reserves estimated at 613.1 thousand tonnes in 2003²⁴. The largest recoverable reserves are in South Africa, followed by Namibia and Niger. These three African countries also currently rank among the ten leading global producers of uranium. Within Africa, Niger led annual production in 2002 with 3,080 tonnes, followed by Namibia with 2,333 tonnes and South Africa with 824 tonnes.

2.2.5 Renewable Energy Resources

In addition to fossil energy resources, there are also many promising renewable energy resources such as hydro, wind, solar, geothermal and biomass in many parts of Africa. The majority of the continent's poor live in dispersed rural settlements, and the cost of extending transmission and distribution grids to these settlements would be high. This creates an ideal opportunity for distributed generation technologies that complement the dispersed nature of sub-Saharan Africa's rural population. For this reason, the region is also perceived to be the ideal place for the deployment of new and innovative electrification technologies. Renewable energy technologies are often considered the most appropriate technology choice for much of rural Africa and they could provide a reliable and ecologically sound long-term alternative for many countries, including current oil-exporting nations, as many of them have abundant and unexploited biomass, hydro, solar and wind resources.

There is an enormous exploitable hydropower potential in Africa, particularly in the sub-Saharan countries. The hydropower resources in sub-Saharan countries account for about 12% of the world's hydropower potential, but only 17.6% of these resources had been harnessed - one of the world's lowest figures. The current geographic

²⁴ WEC, Survey of Energy Resources, 2004

distribution of hydropower in Africa demonstrates the following pattern: North Africa (23%), West Africa (25%) and South/Central/Eastern Africa (51%)²⁵. Technically exploitable hydropower capability amounted to more than 1,917 TWh/yr in 2003, representing about 12% of the global total²⁶.

With the exception of Egypt and Morocco, wind energy has not yet been widely exploited in Africa. In 2002, the world total installed wind capacity was 31,398 MW of which 68 MW was in Egypt and 54 MW was installed in Morocco²⁷.

The average solar insolation in Africa is between 5-6 kWh/m², but solar energy use is still dominated by traditional applications, e.g., direct solar energy to dry crops. Solar dryers (called solar kilns) are used for agricultural products such as grain, tea leaves and other crops, but also for fish-drying and timberwork in some sub-Saharan countries.

Some encouraging results with photovoltaic (PV) systems have been achieved in Ghana, Kenya, Namibia, South Africa and Zimbabwe. An important driving force of a wide use of PV technology in Africa has been a substantial fall in PV systems' production costs, in addition, funding has been made available for rural solar electrification by bilateral and multilateral donors, such as the World Bank and the Global Environment Facility (GEF).

Although there is no reliable, continent-wide data on the deployment of PV technologies, available information for selected countries indicates growing use in Eastern and Southern Africa.

PV technology has proven particularly successful in high-tech applications, such as communications. It is also a viable alternative for vaccine refrigeration. Vaccines can dramatically improve healthcare provision and, in this respect, PV can play a vital role in delivering direct benefits to Africa's rural poor.

Despite its huge potential, the use of solar water heaters in households and commercial buildings is still limited. Some encouraging developments are, however, underway in North Africa (notably Morocco and Tunisia), Mauritius and Seychelles²⁸. In some Northern African countries, for example, Egypt, LPG or natural gas subsidies make it difficult for solar water heaters to compete, and hence they are not widely deployed.

The proportion of the population depending on biomass²⁹ is highest in sub-Saharan Africa. Extreme poverty and the lack of access to other modern fuels, means that more than 80% of the total African population relies primarily on biomass for its energy needs³⁰. Africa's biomass resources are estimated at 82 billion tonnes³¹. In

²⁵ E.A.K. Kalitsi, *Hydropower Development in Africa, Problems and Prospects*, 2003

²⁶ UNDP/UNDESA/WEC, *World Energy Assessment: Energy and the Challenge of Sustainability*, 2000

²⁷ IEA, *Wind Annual Report*, 2002

²⁸ Stephen Karekezi, *Renewables in Africa - Meeting the Energy Needs of the Poor*, 2002

²⁹ Biomass comprises of solid fuels (wood, charcoal, wood wastes, agricultural residues and dung), gas (biogas, landfill gas and other gases from biomass), liquid fuels (alcohols, bio-additives and other liquid fuels) industrial and municipal waste. In this chapter, traditional biomass refers mainly to non-commercial biomass use, which is largely a solid fuel.

³⁰ IEA, *Energy and Poverty*, 2002

³¹ P.P. Zhou, 2003

Kenya, Tanzania, Mozambique and Zambia, nearly all rural households use fuelwood for cooking and over 90% of urban households use charcoal.

2.3. The Power Sector

The power sector in Africa is similar to other industries. It is still in the early stages of development, since only 34.3% of Africans have access to electricity and only 16.9% of those who live in rural areas are connected to power grids³². Table (2.1) demonstrates the electrification rates of Africa compared to the world average and the large disparity between North and sub-Sahara Africa, and also between the urban and rural population.

Electricity generation is concentrated in a few countries with nearly 82% of installed capacity in Northern and Southern regions³³. In 2001, South Africa produced about 45.8% of the total electricity generated in Africa (465.6 TWh). Egypt is the second largest producer, with about 18% (82.7 TWh). Most of South Africa's electricity is generated from coal (over 90%) while the rest of Africa produces electricity from hydro, oil, gas and geothermal.

Table (2.1): Urban and Rural Electrification Rates (2000)

	Total population (million)	Urban population (million)	Total electrification rate (%)	Urban electrification rate (%)	Rural electrification rate (%)
North Africa	138	74	90.3	99.3	79.9
Sub-Sahara	657	226	22.6	51.3	7.5
Africa	795	300	34.3	63.1	16.9
South Asia & sub-Sahara	2010	608	34.9	61.9	23.2
Latin America	416	314	86.6	98.0	51.5
East Asia/China	1835	633	86.9	98.5	81.0
South Asia	1353	381	40.8	68.2	30.1
Middle East	165	109	91.1	98.5	76.6
Developing countries	4565	1739	64.2	85.6	51.1
World	6035	2828	72.8	91.2	56.9

Source: IEA WEO 2002

³² IEA, World Energy Outlook, 2002

³³ Stephen Karekezi, Poverty and Energy in Africa – A Brief Review, 2002

2.4. Commercial Energy Consumption

Though Africa is home to nearly 13% of the world's population, Africa's share of the world's primary energy consumption is only 3%.

Consumption of commercial energy is highly concentrated in the extreme north and south of the continent. In 2002, North Africa dominated oil consumption: Algeria and Egypt together accounted for 30.3% of total consumption. South Africa's share was 19.9% and the remaining 49.8% was spread among all the other countries.

Gas usage is also heavily concentrated in North Africa. Algeria and Egypt account for 72.6% of the continent-wide gas consumption.

Not surprisingly, coal presents a different picture, whereby South Africa accounts for 90.3% of Africa's total coal consumption.

Nuclear energy is used in South Africa only, with consumption of 2.9 Mtoe of uranium for electricity production.

Electricity use follows the same pattern of concentration in the extreme north and south. South Africa accounts for nearly half (46%) of all the electricity consumed in the continent while Egypt, Libya and Algeria together consume a further 30%. Most of Africa has extremely low levels of electricity consumption, as the annual per capita use in some countries is only 24 kWh. These wide differences in commercial energy consumption closely mirror the disparities of per capita income between different sub-regions in Africa.

Chapter 3: The Need for Regional Energy Integration

The ongoing changes in the world economy and the shift from geopolitics to globalisation are being complemented by a move away from special treatment for individual countries in mitigating their systemic market failures and structural weakness to accelerate their integration into the world economy. This is expected to help manage common problems, which stem from rapid global integration³⁴.

The fragmentation of Africa into many nation states with limited economic, political or geographical coherence, following political independence, led African leaders to embrace regional integration as a central element of their development strategies. The small size of the typical African economy provided the rationale for pursuing mutually beneficial economic cooperation and regional integration, particularly among adjacent states. There is a growing realisation among African countries that progressive integration holds a greater potential for minimising the costs of market fragmentation and thus, represents a precondition for integrating African countries into the global economy. Regional cooperation and integration are also necessary to increase Africa's competitiveness and allow it to maximise the benefits of globalisation. Improving Africa's access to global markets, especially in industrialised countries, is an essential condition, alongside debt relief and official aid.

The vision and commitment of African leaders to the objectives and principles of political and economic cooperation, led them to create the Organization of African Unity (OAU) in 1963 as an instrument for fostering African development and unity. This commitment was later reiterated in the Lagos Plan of Action in 1980 and, subsequently, in the Abuja Treaty of 1991, which envisages the ultimate creation of the African Economic Community.

Regional economic integration has an important role to play in accelerating economic growth and sustainable development in Africa and can facilitate:

- Market expansion, which will promote greater specialisation and faster industrialisation through economies of scale and will help mitigate the problems associated with smaller market size in Africa;
- The growth in domestic and foreign direct investment and the increasing competitiveness of African countries in the world economy;
- Rapid and extensive improvement in economic efficiency through enhanced competition among the participating countries and increased incentives for the deployment of new technologies and methods of production alongside rapid innovation³⁵.

Regional energy cooperation and integration offer one of the most promising and cost-efficient options for developing countries, and Africa, in particular, to further develop their energy sectors, in order to gain the environmental, social and economic benefits from a more efficient use of resources.

Four major benefits are associated with regional energy integration:

³⁴ Keynote address by Professor Adebayo Adedeji, African Forum for Envisioning Africa, Nairobi, Kenya, 26 – 29 April 2002

³⁵ ADB, Economic Cooperation and Regional Integration Policy, 2000

- Improved security of supply;
- Better economic efficiency;
- Enhanced environmental quality; and
- Development of renewable resources.

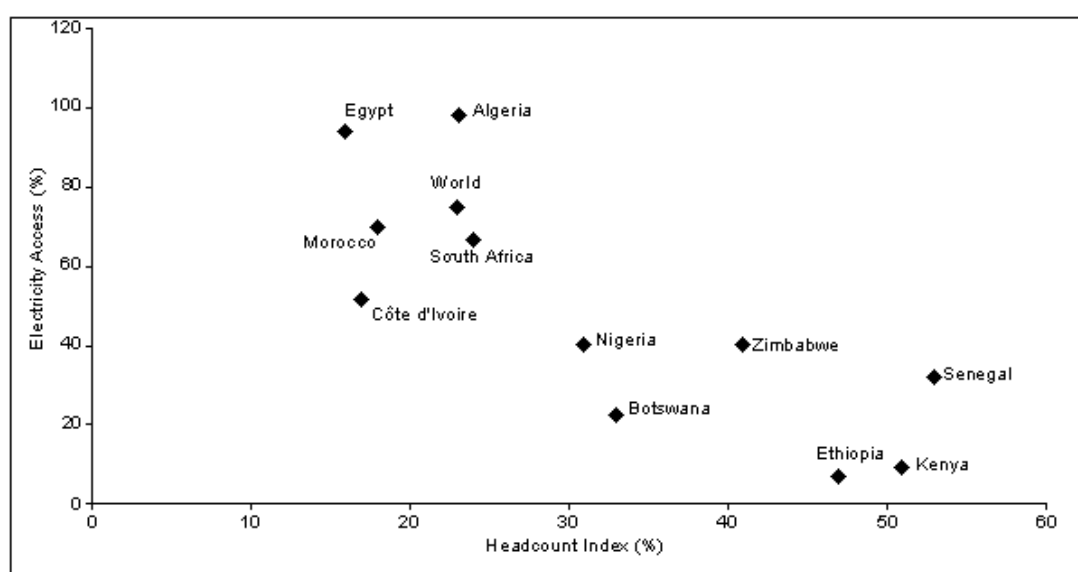
It can also be argued that regional integration and thus regional interdependence enhance peace and stability. Historically, the first two factors have been the driving forces behind power interconnections and regional trading throughout the world. However, with the increasing concern and awareness of the need to integrate environmental considerations in development planning, power interconnections are being considered as a means to develop alternative clean or more environmentally sound energy resources.

3.1. Security of Supply and Accessibility

Access to electricity and other modern energy sources is crucial for economic and social development. Modern energy services are vital to the quality of life. The eradication of poverty requires, among other things, clean water, adequate sanitation and health services, a good education system and a communication network³⁶. None of this can be achieved without energy.

Aggregate data for 2000 shows that the number of people without electricity in the world is 1.64 billion, or 27% of the world's population. Fig. (3.1) shows that electrification rates in Africa are the lowest worldwide³⁷. Lack of electricity is strongly correlated to the number of people living on incomes below US\$1 per day. Similarly, in developing countries, some 2.4 billion people rely on traditional biomass for cooking and heating. Thus extreme poverty and the lack of access to other fuels means that 80% of the African population relies primarily on biomass for their basic needs.

Fig. (3.1): Rate of Electrification and Percentage of Population Under Poverty Line



³⁶ WEHAB Working Group, A Framework for Action on Energy, August 2002

³⁷ IEA, Energy and Poverty, 2002

Regional energy integration has been playing an important role in securing provision of energy services to millions of people in sub-Saharan Africa. At its 3rd meeting held in Accra, Ghana on 5 April 2002, the West African Power Pool (WAPP) Steering Committee adopted Resolution No.1 relating to the “Objectives of the West African Power Pool”. One of these objectives is to increase the overall level of electrification within the region through the implementation of priority generation and transmission projects, as the basis for economic development and the extension of “paid-for” electricity to more consumers.

Another example is the Mombasa-Nairobi petroleum products pipeline, which will be extended from Eldoret in Western Kenya to Kampala in Uganda; with significant cuts in prices for petroleum products shipped to Uganda, and other land-locked regions of north-western Tanzania, Rwanda, Burundi and the Eastern Democratic Republic of Congo (DRC).

Security of supply has been the determining factor in the decision to develop many of the existing power interconnections between countries and regions. Through sharing operational reserves and installed capacity, interconnected power systems were able to avoid additional investment in generating plants. Interconnecting with neighbouring countries or regions provides an alternative supply source for operating reserves and support during emergencies. A good example is the Ghana-Côte d’Ivoire interconnection, where provision of electricity from Ghana is guaranteed during the events of emergency in Côte d’Ivoire. Another example is the link between Algeria and Tunisia, originally established to exchange power in emergency situations in the early 1950s. The drought in the Southern African region in 1992, which resulted in severe electricity shortages due to reduced hydro-electricity generation, also highlighted the need for formal regional power cooperation.

As well as providing access to operational reserves, power interconnections between countries and regions can enhance the diversity of the available sources of energy supply. Rather than relying solely on domestic resources and existing supply infrastructure, an interconnection with other areas can increase system flexibility and reliability by expanding and diversifying the supply portfolio of different energy resources.

The uneven regional and country distribution of Africa’s energy resources, which might create demand/supply imbalances, and the small size of most African economies, suggest that individual country strategies of energy sector development cannot be optimal. This provides a strong impetus for exploring more regionally integrated approaches, in particular, large-scale energy sector projects. A key challenge for sustainable energy development in Africa concerns the optimal utilisation of its enormous energy resources. Their increased use would contribute to improving the rate of electrification and access to modern energy services and help alleviate high levels of poverty in rural areas, and ultimately facilitate sustainable human development in the continent.

3.2. Increased Economic Efficiency

Economic efficiency is one of the three pillars of sustainable development. Energy helps economic development at the local level by raising productivity and enabling local income generation. The availability of jobs, productivity increases or better economic opportunities are all severely limited without access to modern energy.

Interruptions of energy supply, on the other hand, can cause serious financial, economic and social losses. To support the goals of sustainable development³⁸ energy must be available at all times, in sufficient quantities and at affordable prices.

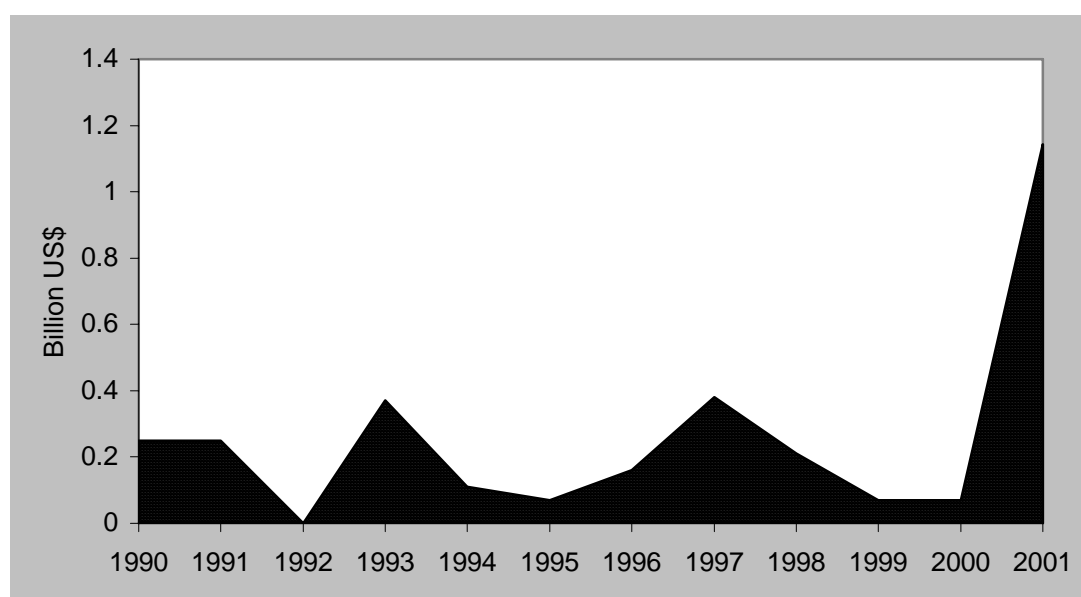
Greater regional co-operation in infrastructure projects such as energy, will reduce transaction costs; facilitate market integration; promote economic integration and growth in Africa, and increase the incentives for investment, particularly by the private sector³⁹.

Improved energy trade and enhanced competitiveness of industries, together with energy integration programmes will contribute to accelerated economic growth; the achievement of the first UN Millennium Development Goal (MDG); the eradication of extreme poverty and hunger; through economic growth and increased availability of electricity for social purposes.

For example, the Republics of Togo and Benin, through their electricity interconnections with Ghana have sustained their economies and guaranteed a minimum quantity of electricity supplied from Ghana for a 25-year period. In addition, there have been opportunities of buying lower cost energy from Ghana compared with local resources.

The energy sector is currently one of the largest sources of foreign debt for many African countries. In addition, investments made in times of higher cost energy infrastructure have contributed to the growth of this debt. Fig. (3.2) shows that during the 1990s, the total World Bank (non-grant) lending to Africa for energy infrastructure projects amounted to approximately US\$3 billion. Naturally, this could have been a major contributor to Africa's debt burden.

Fig. (3.2): World Bank Energy Infrastructure Lending to Africa, 1990s



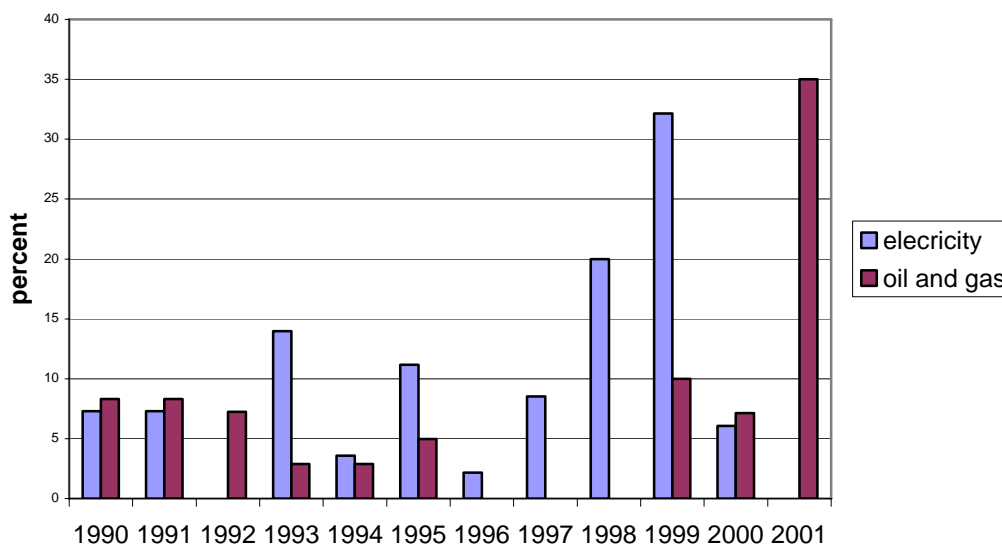
Source: World Bank

³⁸ WEHAB Working Group, A Framework for Action on Energy, 2002

³⁹ Stephen Karekezi, Poverty and Energy in Africa – A Brief Review, 2002

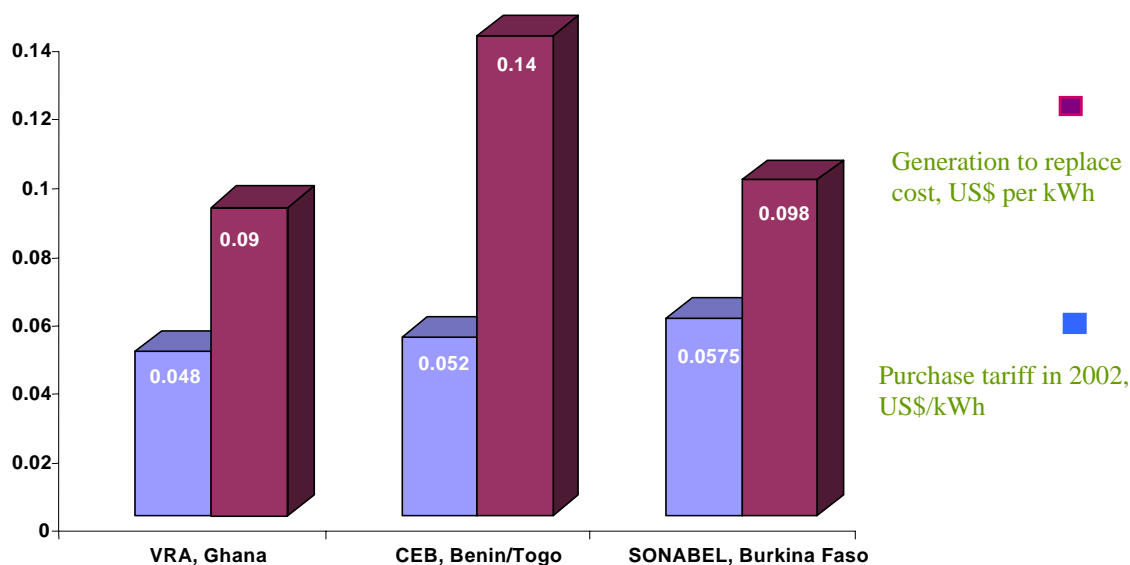
Fig. (3.3) indicates that by early 2001, the share of Africa in the World Bank's natural gas lending reached 35% of the total lending in this sector worldwide.

Fig. (3.3): World Bank Natural Gas Lending to Africa, 1990s



Generally, the economic rationale for regional energy integration is a reduction in the operating costs, and an increase of the generation capacity margin and thus, reduced capital investment in peak capacity. Therefore, the main criterion for evaluating the potential benefits of regional energy cooperation and integration is economic efficiency, minimising the cost of energy supply for a given region. Fig. (3.4) illustrates the cost savings, due to electricity interconnection in the West Africa Power Pool (WAPP). Cost of imported kilowatt hour (kWh) ranges between nearly 37% and 59% of the cost of generated kWh⁴⁰.

Fig. 3.4: Cost Savings due to Electricity Interconnection in the WAPP



⁴⁰ ECOWAS, Ad Hoc Expert Group Meeting 'Assessment of Power Pooling Arrangements in Africa' 24-26 June 2003

Of the total 46 oil refineries in Africa, 9 are located in Egypt; Nigeria, Algeria and South Africa have 4 each, while 17 other countries have a single refinery⁴¹. In terms of refinery capacities, Egypt leads with 726,000 barrels per day, followed by South Africa with 469,000 barrels, Algeria with 450,000 barrels and Nigeria with 439,000 barrels respectively. Regional interconnection provides access to more efficient refineries resulting in considerable savings, in particular to poorer countries. For example, the supply of petroleum products from South African refineries saves other sub-Saharan countries from the need to build their own refineries.

Refining capacity and flexibility in North Africa would particularly benefit from the economies of scale regional integration provides. As a result, Egypt and Libya are planning a pipeline to transport crude oil from Tobruk to Alexandria, to make use of the larger refineries there. The pipeline should be completed in 2005.

The South African Power Pool (SAPP) Planning Sub-Committee (PSC) has developed a twenty-year generation and transmission expansion plan. This plan clearly shows the benefits of coordinated planning and cost reductions that can be achieved, compared to individual utility expansion plans. The coordinated plan requires the expenditure of US\$8 billion, while the sum of the individual utility expansion plans would require US\$11 billion. Thus a saving of US\$3 billion can be achieved through coordinated regional planning⁴².

Power interconnections and regional trade have gained importance as a mechanism for improving the economic efficiency of power systems. The value of the power interconnection is derived from the ability to achieve economies of scale as individual smaller power systems can be operated and expanded as part of a larger regional system. Table (3.1) shows that apart from South Africa and Egypt, many of the African power systems are small, e.g., 24 MW in Seychelles. In addition, most of these systems are also characterised by poor technical and financial performance. Integrating some of these smaller systems into larger regional ones could contribute to improving their economic efficiency.

⁴¹ WEC, *The Potential for Regionally Integrated Energy Development in Africa*, 2003

⁴² IEA, *Key World Energy Statistics*, 2004

Table (3.1): Installed Capacity of Selected African Countries (2001)

Country	Installed capacity (MW)
Botswana	132.00
Malawi	306.00
Namibia	294.00
Seychelles	24.00
Uganda	263.00
Kenya	1193.80
Tanzania	883.00
Zimbabwe	1961.00
South Africa	41,298.00
Egypt	17,800.00

Source: AFREPREN, EIA, 2002

Furthermore, the creation of a regional power pool by a group of small economies is a way of pooling risks, thereby making the development of a country or a region's capital-intensive power projects more attractive to both domestic and international investors, as well as to bilateral and multilateral lenders.

Economies of scale are derived from sharing the responsibility for providing the reserve margin over the entire region rather than for each individual system having to provide its own reserve margin, from the introduction of larger generating facilities for better power quality and lower costs, and the optimisation of investment in power supply infrastructure.

Economic efficiency is improved further, when interconnected regions have complimentary load profiles, on either a daily or seasonal basis.

3.3. Enhanced Environmental Quality

Fossil fuels used in the production of electricity emit SO₂, NO_x, CO₂ and other pollutants. This results in environmental impacts, poor air quality and thereby affects public health and quality of life. At the global level, one of the most serious environmental problems today, is the increase in atmospheric concentrations of greenhouse gases (GHG), which can lead to changes in climate patterns. Although climate change is a global phenomenon, and industrial countries are the principal source of GHGs, the negative effects will be most severe in developing countries. Africa's least developed countries would be most vulnerable to the negative impacts of climate change.

Introduction of clean technologies and reductions in the use of fossil fuels for electricity production is one of the mitigation options for air pollution and GHG emissions control. Wider deployment of renewable energy sources, such as hydropower, solar, wind or geothermal; or switching to natural gas rather than coal or oil would reduce Africa's dependence on high carbon fuels and decrease the corresponding air pollution and GHG emissions.

Africa's substantial renewable energy resources could be a significant driver for regional energy integration. The continent has about 1.1 GW of hydropower capacity, and about 9000 MW of geothermal potential. Development and use of such clean energy sources through regional integration projects would help enhance environmental quality for the African people.

Particularly in sub-Saharan countries, cross-border electricity exchange has evolved around major hydropower resources' development projects. In 1958, the first cross-border interconnection was the 132 kV transmission line linking Uganda's Owen Falls' hydropower station to Nairobi for bulk power supply to Kenya.

Natural gas offers Africa environmental benefits, greater industrial diversity, more prospects for regional cooperation, and new trade opportunities. With regards to the utilisation of natural gas, the main options are either to construct a natural gas pipeline from the energy source to the generation facilities close to the consumption centres or to generate at the wellhead and transmit the electricity through the transmission grid to the load centres. In 2002, Africa produced 8.3% of the world's natural gas. In addition, the major gas producers like Algeria, Nigeria, Angola and Egypt are considering the expansion of their natural gas production capacities. This would help increase the potential of regional trade. Many other factors contributed to the development and planning of cross-border gas pipelines in Africa, they include the growing energy demand and the necessity for oil producers to utilise natural gas resources, most of which historically used to be flared.

Although gas markets are usually established on a country-by-country basis, ultimately regional development becomes an important medium to long-term goal. The Mozambique to South Africa gas pipeline project could be an example of regional integration initiatives. Another regional gas pipeline is the West Africa Gas Pipeline (WAGP) from Nigeria to Ghana through Benin and Togo, which provides economic and environmental benefits to several nations.

In addition, natural gas could also play an important role in cross-border electricity trade from gas-fired generating plants. Natural gas offers an opportunity for developing countries in Africa and developed nations to establish lasting relationships with each other⁴³. A good example of such a trading partnership is the Trans-med project linking Algeria to Italy via Tunisia, and the Maghreb-Europe Gas Pipeline linking Algeria to Spain and Portugal via Morocco and thus reinforcing the country's position as one of the world's leading gas producers and exporters.

Though regional energy integration can achieve considerable environmental benefits, there have been many cases of energy projects that were cancelled in Africa, due to failure to meet environmental requirements. This is mainly due to the environmental standards set by international financing institutions such as the World Bank, as a prerequisite for projects finance.

Examples of these environmental requirements include: placing energy projects such as power stations, dams or refineries away from environmentally sensitive locations or nearby populated areas; avoiding relocation of human settlements to build

⁴³ Regional Electricity Trading: Issues and Challenges, Workshop on Regional Power Trade, Kathmandu, Nepal, 19 March 2001

hydropower stations; and undertaking environmental impact assessments. Epupa on the Namibia/Angola border is an example, and older schemes, such as Manantali in Mali and Kariba on the Zambia/Zimbabwe border have been criticised for their effect on local populations. It is worth mentioning that, though mitigating environmental and social impacts of energy or any infrastructure projects in Africa is important, priorities should be given to achieving a higher degree of energy access to help eradicate poverty and achieve socio-economic development.

3.4. Facilitate Development of Renewable Energy Resources

Renewable energy resources such as hydro, geothermal, or wind are site specific and thus are not easily transportable except through electricity interconnections. For some fuels or resources, such as hydropower, lignite and renewable resources, power interconnection is the only feasible means of making these resources available to other areas. Power interconnections facilitate the development of these diverse energy resources for the benefit of the entire continent. For instance, Africa's huge hydropower potential could be developed for the benefit of the vast majority of Africa's population, if included in regional integration projects. Historically, most of the African power interconnections originated from the development of hydropower projects, including Owen Falls' hydropower station in Uganda (1950s), Kariba North hydropower station on Zambia-Zimbabwe border (1960s), Akosombo hydroelectric dam in Ghana (1960s)⁴⁴. The Inga hydropower station in the Democratic Republic of Congo (DRC), includes a 351 MW plant (Inga 1) commissioned in 1972 and a 1424 MW plant (Inga 2) which has been in operation since 1982. It has been supplying electricity to the Republic of Congo through a 220 kV line linking Inga to Brazzaville, as well as, to other countries in the Southern Africa region through the 500 kV HVDC linking Inga to Kolwezi (Katanga province) and then through the existing 220 kV power line linking DRC to Zambia.

Lastly, local, especially remote small economies can benefit from the initiation of power interconnection projects and the associated power generating facilities. Development of energy resources, such as hydropower, which rely on power interconnections for delivery to major load centres, will enhance the business opportunities of the remote areas through additional employment, tax revenues and other income.

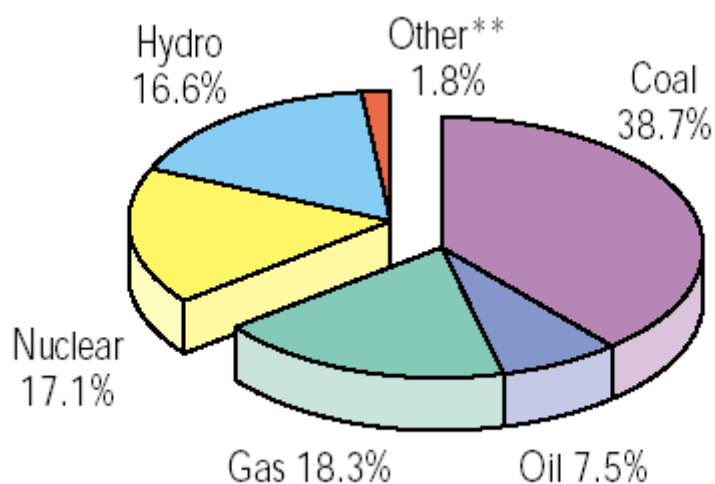
⁴⁴ ECA, Assessment of Power Pooling Arrangements in Africa, 2004

Chapter 4: Natural Gas in Africa

4.1. Introduction

Responding to environmental concerns and to economic and efficiency incentives, developing countries have increased significantly their consumption of natural gas, mainly for power generation. In addition, the electricity industry is taking advantage of recent efficiency improvements in gas-based combined-cycle plants. In 2002, gas-based electricity generation represented 18.3% of the world's total electricity generation, Fig. (4.1)⁴⁵. Combined cycle has been projected to account for 28% of the world's electricity generation mix by 2006⁴⁶.

Fig. (4.1): Fuel Mix of World Electricity Generation (2002)



Source: IEA Key World Energy Statistics 2004

Due to domestic market limitations related to their size and credit-worthiness, and to the significant investments and sizable minimum reserves required to support export projects, natural gas has been substantially underutilised or wasted in many African countries where very large quantities of natural gas associated with oil production are being flared; wasting the resource and causing significant environmental damage. In 2002, 14.1% of the gross gas production in Africa was flared.

The development of commercial markets for such gas will be especially beneficial, both environmentally and economically.

Africa is connected to European gas markets via a pipeline from Algeria, through Tunisia to Italy. At present, a direct Algeria-Spain gas pipeline is under consideration, while a 260 km gas pipeline from Egypt to Jordan is being constructed to supply power stations in Jordan.

⁴⁵ IEA, Key World Energy Statistics, 2004

⁴⁶ <http://www.imia.com/documents/gas.htm#4>

Liquefied natural gas (LNG) has been exported to Europe from Algeria across the Mediterranean Sea for decades. Expanding natural gas exports from Africa will achieve considerable advantages:

- A cleaner environment. Much of Africa's gas development will reduce greenhouse gas (GHG) emissions by using millions of cubic feet of gas a day that otherwise would have been burned off - a double benefit for the environment.
- Economic benefits. Natural gas enjoys a steeper projected growth curve than oil, at least over the next 20 years. This is beneficial for African jobs, investment and local economies.
- Improved regional cooperation. Projects like the West Africa Gas Pipeline (WAGP) distribute economic benefits to several nations, and the success of those projects involves governments and the private sector working together.

Thus, natural gas could play a vital role in Africa's regional energy integration, as well as Africa's integration in the global economy in the long-term.

4.2. Natural Gas Resources

World natural gas reserves totalled 170 trillion cubic meters (tcm) in 2002⁴⁷ whereof Africa holds about 7.6%. Table (4.1) displays the distribution of proven gas reserves in Africa between Northern African and sub-Saharan countries. There are gas resources in another 19 sub-Saharan countries. Half of the gas resources in sub-Saharan Africa are associated with gas produced during oil production, a large share of which is either flared or re-injected to the oil fields. However, the amount of non-associated gas produced remains limited.

⁴⁷ WEC, Survey of Energy Resources, 2004

Table (4.1): Proven Gas Reserves and Leading Gas Producers in Africa (2002)

	Proven reserves		Net Production		Consumption		R/P ratio
	bcm	bcf	bcm	bcf	bcm	bcf	Years
Algeria	4000	141260	79.3	2799	23.3	824	45.0
Angola	113	4000	0.6	22	0.6	22	22.2
Cameroon	110	3900	n/a	n/a	n/a	n/a	67.9
Congo (Brazzaville)	91	3200	n/a	n/a	n/a	n/a	67.4
Côte d'Ivoire	24	845	1.3	47	1.4	50	17.9
Egypt (Arab Rep.)	1657	58500	26.7	941	25.2	891	54.2
Equatorial Guinea	70	2472	1.3	45	1.3	45	29.5
Gabon	33	1165	0.1	3	0.1	3	18.9
Libya/GSPLAJ	1314	46404	6.2	219	5.6	197	>100
Morocco	1	43	0.1	2	0.7	23	20.0
Mozambique	127	4500	0.1	2	0.1	2	>100
Nigeria	5055	178517	14.2	501	6.4	225	>100
Senegal	11	388	0.1	2	0.1	2	>100
South Africa	37	1300	2.3	81	2.3	81	15.0
Tunisia	78	2755	2.2	76	3.8	136	31.2
Total Africa	13010	459449	134.2	4741	70.9	2501	70.4
Total North America	8117	286665	782.6	27639	785.1	27725	9.6
Total South America	6386	224813	89.0	3143	88.7	3135	57.8
Total Asia	16905	596945	386.4	13649	410.8	14502	40.1
Total Europe	53684	1895784	929.8	32839	1002.0	35375	56.1
Total Middle East	71 119	2511569	237.9	8401	216.6	7649	>100
Total Oceania	1330	46 961	40.7	1436	29.8	1005	29.5
TOTAL WORLD	170531	6022186	2600.6	91847	2603.9	91942	59.8

Source: WEC Survey of Energy Resources, 2004

4.3. Natural Gas Production

Total world natural gas production amounted to 2,600.6 billion cubic meters (bcm) and the total production in Africa was 134.2 billion cubic meters in 2002.⁴⁸

In addition to the leading natural gas producers a number of sub-Saharan oil producing African countries also produce gas, which is mostly flared or re-injected to enhance oil fields recovery. Gas flaring and venting is widely practiced in sub-

⁴⁸ IEA, Key World Energy Statistics, 2004

Saharan Africa, and it is estimated that 70% of the associated gas produced is vented by the oil producing companies. Gas is generally disposed of, due to lack of adequate markets or lack of institutional and regulatory framework to support its utilisation, which ultimately represents an economic loss for Africa. Moreover, gas flaring and venting represents an environmental threat by increasing the release of GHGs into the atmosphere, in particular carbon dioxide and methane, responsible for global warming.

4.4. Natural Gas Consumption

In 2002, total world gas consumption was about 2600 bcm of which only 2.7% in African countries, mainly in the gas producing countries such as Algeria, Egypt and Nigeria. Algeria and Egypt together account for about 73% of the continent's gas consumption. For example, daily consumption of natural gas in Egypt is about 0.07 bcm, accounting for about 45% of the country's total energy consumption, which mainly goes to electricity generation. Current estimates show about 1.85 million Egyptian residential and commercial customers of natural gas. Some sub-Saharan African countries consume limited amounts of gas; the highest share is found in Nigeria, where gas represents 22% of primary energy demand, mainly for power generation.

Traditional gas markets (residential and commercial sectors; conventional industry) in sub-Saharan Africa are, and will remain, small. The potential demand of residential and commercial markets is limited to domestic uses (cooking and water heating), which makes the profitability of dedicated gas networks unlikely.

While gas requirements in the conventional industrial sector are not negligible, they are concentrated in a limited number of countries, where the size of the industrial market has reached the critical mass that could trigger distribution projects. An example is the increasing industrial gas demand in Egypt either as a feedstock for petrochemical industries or as a fuel for the cement, ceramic and chemical industries. About 11% of the gas sales in Egypt are being used as a feedstock for petrochemical and fertiliser industries, while 14% is utilised to fuel other industries.

The medium and large-scale industry prefers gas to heavily polluting coal and high sulphur fuel oil. In almost every single industrial branch, gas has in less than three decades become the preferred fuel in those activities where cleanliness, flexibility and easy use are key factors to ensuring high quality output while containing operating costs. This is found in industries, such as food processing and refrigeration, vegetal oil processing, ceramics and tiles, glass and metal surface treatment, cement, etc.

Switching to natural gas is an attractive policy option that allows the saving of economic resources by reducing fuel imports or saving more oil for further exports. A good example of a successful policy is Cameroon, where oil exports have been steadily decreasing for several years. With only about 11 years of reserve to production (R/P) ratio, Cameroon, a long-standing net oil exporter, might become a net importer in the near future, as new oil discoveries do not compensate for field depletion. Although promoting the use of natural gas cannot not reverse the trend on its own (only new discoveries can), developing gas in the industrial sector and for power generation would help the country remain an oil exporter for an extra period of

time, and give international oil companies (IOC) more time to pursue exploration campaigns⁴⁹.

A second example of a successful policy is the case of Egypt. By placing oil with gas, the share of natural gas in the country's hydrocarbon consumption has been increased from 12% in 1981 to 47% in 2001, leading to securing domestic energy supply and compensating for declined oil production⁵⁰.

4.5. Natural Gas Exports

Africa is a net exporter of natural gas. The three major exporters are Algeria, Nigeria and Libya. Nearly 50% of the gas produced in Africa is being exported to the world market, mainly to Europe. In 2002, LNG exports from these three countries accounted for about 23% of the natural gas traded in the world and 52% of Africa's natural gas production. In the same year, Algeria, exporting 2 tcf of gas, provided 16% of Europe's gas imports by pipeline and an additional 31% as LNG⁵¹. More than 85% of Africa's gas exports went to Western Europe, with some LNG exports also going to the United States.

4.6. Natural Gas Market Development

Infrastructure will undoubtedly play a key role in the development of the African natural gas industry. Unlike oil, which can be easily transported by trucks and tankers, gas must be processed just before it is used. Currently, the only two ways to move gas around and out of Africa are through pipelines and liquefaction, a costly but necessary process if Africa wishes to sell gas to more distant markets.

Algeria has a well-developed transportation infrastructure, including 4,300 miles of domestic pipeline and 1,460 miles of international pipeline. The two largest international pipelines are the Trans-Mediterranean pipeline, at 850 billion cubic feet per year (bcf), and the Maghreb-Europe Gas (MEG) pipeline, at 285 bcf per year. The Transmed comprises segments through Algeria, Tunisia and under the Mediterranean Sea to Sicily and mainland Italy, with an extension into Slovenia. Planned upgrades would increase the capacity of the Transmed pipeline to 1.0 trillion cubic feet per year.

The MEG pipeline runs from Algeria to the Iberian Peninsula via Morocco, carrying 350 bcf per year for 1,013 miles and ties into the Spanish and Portuguese transmission networks. At the end of 2004, planned upgrades increased MEG's transmission capacity to 460 bcf per year. The Medgaz consortium also has plans to build a new 279-mile pipeline between Algeria and Spain, to come into operation in 2006.

Egypt is also beginning to export natural gas via pipelines to the Middle East. The first phase of the Middle East Gas Pipeline Project was completed in January 2004, linking the city of Aqaba in Jordan to Egypt's gas distribution network. The second phase will extend approximately 230 miles from Aqaba to a power plant in northern Jordan by 2005. The pipeline could be extended to Syria and Lebanon by 2006.

⁴⁹ ESMAP, Africa Gas Initiative, Main Report, Volume I, 2001

⁵⁰ Egyptian Natural Gas Holding Company, Annual Report 2001

⁵¹ IEA, World Energy Outlook 2002

Despite a 1,000-mile pipeline network, the Libyan grid is inadequate to serve growing demand. There are plans to build additional transmission capacity to serve power generation. Spain is the only current major foreign importer of Libyan gas. Eni (Italy) and the Libyan government energy company have started developing the US\$5 billion Western Libyan Gas Project (WLGP). The WLGP is expected to export 280 bcf of gas per year to Italy and France beginning in 2006, via a 370-mile pipeline under the Mediterranean Sea, mainly for power generation.

Currently, Africa's gas liquefaction capacity includes Algeria's two LNG plants, with a combined annual liquefaction capacity of 23 million metric tonnes of LNG, Nigeria's LNG plant at Bonny Island which has three trains with a capacity of 9.5 million metric tonnes per year, and Libya's LNG facility at Marsa Elberegga.

A number of liquefaction projects are under development in Africa. In Egypt, a consortium of international oil companies has built one of the largest LNG projects in the world. The project has two LNG trains, which each has a capacity of 3.6 million tonnes per year; the first train to be commissioned in 2005 will export its LNG to Gaz de France (GdF) within a 20-years gas supply contract. Another project is an Egyptian-Spanish venture formed to construct the second gas liquefaction plant of 7.56 bcm per year capacity. The plant will be located in Damietta by the Mediterranean Sea to utilise offshore gas northwest of Egypt, while 4 bcm of LNG will be exported annually to Spain⁵².

In Nigeria, two additional trains under construction will add an additional 8.2 million metric tonnes in 2005, and a sixth train has been proposed for mid-2006. Three new LNG plants—West Niger Delta, Brass River LNG and a floating LNG plant—have been proposed. If funded, they would come into operation between 2008 and 2010.

Angola is developing projects to utilise associated natural gas, which is currently flared or re-injected (nearly 83%). The Angola LNG project is expected to come on-stream in 2007. The LNG plant is expected to consist of a single train with annual capacity of producing four million tonnes of LNG. Angola is exploring further uses for the gas, including power generation and gas-to-liquid fuels' project.

Associated gas recovery is an expensive operation. Whether gas is used for re-injection or for export, it requires the construction and the operation of a gas treatment unit where LPG is removed. It is then either re-injected into the reservoirs, or sent through high-pressure pipelines to remote consumers. Benefits from increased oil production, LPG recovery or possible future sales of gas, must be sufficient to bring adequate returns on investments for exports to be considered. Therefore, gas flaring recovery is usually only considered for larger projects, and it is often not chosen for small fields. Such large-scale recovery projects, however, are being implemented in Egypt, Algeria and Nigeria.

The introduction of private sector power producers has opened up a large market potential for development, which can be attractive to gas producers. An example is the 682.5 MW gas-based power plant commissioned in Egypt in 2002, which is located in Sidi Kreer 20 km west of Alexandria.

⁵² Stephen Karekezi, *Poverty and Energy in Africa – A Brief Review*, 2002

Gas demand development could also be driven by more recent applications, which have either already started to be introduced in Africa, such as gas-based power generation, or using compressed natural gas (CNG) as a transport fuel, or which are still under development, such as gas-to-liquid projects. In 2004, South Africa's synthetic fuels and chemicals producer 'Sasol' announced the first delivery from Temane's natural gas fields in Mozambique to Sasol's synfuel plant at Secunda, near Johannesburg.

4.7. The Need for a Regulatory Framework

In light of increasing social needs, such as education and health, governments have begun to realise that the only way to establish gas infrastructure projects is to allow private sector participation. In terms of regulation, most African governments consider that the definition and the implementation of institutional and regulatory frameworks are of a political nature and should remain their responsibility. While most governments are currently not ready to establish independent agencies and to lift all political control over such bodies, several countries now allow and encourage companies that discover gas to develop and operate gas fields, instead of the State presiding over all developments.

Efforts must focus on making the net revenues from marketing gas much more attractive for the operator, than the financial benefits of flaring; an effective institutional framework and regulatory regime are also necessary. In addition, petroleum legislation needs to be protective of State interests and yet be flexible to allow growth and private sector participation. Creating an enabling environment for gas markets, providing incentives to international oil companies (IOC), evaluating and financing projects are possible only with the close co-operation between host governments, IOC and investors, which in turn can be achieved, once a level-playing field has been established.

As far as downstream activities are concerned, dedicated regulation should be put in place. The main areas include: the structure of the gas industry, competitive access to market, and economic regulation (prices and tariffs). In addition, technical, safety and environmental standards should also be developed⁵³.

Therefore, a regulatory framework must be implemented without delay, to organise the gas industry efficiently and to ensure free competition in the market. Institutional reform must accompany the emerging gas industry. On the upstream side, hydrocarbons' laws are generally unclear about the ownership of gas and the responsibilities of the contractual parties. If there is downstream regulation, which is quite unusual, this is done through inappropriate legislation and case-by-case, contractual arrangements. Designing a dedicated gas regulatory framework, including the industry's structure, competition management, access to markets and economic regulation is one of the initial incentives that should be put in place to attract private capital. A number of countries are considering amending their existing petroleum laws, or adopting new laws, that address the various problems related to the development of gas reserves and flaring. An example is the recent evolution of the gas industry in Egypt, where the restructuring of the petroleum sector was followed by the creation of the Egyptian Natural Gas Holding Company (EGAS) and its separation from the Egyptian General Petroleum Company (EGPC) in 2001.

⁵³ UNDP, Human Development Report, 2003

Chapter 5: Hydropower in Africa

5.1 Hydropower and Sustainable Development

As stated in the Implementation Plan of the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002, there is a broad consensus about the necessity to diversify energy supplies by developing advanced, clean, more efficient, affordable and cost-effective energy technologies, including fossil fuel and renewable energy technologies, large hydro and their transfer to developing countries on concessional terms⁵⁴. This specific reference to Item 19e of the WSSD Implementation Plan is seen as an essential mandate for the future role of hydropower. It supports the following:

- Hydropower is renewable and clean;
- Renewables policy should include hydropower of all sizes;
- Attempts to define hydropower as an "old" or "new" renewable are irrelevant;
- Hydropower's deployment (including refurbishment/upgrading) should be increased;
- Depending on the circumstances, there is a role for both large and small schemes;
- Environmental awareness and sensitivity to locally affected people are key aspects.

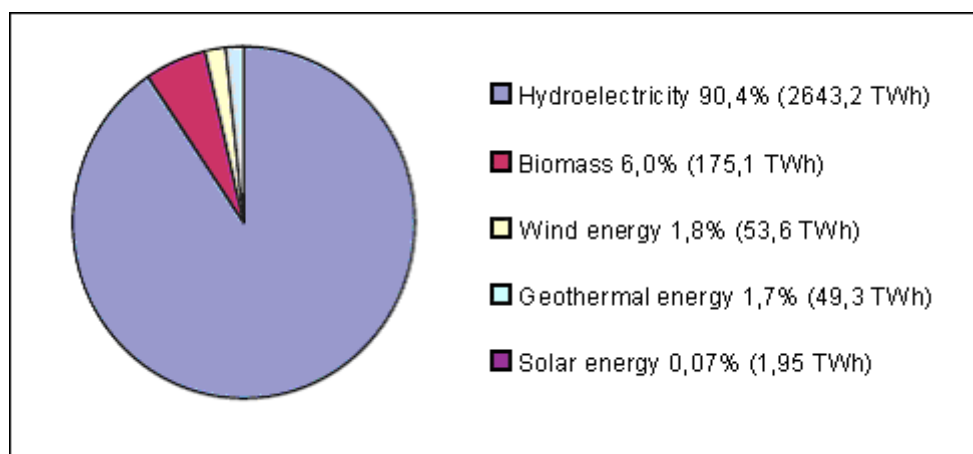
As far as sustainability is concerned, hydropower has a huge potential to improve economic conditions, preserve ecosystems and enhance social justice. Carefully planned, built and operated, hydropower schemes can make a significant contribution to achieving these three pillars of sustainable development. Nevertheless, each individual hydropower project will not necessarily contribute equally to all three pillars, as the positive and negative effects of such projects are site-specific.

More than two-thirds of the world's electricity still comes from fossil fuels, whereas hydropower provides the bulk of electricity generated by renewable sources Fig. (5.1)⁵⁵. This is not expected to change over the next few decades; however, a pronounced shift in the generation fuel mix in favour of natural gas is expected to take place⁵⁶. According to the International Energy Agency (IEA), hydroelectricity will increase by 60% over the projection period, while its relative share will fall.

⁵⁴ WSSD, Johannesburg Plan of Action, 2002

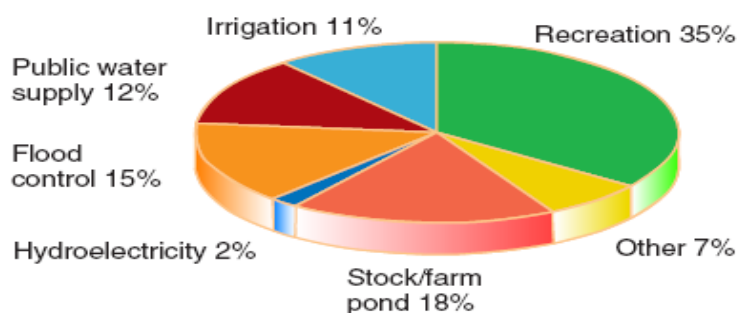
⁵⁵ The Dams Newsletter, No. 2 - May 2004

⁵⁶ IEA, Key World Energy Statistics, 2004

Fig. (5.1): Structure of the World Production of Renewable Electricity in 2002

Source: IEA, Key World Energy Statistics, 2004

More affordable electricity is a necessity, especially in poor developing countries. Therefore, the cost of producing electricity is a fundamental criterion for decision-making. As shown in Table (5.1), hydropower is the least expensive source of renewable electricity. Moreover, the usual type of cost accounting does not include a whole range of secondary benefits; for example, through the multi-purpose nature of reservoirs, hydropower has more non-energy benefits than any other energy source such as water supply, flood control, navigation, irrigation and recreation. Another example, in terms of recreation, hydropower projects in the United States provide the public with more than 47,000 miles of shoreline; 2,000 water access sites; 28,000 tent, trailer, and recreational vehicle sites for camping; 1,100 miles of trails and 1,200 picnic areas, Fig. (5.2)⁵⁷.

Fig. (5.2): Non-energy Benefits of Hydropower Schemes

Source: U.S. Army Corps of Engineers, National Inventory of Dams
Primary purposes or benefits of U.S. dams.

⁵⁷ DOE, Hydropower Today, 2004

Table (5.1): Energy Technologies and their Current Generating Costs

Technology	Costs in US\$
Biomass energy Electricity Heat Ethanol	5-15 cent kWh 1-5 cent kWh 8-25 S/GJ
Wind electricity	5-13 cent kWh
Solar photovoltaic electricity	25- 125 cent kWh
Solar thermal electricity	12-18 cent kWh
Low-temperature solar heat	3-20 cent kWh
Hydroelectricity Large Small	2-8 cent kWh 4-10 cent kWh
Geothermal energy Electricity Heat	2-10 cent kWh 0.5-5 cent kWh
Marine energy Tidal Wave Current	8-15 cent kWh 8-20 cent kWh 8-15 cent kWh
Pulverised coal-steam-electric plant with flue gas desulphurisation	3.2-3.9 cent kWh
Coal integrated gasifier combined cycle (IGCC) plant – air-cooled turbine	3.6-4.2 cent kWh
Coal integrated gasifier combined cycle (IGCC) plant – steam-cooled turbine	3.1-3.7 cent kWh
Natural gas combined cycle (NGCC) plant – air-cooled turbine	3.1–3.4 cent kWh
Natural gas combined cycle (NGCC) plant – steam-cooled turbine	2.9-3.2 cent kWh
Natural gas combined cycle (NGCC) plant – cogeneration facility	2 cent kWh
Diesel engine-generators	6.3-8.5 cent kWh
Spark-ignition engine-generators	6.9 cent kWh
Microturbine generators	4.2 cent kWh

Source: Adapted from UNDP, *World Energy Assessment, 2000*

Hydroelectricity enjoys several advantages over other sources of electrical power, including a high level of reliability, fairly simple, proven technology, high efficiency, very low operating and maintenance costs and the ability to adjust to load changes easily. In order to cope with the fluctuations in power demand, utilities generally combine diverse power plants, the services of which differ in terms of continuity, as illustrated by Table (5.2). Some electricity generating plants are better suited to be operated as base load plants, others as peaking plants. For example, nuclear power plants run optimally at a stable output, making them essentially base-load generators. Hydropower plants may, depending on their design, provide electricity for base or peak demand, or both. This flexibility in energy supply is one of the main technical advantages of hydropower.

Table (5.2): Flexibility and Reliability of Electricity Generating Options

Electricity generation systems	Comments on reliability and flexibility of electricity production
Systems capable of meeting base load and peak load	
Hydropower with reservoir	High reliability and flexibility Many run-of-river plants can rely on an upstream reservoir, and therefore can be considered as having reservoirs
Diesel	High reliability and flexibility
Base load systems with less flexibility	
Natural gas combined-cycle turbines	Mostly base load with high technical flexibility, but high use factors are needed to buy gas at low price, which reduces flexibility
Coal	Mostly base load with some flexibility
Heavy oil	Mostly base load with some flexibility
Hydropower run-of-river	Mostly base load with low flexibility
Biomass	Mostly base load with low flexibility
Nuclear	Base load only, almost no flexibility
Systems designed to meet peak load	
Increased capacity on existing hydropower	Designed to add capacity without adding energy
Pumped-storage hydropower	Designed to add capacity, while reducing total energy
Light oil: single cycle turbines	Adds capacity and energy. Generally low use factor
Intermittent systems that need a backup production (no flexibility)	
Wind power	Needs a backup system with immediate response, such as hydropower with reservoir or diesel.
Solar photovoltaic	

Sources: International Energy Agency (IEA) 2000, Hydropower and the Environment: Present Context and Guidelines for Future Action Vol. I, II, III

Any comparison of power generation options must also take into account the ancillary services, such as reliability, power on demand, a fast “cold” start-up, energy storage in reservoirs, etc. These added advantages make hydropower a possible producer of base load, of peak load, of voltage and frequency regulation, of energy storage and of other services.

Hydropower does not produce emissions that contribute to air quality problems, acid rain and global warming; it is a renewable resource.

Currently, not only does hydropower supply nearly one-fifth of the world’s electricity supply, it by far exceeds the capacity of any other renewable energy resource. Despite the dominance of fossil fuels, in terms of total electricity generated worldwide, more than 60 countries currently use hydroelectricity for 50% or more of their electricity needs. Most of the installed hydroelectric capacity resides in North America, Brazil, Russia, China and Europe. Most of the potential hydropower, however, exists in less developed regions in Asia, South and Central America and Africa.

Demand for electricity worldwide is expected to increase, as emerging economies modernise and developed nations continue along paths of economic growth and prosperity. Some forecasts indicate that total electricity demand in the world will double between 1990 and 2020, i.e., a growth rate of slightly more than 2% per year over 30 years. Tremendous differences in electricity demand per capita exist among

different regions of the world, Table (5.3)⁵⁸. Since only 10% of the African population has access to electricity, the per capita electricity consumption in Africa is the lowest in the world. The growth rates of per capita electricity demand are expected to be greatest in South and Central America, Asia and Africa. Fortunately, the hydropower potential in those rapidly growing regions of the world is also the greatest. Carefully planned hydropower development can make a significant contribution to improving living standards in the developing world.

Table (5.3): Per Capita Electricity Consumption by Region

Country/Region	kWh/year Per Capita
Asia	549
Africa	515
China	1093
Latin America and Caribbean	1511
Non-OECD Europe	2660
Middle East	2642
FSU	3842
OECD	7879
World	2326

Source: IEA, Key World Energy Statistics 2004

5.2. Hydropower Situation in Africa

Two large areas of sub-Saharan Africa are particularly rich in resources for the generation of hydroelectricity: the axis of the great African lakes from Kenya to Zambia, and the Atlantic coastline from Guinea to Angola. These two zones possess nearly 60% of total African hydroelectric resources. The gross theoretical capability of hydro resources in Africa is estimated to be 3876 TWh/yr at the end of 1999, concentrated almost totally in sub-Saharan Africa, with 49% considered technically exploitable. Africa's technically exploitable resources represent about 13% of the corresponding world total⁵⁹. According to the International Hydropower Association (IHA), only 7% of Africa's technically feasible hydropower resources have been developed⁶⁰.

Africa's share of the world's hydroelectricity generated in 2001 was only 3%, Fig. (5.3)⁶¹. Hydropower provides 32% of Africa's primary energy supply, Fig. (5.4)⁶². In many African countries such as Angola, Burundi, Cameroon, Zaire, Congo, Ethiopia, Mozambique, Namibia, Rwanda and Uganda; hydropower is already dominant in electricity production.

⁵⁸ IEA, Key World Energy Statistics, 2004

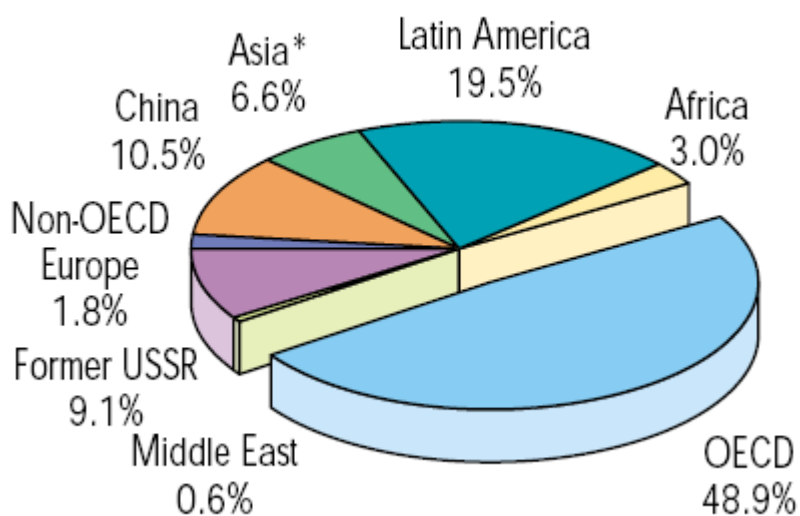
⁵⁹ WEC, Survey of Energy Resources, 2001

⁶⁰ IHA White Paper, 2003

⁶¹ IEA, Key World Energy Statistics 2004

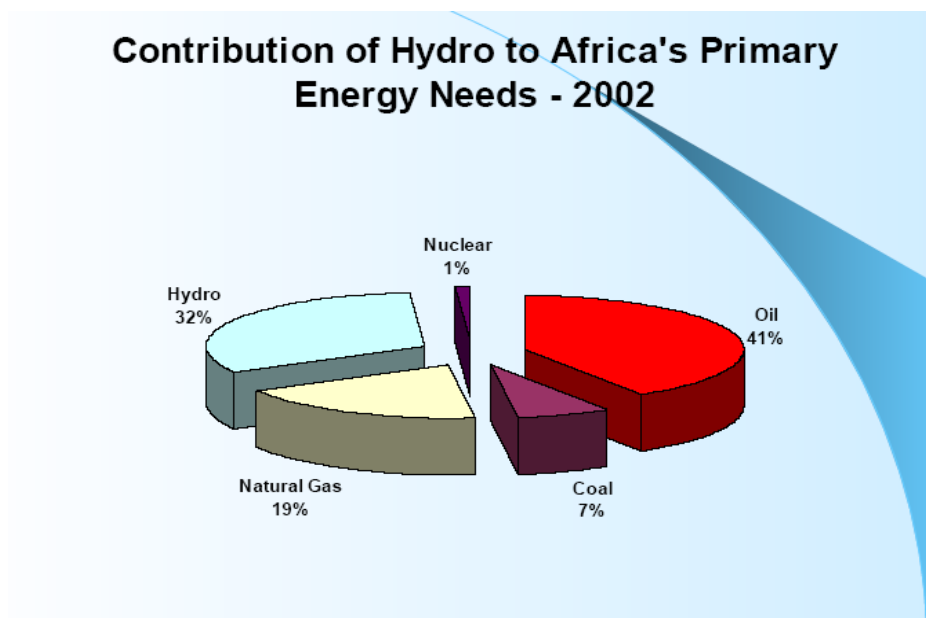
⁶² E.A.K. Kalisti, Hydropower Development in Africa, Problems and Prospects, 2003

Fig. (5.3): Hydro Electricity Generation by Region, 2002



Source: IEA, Key World Energy Statistics 2004

Fig. (5.4): Contribution of Hydro to Africa's Primary Energy Needs - 2002



Source: E.A.K. Kalisti, Hydropower Development in Africa, Problems and Prospects, 2003

Low levels of access to electricity create opportunities for hydropower development in Africa. In addition, there is a vast potential of large hydropower resources in Africa that can be exploited, such as INGA. It would be more efficient to develop these huge resources as regional rather than national projects. This would help expand energy market in these regions, and secure supply to those who presently have no access to electricity. One crucial issue is the need to expand interconnected systems and power pools and develop regional transmission infrastructure for power transmission and market expansion. Proposed regional hydro projects include INGA in the Democratic Republic of Congo (DRC), Kafue Gorge Lower in Zambia, Cabora Bassa in Mozambique, Maguga in Swaziland, Bui in Ghana, and Bujagali in Uganda. Apart from DRC, four countries sharing the Nile basin: Uganda, Tanzania, Sudan and Ethiopia, have considerable indigenous hydropower resources, which are well above the demand of these countries in their present long-term sub-sector planning periods.

Proposed regional transmission projects include upgrade of Zambia-DR Congo-South Africa Interconnection, Zambia-Tanzania Interconnection, Namibia-Botswana Interconnection, and West Africa Grid Network and Power Pool.

It should be noted that major problems facing hydropower development in Africa include high up-front investments and high risks (political, technical, economic, commercial, environmental and social).

5.3. Hydropower: An Engine for Africa's Energy Integration

Africa's huge hydropower potential could be developed for the benefit of the vast majority of Africa's population, in particular as regional integration projects. The Inga Falls hydroelectric power plant today consists of two hydroelectric stations. The 1,725-km high-voltage power line stretches over almost the entire width of the DRC, from Inga Falls in the west of the country to Kolwezi in the heart of Shaba's mining region and Inga Fall-South Africa interconnection as well as the construction of a second power line that will supply power to Kinshasa.

While some African countries and/or regions have excess generation capacity, others are experiencing shortages, with serious consequences for their economic and social development. Although it is technically feasible for each country to develop sufficient energy resources to meet their needs in the medium to longer-term, the economic and environmental efficiencies through regional co-operation would not materialise. Such cooperation would allow under-supplied regions, or countries over-dependent on hydroelectricity, where supply can vary during drought seasons, to have immediate access to a pool of electricity, and to contribute to such a pool when water levels are high. This would facilitate uninterrupted power supply throughout Africa.

The DRC's rivers, with an estimated hydroelectric power potential of 150,000 MW, could provide energy to develop Africa. If harnessed, these hydro resources would meet the demand for electricity throughout Africa. The hydroelectric power potential of the Inga Falls could be developed in phases. Initially the Inga Falls project could reach 3000-5000 MW, or 10% of Inga's total potential, with later phases raising the project up to 39,000 MW⁶³.

⁶³ www.expotimes.net

One of the long-term objectives of development of DRC's hydro resources is to expand the electrification of Africa through interconnections between the various countries, to create one interconnected transmission grid. In line with large-scale development of the hydro resources of central and southern Africa, the transmission line from Inga Falls to Zambia would be upgraded and the western transmission corridor from Inga Falls through Angola, Namibia and Botswana to South Africa developed. A pan-Africa grid would be created between the Southern African Power Pool (SAPP) and the West Africa Power Pool (WAPP). This will require the developing of a DRC-Congo Brazzaville-Gabon-Equatorial Guinea-Cameroon-Nigeria high voltage (HV) transmission line. Another direct connection to the Eastern Africa market is the proposed development of a HV transmission line from Inga Falls to Uganda. In the medium to long-term horizon, there is the proposed link of Inga Falls to Cairo by an HV transmission line from Nigeria, or Cameroon via Chad, Libya and Egypt.

The attempt to tap Inga's energy potential for the overall development of Africa fits well into the thinking that energy access has been identified as a universal priority of the New Partnership for Africa's Development (NEPAD). In this regard, NEPAD specifically states that "energy plays a critical role in the development process, first as a domestic necessity but also as a factor of production whose cost directly affects prices of other goods and services and the competitiveness of enterprises".

According to NEPAD, regionally viable projects are proposed in the context of developing a pan-African transmission grid and the hydro resources of the Inga Falls via development of the Eastern transmission corridor through the completion of the SAPP interconnection network to Tanzania and Malawi, and further extension of the SAPP grid to Eastern Africa through an HV transmission line from Arusha, Tanzania to Nairobi, Kenya. The transmission lines will, in the short-term, enable the wheeling of power from existing excess capacity markets (South Africa, Zambia, Mozambique and the DRC), to existing capacity-short markets (Tanzania, Malawi and Kenya).

In the medium to long-term, these lines will enable the delivery of power from future refurbished and newly developed hydro resources in the DRC, Zambia and Mozambique to Eastern Africa including Kenya, Sudan, Ethiopia and Eritrea. As a second development phase it is proposed to further develop the enormous and stable hydropower resources of central Africa through the refurbishment of existing plants such as the Inga 1 and 2, which would add about 1000 MW, and the development of new plants such as the Inga 3 (1500-3500 MW). In the medium to long-term, a further 40,000-50,000 MW could be added to the Inga Falls' potential.

5.4. Environmental Impacts of Hydropower

While all sites are unique, the environmental impacts of hydropower fall into two main categories: those caused by dams and reservoirs; and those due to the dam operating mode.

5.4.1. Impacts due to Dams and Reservoirs

A. *Upstream of dams, the creation of a reservoir in place of a river valley would flood a vast area of land.*

This would include terrestrial and river ecosystems of various habitat types, including forest habitat. These habitats are replaced by a relatively uniform reservoir, which will usually provide habitat for a much smaller range of species.

B. Changes in downstream morphology of riverbed and banks, delta, estuary and coastline due to altered sediment load.

Much of the impact of dams on downstream habitats is through changes in the sediment load of the river. All rivers carry some sediment as they erode their watershed. When the river is held behind a dam in the reservoir for a period of time, most of the sediment will be trapped in the reservoir, and settle to the bottom, so that water released by the dam will be much clearer, with less sediment than it had previously. Clear water below a dam will recapture its sediment load by eroding the downstream bed and banks. Eventually, downstream river will tend to become narrower and deeper, which will also reduce the diversity of animal and plant life that it can support.

C. Changes in downstream water quality.

When river water is held in a reservoir for a period of time, the quality of the water is affected in several ways: for example, the temperature changes, nutrients are removed, forests are flooded and decompose, and there may be colonisation of the water by aquatic plants. Each of these effects may have an impact on the life that depends on that water. These impacts are generally related to the time the water has remained in the reservoir. Particularly severe effects can occur when a reservoir is initially created, and submerged vegetation and soil decomposes, depleting oxygen in the reservoir water. Deoxygenated water can be lethal to fish downstream.

D. Reduction of biodiversity, due to limiting of movement of organisms and because of changes A, B and C above.

Perhaps the most significant environmental consequence of dams is that they tend to fragment river ecosystems, isolating species populations living up and downstream of the dam and cutting off migrations and other movements, often with great impact on fish populations.

5.4.2. Dam Operation Impacts

The impacts of these changes are magnified by changes in the flow pattern of rivers downstream that is caused by normal operation of dams. These changes, whether in total stream flow, in seasonal timing, or in short-term, even hourly fluctuations in flows, generate a range of impacts on rivers. This is because the life of rivers is usually tightly linked to the existing flow patterns. Any disruption of those flows, therefore, is likely to have substantial impacts.

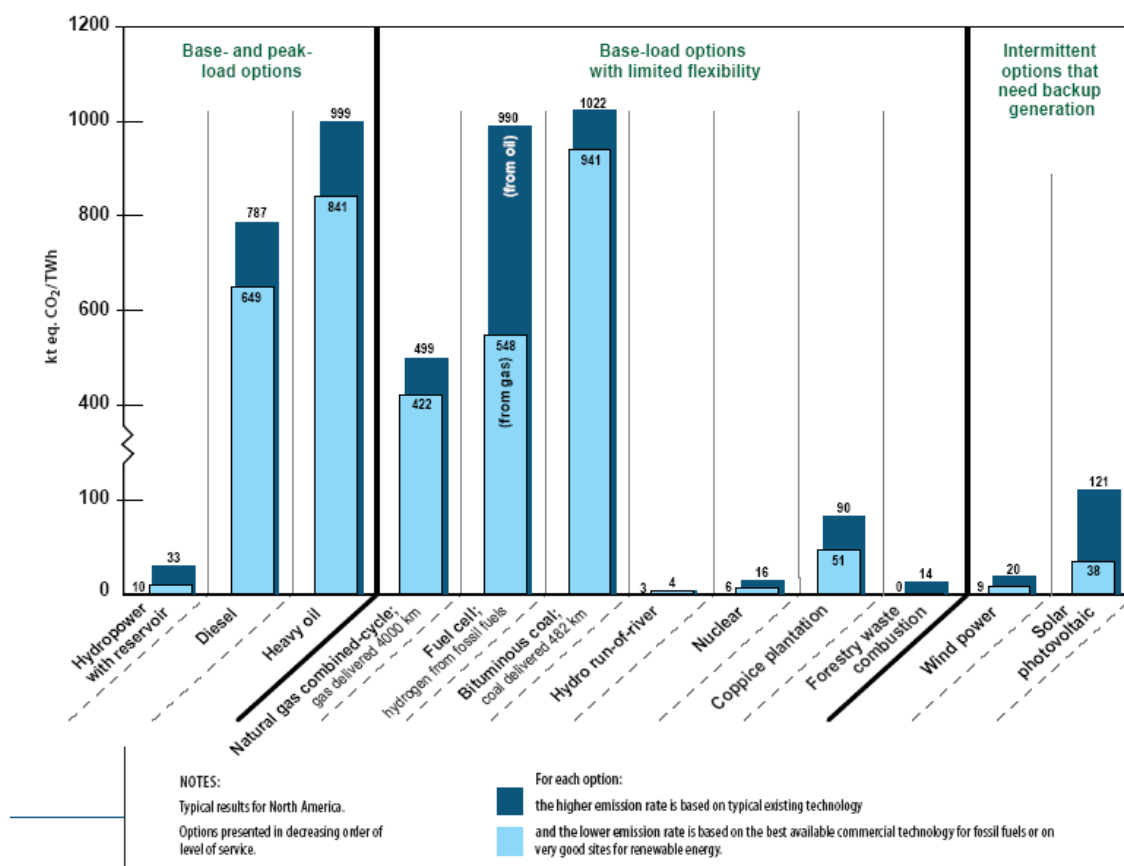
5.4.3. Dams and Climate Change

It has often been argued by supporters of dams that they provide a major environmental benefit, by reducing the need for other sources of electricity, such as fossil plants that generate greenhouse gases (GHG), and therefore contribute to the global climate change. However, in recent years there have been several reports concluding that hydroelectric reservoirs are themselves actually major sources of greenhouse gases. This has been a focus of lively debate⁶⁴. Continued international research confirms that the GHG emission factor for hydro plants is substantially less

⁶⁴ Rosa, Luiz Pinguelli, Roberto Schaeffer, Marco Aurelio dos Santos, "Are hydroelectric dams in the Brazilian Amazon significant sources of 'greenhouse' gases?" Environmental Conservation, 1996,

than the factors for fossil fuel generation, taking into account net emissions from reservoirs. Current initiatives involve the review, validation and standardisation of various measuring techniques and efforts to obtain greater consensus on the processes determining the river-basin carbon budget⁶⁵. Based on life cycle assessment of different generation technologies, hydropower proved to produce less emissions of GHG than other options, Fig. (5.5)⁶⁶.

Fig. (5.5): GHG Emissions from Electricity Generation Technologies



International experience in designing hydropower projects and managing their environmental impacts has identified other major environmental considerations:

- Integrating the preservation of biodiversity and productivity in project design;
- Optimising flow regimes downstream of a reservoir;
- Improving fish passages for valuable migratory species;
- Improving sedimentation management in reservoirs;
- Limiting water quality problems through good site selection; and
- Managing reservoir eutrofication and water contamination problems during operation.

⁶⁵ IEA, Key World Statistics 2004

⁶⁶ Luc Gagnon, Direction – Environnement, January 2003

5.5. Social Impacts of Hydropower

Socio-economic impacts and benefits associated with hydropower projects; particularly in countries affected by political instability, competing water needs and a scarcity of resources are still a global challenging issue. Socio-economic concerns include:

- Poorly managed involuntary displacement of populations and loss of livelihood support traditional ways of life, particularly in the case of culturally vulnerable indigenous groups that are largely dependent on locally available land and natural resources;
- Higher incidences of waterborne or behavioural diseases, particularly among vulnerable communities; and
- Low regional economic development returns and inadequate redistribution of project benefits to affected communities.

Most importantly, dams have led to, the relocation of millions of people, where the economic well-being and health of those affected have declined after being relocated.

Dams can also cause a range of other human-related impacts. Various diseases have spread, as a direct consequence of dams and related projects. Large areas of standing water created by dam reservoirs or irrigation projects provide a good habitat for water-borne disease parasites, such as mosquitoes that spread malaria, which now affects about 300 million people and the number is growing.

For a variety of reasons, the impacts of dams are often felt disproportionately by women. Compensation payments to those displaced by projects are most often made to men, converting the collective assets of families into disposable cash held by the men. Women are also often more dependent on the common resources that are eliminated by dam projects and vulnerable to the social and cultural breakdown that commonly occurs within communities forced to relocate.

However, it is becoming increasingly common to seek effective public participation from the early stages of a project. When the project is considered as an opportunity for the community, the people affected will be able to enjoy a higher standard of living through associated infrastructural developments such as the provision of water and sanitation services. Concerted efforts are being made in this respect in Laos, Uganda, India, China, Japan and Brazil⁶⁷.

5.6. Hydropower, The Way Forward

The debate on hydropower and dams has been both emotional, and to a certain degree counterproductive. There is no single solution that would be valid for all circumstances. The world has different climatic, physical, social, economic and environmental conditions. Countries have different institutional, technical and management capacities; institutional and legal frameworks for development. What is needed is a systemic approach, where the main objectives of energy and water development are identified within the context of sustainable development. The best available alternative to achieve these objectives for the area in question should then be selected. Solutions will be case-specific, and they will vary from one location to

⁶⁷ IEA, Key World Energy Statistics 2004

another, and even at the same location over time. Solutions may include construction of hydropower stations or other alternative energy projects.

The main question facing the developing countries of Asia, Africa and Latin America is not whether large dams have an important role to play in the future, but rather how best we can plan, design and construct them where they are needed. This will ensure that their performance in economic, social and environmental terms can be maximised and their adverse impacts can be minimised, and how we can at the same time ensure that those who may have to pay the costs of their implementation are explicitly made main beneficiaries. This will not be easy to accomplish, but it is nevertheless an essential task⁶⁸.

In assessing future energy supply, policies emphasising sustainability and maximising use of renewable energy to meet future needs are most desirable. The world cannot afford to dismiss any form of renewable energy from the supply mix.

To address this ‘debate’ about dams, the World Commission on Dams (WCD)⁶⁹ was formed and funded by the World Bank and the World Conservation Union. Its twelve commissioners were drawn mainly from representative groups with views for and against dams in the world of water resources and sustainability. They had a two-year brief to examine the development effectiveness and the environmental and social impacts of dams and to publish their findings and recommendations, including guidelines on the future development of dams.

The WCD report⁷⁰ was presented in London on 18 November 2000. In summarising the issues, Nelson Mandela, former President of South Africa, said that for all the problems around dams “the problem is not the dams. It is the hunger. It is the thirst. It is the darkness of a township. It is the townships and rural huts without running water, lights or sanitation”.

The IEA/Hydropower Implementing Agreement⁷¹ has recently completed a comprehensive five-year study on ‘Hydropower and the Environment’. The study analysed virtually all environmental aspects of hydropower and offers a compelling list of recommendations, which address the issues of hydropower development and offer solutions for future development. The analysis covered social, cultural and economic impacts and environment. Considering the potential ramifications of development, the report proposes that a comprehensive approach to planning should be adopted for both existing and future hydro projects. These recommendations, taken cumulatively, could form the basis of guidelines for the development and management of hydropower projects:

- **The need for an energy policy framework**

Nations should develop energy policies, which clearly set out rational objectives regarding the development of all power generation options, including hydropower, other renewable sources, conservation and energy efficiency measures.

⁶⁸ Asit K. Biswas, *International Journal of Water Resources Development*, March 2004

⁶⁹ www.dams.org

⁷⁰ *The World Commission of Dams, Dams and Development: A New Framework for Decision Making*, 2000

⁷¹ IHA, *Hydropower and the World's Energy Future*, 2000

- **The requirement for a decision making process**

Stakeholders should establish an equitable, credible and effective environmental assessment process, which considers the interests of the people and the environment within a predictable and realistic schedule. The process should focus on achieving the highest quality of decisions in a given period of time.

- **A comparison of hydropower project alternatives**

Project developers should include environmental and social assessment criteria when comparing project alternatives, to eliminate unacceptable alternatives early in the planning process.

- **Improving environmental management of hydropower plants**

Project design and operation should be optimised, by ensuring the proper management of environmental and social issues throughout the project cycle.

- **Sharing of benefits with local communities**

Sharing local benefits with local communities, both in the short and long-term⁷².

Congo River to Power Africa Out of Poverty

Nairobi, 24 February 2005 - Plans to harness the power of the mighty Congo River to generate electricity are being drawn up by one of Africa's biggest energy companies.

The scheme, which will initially focus on the Inga Rapids, aims to eventually generate more than enough electricity to power Africa's industrialisation.

Mr Khoza, chairman of the South African-based power company, Eskom Holdings said: "Africa urgently needs energy to lift its people out of poverty and deliver sustainable development. The Congo River offers enormous opportunities for doing this. We calculate that hydro electricity from the Congo could generate more than 40,000 megawatts, enough to power Africa's industrialisation with the possibility of selling the surplus to southern Europe".

He said the idea had been suggested in the past, but that it was now gaining real political momentum under the New Partnership for Africa's Development (NEPAD).

He said the plans envisaged engineering works that would siphon off the river, divert it through electricity-generating turbines, before funneling the water back into the Congo.

At least half if not more of the electricity can be generated in this way that, according to Eskom, makes the project environmentally friendly.

It had also been agreed that the Congo project would qualify for such carbon offset projects that are run under the Protocol's Clean Development Mechanism.

Source: UNEP Press Release, Nairobi February 2005

⁷² <http://www.ieahydro.org/Bur-Recl-web/hydronet.htm>

Chapter 6: Assessment of the African Experience in Regional Electricity Integration

6.1 Introduction

Pooling arrangements within the Southern African Power Pool (SAPP), the first and so far the only operational regional power pool in Africa, have evolved from previously loose pool arrangements dominated by long-term bilateral contracts among vertically integrated utilities towards competitive pool, where bilateral contracts are complemented by the short-term energy market (spot markets). The terms and conditions of most of these agreements have remained unchanged for many years and have not been adapted to suit the new way of doing business in a restructured electric power industry. Recently, transactions in a short-term energy market within a regional power pool have taken place, namely the short-term energy market (STEM) within the SAPP. Thus, the SAPP was initially created as an “association of vertically integrated electric power utilities” representing twelve Southern African Development Community (SADC) member countries. Most of these utilities were already interconnected and had been maintaining a long tradition of close cooperation in electricity exchange.

Therefore, the establishment and operation of the SAPP can be considered as a major achievement and a good example of successful regional electricity cooperation and integration. It serves as a model for other regional power pools in Africa.

This chapter focuses on the issues relevant to regional electricity interconnections especially in Africa. The SAPP was selected, as it is the only operational power pool on the African continent. The aim is to draw some lessons that could be learned from it and applied to the currently planned African regional electricity interconnections especially within the New Partnership for Africa's Development (NEPAD) priority list. In particular, the interconnection between Algeria and Spain has been selected as a potential beneficiary from the experiences of SAPP.

6.2 Historical Background

Experience of development and operation of selected power pools in Europe and the United States indicates that power pooling arrangements have for the most part evolved from simple interconnections between neighbouring utilities to support each other in case of emergencies, into more sophisticated formal legal entities with differing responsibilities in system operation and power market regulation.

In Africa, cooperation in establishing cross-border interconnections and associated electricity exchange can be traced back to the 1950s. Algeria and Tunisia first linked their electricity networks to exchange power in emergency cases in the early 1950s, and a power line was constructed in 1958 to link Nseke in Congo Belge (Democratic Republic of Congo) to Kitwe in Zambia to supply electricity to Zambia's copper mine. This was followed by a number of interconnections linked mostly to the development of major hydropower projects, such as: the interconnection of Kenya and Uganda grids from Owen Falls hydropower station, the interconnection of Zambia and Zimbabwe grids from Kariba South hydropower station, the interconnection of Ghana to Togo-Benin grid through the Communauté Electrique du Benin (CEB) from Akosombo hydropower station, the interconnection of Democratic Republic of Congo

(DRC) from Inga hydropower station, and the interconnection of Côte d'Ivoire to Ghana for electricity supply from Akosombo hydropower station.

6.3 Cross-border Electricity Connections: The South African Power Pool (SAPP)

Utilities tied together by coordination arrangements for the operation and planning of their generation facilities and transmission networks, as if it was a single system, can be considered as forming a “power pool”. A power pool is traditionally referred to as an arrangement between two or more interconnected electric systems, which are planned and operated to supply power in the most reliable and economical manner for their combined load requirements. Pooling total production capacity from all the power plants facilitates the dispatching of excess capacity from one system to another. That is why a power pool is also defined as an arrangement where outputs from different power plants are “pooled” together, scheduled according to increasing marginal cost, technical and contracts’ characteristics and dispatched according to this “merit order” to meet demand. According to this definition, centrally dispatched power pools are expected to achieve increased efficiencies by selecting the least-cost mix of generating and transmission capacity, by coordinating maintenance of units and by sharing operating reserve requirements.

The Southern African Power Pool (SAPP) was created in August 1995 when a majority of member countries of the Southern African Development Community (SADC) signed an Inter-Governmental Memorandum of Understanding (MOU). Later in the year, an Inter-Utility Memorandum of Understanding was then signed by the national utilities of the SADC countries that were signatories to the MOU, membership to the SAPP is limited to the national utilities of the twelve continental members of SADC. The twelve SAPP members are listed in Table (6.1).

Table (6.1): Members of SAPP

Country	Utility	Status
Angola	Empresa Nacional de Electricidade (ENE)	Non-Operating
Botswana	Botswana Power Corporation (BPC)	Operating
Democratic Republic of Congo	Société Nationale d'Electricité (SNEL)	Operating
Lesotho	Lesotho Electricity Supply Commission (LEC)	Operating
Malawi	Electricity Supply Commission (ESCOM)	Non-Operating
Mozambique	Electricidade de Moçambique (EDM)	Operating
Namibia	Namibia Power (NamPower)	Operating
South Africa	South Africa's Electricity Supply Commission (Eskom)	Operating
Swaziland	Swaziland Electricity Board (SEB)	Operating
Tanzania	Tanzania Electricity Supply Company (Tanesco)	Non-Operating
Zambia	Zambia Electricity Supply Corporation (ZESCO)	Operating
Zimbabwe	Zimbabwe Electricity Supply Authority (ZESA)	Operating

Due to the fact that some of the SAPP members are not yet connected to the grid, membership is divided into operating and non-operating members. Operating members are those utilities, which participate in the operation of the power pool. Non-operating members such as Angola's ENE, Malawi's ESCOM and Tanzania's TANESCO participate in all activities, except those related to operation of the power pool. Given the increasing activity of independent power producers (IPP) and independent transmission projects (ITP), it was deemed necessary to give these new entrants into the regional energy market at least an observer status. Thus, an observer may be a utility within the SADC region (but not a national power utility) or a non-SADC power utility.

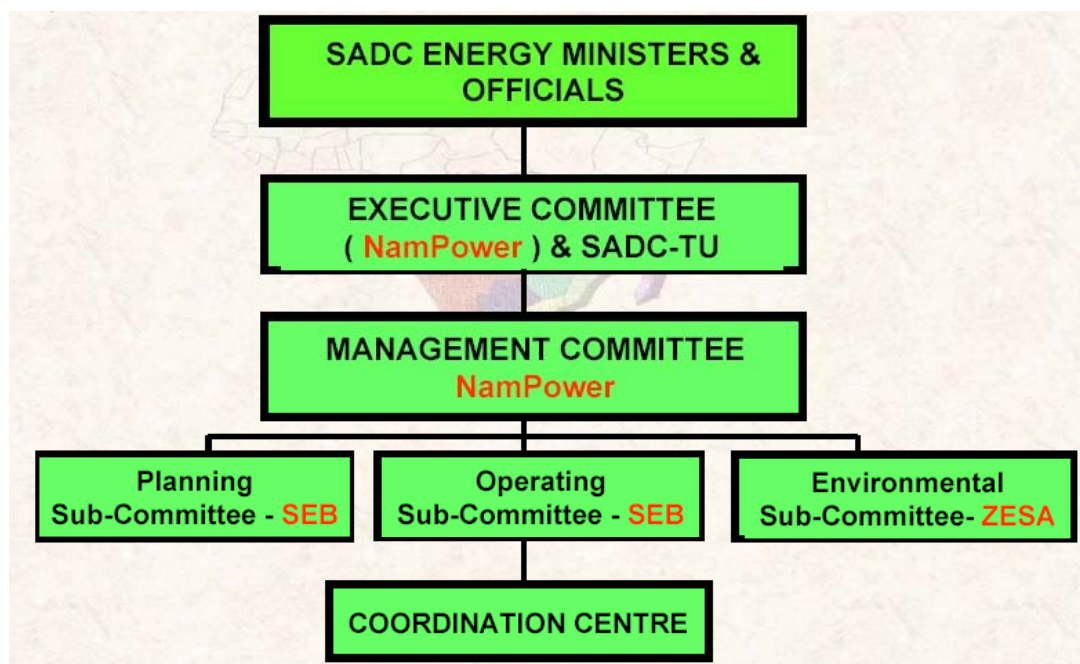
6.3.1. SAPP Governance

The Southern African Power Pool (SAPP) can be defined as an “Association of 12 member countries represented by their respective electric power utilities organised through SADC”, and is based on agreements rather than the law. The SAPP is governed by four agreements: the Inter-Governmental Memorandum of Understanding (MOU), which enabled the establishment of SAPP; the Inter-Utility Memorandum of Understanding, which established SAPP's basic management and operating principles; the Agreement between operating members, which established the specific rules of operation and pricing; and the Operating Guidelines, which provide standards and operating guidelines.

The Inter-Governmental Memorandum of Understanding (MOU) establishes that the SAPP agreements must be interpreted in a manner consistent with the SADC treaty and that the final and binding dispute resolution forum is the SADC Dispute Resolution Tribunal. The energy ministers are responsible for resolving major policy issues in the SAPP and for admitting new members to the pool.

The SAPP is organised under the Executive Committee, which acts as the board of directors of the pool, and a Management Committee, which oversees the administration of the pool. Three subcommittees serve under the direction of the Management committee: the planning subcommittee (which focuses on reviewing wheeling rates annually and developing an indicative SAPP expansion plan every two years), the operating subcommittee and its associated coordination centre, and the environmental subcommittee. The co-ordination centre is responsible for such tasks as undertaking most pool monitoring activities, carrying out operating and planning studies, determining transfer limits on tie-lines, administering a regional database, disseminating maintenance schedules, providing technical advice, and seeking funding for its needs, Fig. (6.1).

The SAPP is designed to operate as a “loose pool”. Each utility maintains full authority and responsibility for its own generation and transmission system. However, a coordination centre located in Harare, Zimbabwe, monitors compliance of the SAPP utilities with the various operating rules, and administers a short-term energy market, which began in 2001. It is a day-ahead market for exchange of surplus energy at a low price. Loose pools emphasise the constant exchange of information, in order to maximise both the economic and reliability benefits from trading and system autonomy. Loose pools may provide central services including: producing continuous, real-time data to match generation and demand, developing indicative expansion plans, and implementing emergency procedures. Loose pools also establish detailed common design and operational standards to ensure system security, reliability and to facilitate trades.

Fig. (6.1): SAPP Structure

Source: Dr. Lawrence Musaba, *Assessment of Power Pooling Arrangements in Africa*, Addis Ababa, Ethiopia JUNE 24-26 2003

6.3.2. The SAPP Pooling Arrangements

The SAPP agreements state the purpose of the pool as, allowing its members to coordinate the planning and operations of their systems whilst maintaining reliability, autonomy and self-sufficiency and to share in the benefits of operating the pool, reduction in required generating capacity and reserves, reduction in fuel costs and improved use of hydroelectric energy. The objectives include: reduction in investment and operating costs and enhancement of the reliability of supply through providing opportunities to coordinate the installation and operation of generation and transmission facilities. Under SAPP agreements, each member must meet its accredited capacity obligation, a requirement that each utility have sufficient capacity to cover the forecast monthly peak. Each member is also obligated to supply emergency energy for up to six hours, to provide automatic generation control and other facilities in its control area, to allow wheeling through its system where technically and economically feasible, to submit maintenance schedules, to disclose information and costs related to thermal generating facilities, and to contribute towards the coordinating centre's costs.

A key element in the operation of the pool is the SAPP pricing arrangement, set out in thirteen detailed schedules in the operating agreement. These schedules cover four broad types of transaction: firm power contracts of varying duration; non-firm power contracts of varying generating reserve; emergency energy and control area services; and scheduled outage energy, energy banking and wheeling.

6.3.3. Market Operations within the SAPP

Within the SAPP, regional electricity cross-border trading is governed by fixed co-operative bilateral agreements, generally of a long-term duration. Since April 2001,

the Short-Term Energy Market (STEM) was introduced and is designed to work over and above the long-term bilateral contracts. The main features in the STEM for power sharing are that the available resources are shared equally to all qualified bidders of energy. The energy dispatch is bid-based, and will be replaced soon by a cost-based system.

6.3.4. SAPP Challenges

While the performance of the SAPP operation and effectiveness of related pooling arrangements could be considered as satisfactory, there have been a number of challenges that have been faced by SAPP since the beginning. The challenges include:

- Language of communication – SAPP members speak different languages: English, French and Portuguese. This situation created some operational and communication difficulties.
- Legal framework – SAPP member countries have had different legal frameworks. As national regulatory agencies develop and begin to assert their authority, there is a risk that they might not be sufficiently attuned to the needs of the regional market, thus forming trade obstacles. A regional regulatory body should be created as a matter of urgency to deal with such challenging issues as: rules for access to transmission grid, transmission pricing, facilitation of competition, stimulation of regional trade and incentives for the development of the regional transmission grid system.

Current and future challenges include:

- Power sector reforms and restructuring – because of the power reforms and restructuring taking place in member states, member utilities may cease to exist in their present form.
- The governance and membership of SAPP was initially derived from the desire for economic co-operation. The socio-economic and political context under which SAPP now operates has significantly changed.
- Competitive vs. co-operative pool – The SAPP is faced with the challenge of moving from a co-operative pool to a competitive pool and eventually into a spot market.
- SAPP interconnections – SAPP will need to interconnect all members into the grid. There is a need to invest in high-capacity tie lines on the interconnected grid system allowing increased transactions on the STEM, thereby accelerating the transition to the regional spot market.
- Development of a consistent approach to transmission capacities access in the region. This is a major challenge facing the SAPP, due to the increased interest shown by both independent power producers and independent transmission projects to invest in the region. In order to meet this challenge, the SAPP will have to find ways to finance extensions and harmonise the existing grid networks of the twelve member states. The success of the SAPP, to a large extent, will be dependent on its ability to find financially viable and sustainable ways of doing this.

- Generation capacity – The SAPP generation capacity expansion plan is expected to run from 2008-2009. If no investment is made now, the region will face serious problems. Attracting private investment is essential.

6.4 Lessons Learned

Since the Southern African Power Pool (SAPP) is the only functioning power pool in Africa, a number of lessons could be drawn from its development and operation. In 2002, the UN Economic Commission for Africa (ECA) published a report entitled “Assessment of power pooling arrangements in Africa”⁷³ from which a number of lessons could be drawn. These lessons include:

6.4.1 Evolution from Bilateral Interconnection to Regional Power Pool

In Africa, power pooling through the establishment of regional power pools is a recent phenomenon, although cross-border interconnections and inter-country bilateral electricity exchange can be traced back to the 1950s. A key characteristic of these bilateral agreements is that they were signed between vertically integrated utilities, performing the three main functions of generation, transmission and distribution simultaneously. Arrangements governing these inter-utility electricity exchanges did not provide for coordinated planning of generating capacity expansion, in order to maintain and improve the reliability of the interconnected system. Therefore, utilities tied together by simple interconnections and related bilateral electricity supply agreements were not forming power pools. However, these bilateral arrangements deserve the credit of helping to build confidence and trust among contracting parties, thereby serving as a basis for creating regional power pools.

6.4.2 Political Will and Commitment

For any cross-border electricity interconnection proposal to materialise the partners’ involved and affected stakeholders must address major technical and non-technical issues and concerns. Regional cooperation and the recognition of a certain level of mutual dependence with regards to development of energy resources will be necessary. Political will and support will become increasingly important as the parties work through these issues.

The collection of electricity import bills constitutes one of the most critical problems in bilateral power trading arrangements. One example is the dispute over settlement of outstanding bills by Ghana’s VRA to CIE (totalling US\$35 million by end of June 2002). However, since the contracts signed between the IPP and the Government of Côte d’Ivoire are of the “single-buyer model” type, CIE has continued to supply electricity to VRA, whilst waiting for political intervention for the settlement of its outstanding bills for VRA’s electricity imports.

SAPP agreements incorporate the SADC treaty, the SADC dispute resolution tribunal, the SADC energy ministers, and the Technical and Administrative Unit. The SADC and its predecessor, the Southern African Development Coordination Conference, served as a focal point for the promotion of regional integration, facilitating investment in projects (such as interconnection projects) that allowed increased regional power trade. The momentum for regional integration, including increased power trade, was further strengthened by the emergence of more democratic governments in several countries and the cessation of hostilities in others. Having at

⁷³ The lessons drawn from SAPP experience are primarily based on the findings of this study

least one country or partner, (i.e., South Africa) act as a driver, or a champion encouraging more passive parties has also been helpful.

6.4.3. The Regulatory Regime

As national regulatory agencies develop and begin to assert their authority, there is a risk that they might not be sufficiently attuned to the needs of the regional market. Experience in other countries shows that although a pool can operate where regulatory regimes differ, as they do among SAPP countries, opportunities for playing the market, or creating unfair advantage, due to differences in regulatory systems can undermine members' willingness to participate. National-level regulations should be carefully drafted so that the agency jurisdictions are properly defined, directed and controlled, in order to avoid regulatory obstacles to trade. Although the SAPP co-ordination centre has been playing a key role in technical regulation and conducting studies on system operations, including wheeling charges and other transmission access issues, there is still a need for a regional regulatory set-up to deal with energy pricing matters and dispute resolution. Indeed, regulatory bodies are at different stages of development in most of the SAPP members, and the SADC Energy Ministers approved the establishment of the Regional Electricity Regulatory Association (RERA) at their meeting held in Kinshasa, DRC, in June 2001. An independent regional regulatory agency would supervise the creation of an effective system for resolution of disputes and enforcement of the regulations; create effective communication with member state governments, regulators and utilities; enforce standard technical rules for the management of trade on the interconnected grids; and review bulk power transactions to analyse their efficiency and monitor their vulnerability to anti-competitive conduct.

6.4.4 Existence of a Dispute Resolution Mechanism

Access to the transmission grid is open to all SAPP members and independent power producers (IPP) in the SADC region. Wheeling charges are, however, payable by the buyer of electricity. An interim wheeling rate of 7.5% of the energy price was decided by the SAPP Executive Committee and enabled remarkable cross-border electricity exchanges under bilateral agreements in the region. This interim wheeling rate should be replaced by wheeling charges based on the MW-km method. The application of the interim wheeling rate has often led to dispute over modalities of sharing of wheeling revenues. This was the case for a dispute that arose between the Botswana Power Corporation (BPC) and the Zimbabwe Electricity Supply Authority (ZESA), concerning appropriate sharing of wheeling revenues for power flowing between ZESA and Eskom, a portion of which flows through the BPC 220/132 kV system. It was agreed that about 8% of the power flowing between ZESA and Eskom would be subject to a wheeling charge to be collected by BPC.

Successful regional integration of electricity systems requires a framework for transactions to take place, arrangements for system operations, a system of tariffs for use of transmission infrastructure, and agreed principles and procedures for dispute resolution. An acceptable legal framework or a binding legal agreement between members should be put in place. Within the legal agreement, a mechanism to resolve disputes should be clearly outlined and arbitration procedures should also be included. Members should be encouraged to abide by the agreements.

6.4.5. Development of Pool Infrastructure

Improving reliability of supply within an interconnected system implies, amongst other things, that there is an adequate generation and transmission capacity available

to meet projected customer needs for electricity, in addition to reserves for contingencies. Utilities and/or organisations involved in production and transmission of electricity must therefore ensure that the power generation and transmission capacities are adequate to meet demand. They should also carry out planning of power generation and transmission expansion in an integrated and coordinated manner.

Most of the SADC bilateral agreements for electricity exchange, between state-owned vertically integrated utilities are based on least-cost power generation from some of the major hydroelectric power stations. Exporting utilities and independent power producers (IPP) have for decades continued to rely solely on the generating capacity of these hydropower stations, without considering any new investment in power generation expansion. As a result, some utilities have faced problems in meeting their contractual obligations for continual electricity supply to their importing partners.

In addition, the most pressing requirement of the SAPP (and Africa in general) remains the need for new and upgraded infrastructure, in order to facilitate power-trading transactions. Improved regional transmission network with high-capacity power lines would increase reliability and security of supply by facilitating diversification of sources of supply, removing energy flow bottlenecks and thereby ensuring better transmission congestion management. One of the most critical bottlenecks for bulk power transmission on the SAPP grid is the Zambia-DRC tie line, which limits the transfer capacity from Inga power stations to 210 MW. Zambia and the DRC are to upgrade the existing interconnection to a more higher transmission level to allow other SADC countries to tap into Inga's energy supplies.

Thus, conditions that must be met before full coordination of a power pool is made possible, would include:

- The necessity for high-capacity inter-system tie lines among the participating systems, in order to realise the benefits from the optimum capacity and energy transfers. These inter-system tie lines also contribute to improved system reliability;
- The need for a central dispatching headquarters to coordinate the operation of the member systems, in order for maximum benefits of the high-capacity tie lines to be obtained. The central office should be responsible for the accounting and allocation of savings and costs to the member systems, in accordance with the principles found in the formal agreement under which the pool operates. It will be responsible for such tasks as undertaking most pool monitoring activities, carrying out operating and planning studies, determining transfer limits on tie lines, administering a regional database, disseminating maintenance schedules, providing technical advice and seeking funding for its needs;
- The need for committees to have a working agenda, for example:
 - An administrative committee to set policy and to oversee activities of the other committees;
 - A planning committee to coordinate planning of major facilities; and
 - An operating committee to establish policies and practices of day-to-day operation and to schedule maintenance outages of major equipment.

6.4.6. Investment Environment

Utilities involved in bilateral electricity exchange agreements have also continued to carry out power system expansion planning from a national self-sufficiency rather than an inter-country perspective. This can lead to generation capacity constraints due to under-investment in some cases, while there is over-investment in other cases. Failure to finance power pool expansion plans could be a potentially serious threat to the sustainability of the pool operation. For SAPP, US\$15 billion of new investment is required by 2006, whereof only 27% will be self financed and the rest should be secured from the private sector, the World Bank and other development agencies⁷⁴. Member countries should put in their best efforts to attract investments in power generation and transmission. On the other hand, power sector reform including authorisation of private sector participation in the electricity supply industry as independent power producers (IPP) can result in timely power generation expansion. For example, Côte d'Ivoire succeeded to attract private investment for two IPP projects, which enabled it to have excess generating capacity, and a net exporter of energy in the West African region.

Historically, the investment climate in Africa has not been conducive to the flow of foreign direct investments (FDI). During the 1980s, FDI inflow to Africa accounted for only 2-3% of the total inflow to developing countries⁷⁵. Foreign direct investment flows to Africa increased from US\$11 billion in 2002 to US\$14 billion in 2003. The region's share in global FDI flows at around 2%. New opportunities in the oil sector, the ongoing privatisation programmes and the implementation of regional and inter-regional free-trade initiatives should allow for a moderate increase in FDI. FDI to Africa has mainly been limited to raw materials sectors. Oil-producing countries, particularly Algeria, Angola, Chad and Nigeria have been the main beneficiaries. FDI inflows to Africa are expected to continue to grow, although they will most likely be concentrated in South Africa and in the oil-producing countries. The obstacles to FDI in Africa are still numerous and formidable. According to a survey of transnational companies, the worst impediments are corruption, extortion and bribery, with almost 50% of companies stating this as a major deterrent, Table (6.2). Poor links with global markets, an uncertain political outlook and the lack of access to financing have been identified as other serious impediments to investment, particularly outside the natural resources sector. The most attractive countries for FDI are those with large markets such as South Africa, Egypt, Morocco and Nigeria, and those that have addressed barriers to investment by improving their business environment such as Ghana, Ethiopia, Mauritius, Mozambique, Tanzania and Uganda, Fig. (6.2).

⁷⁴ Francis Masawi Transmission Director, ZESA. Chairman, SAPP Management Committee, 1999

⁷⁵ ECA, Reviving Investment In Africa: Constraints And Policies, 1995

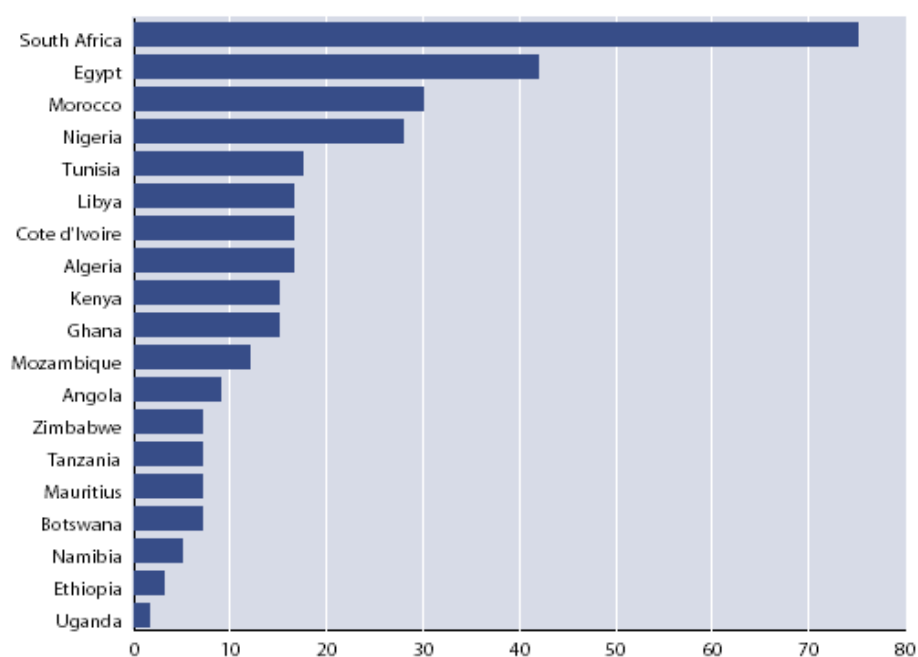
Table (6.2):
Obstacles to FDI in Africa as perceived by TNCs, 2000-2003 (%)

Determinants with negative influence on FDI decisions	
Determinants	Share in overall responses (%)
Level of extortion & bribery	49
Access to global markets	38
Political & economic outlook	27
Access to finance	27
Administrative costs of doing business	27
State of physical infrastructure	25
Tax regime	24
Access to low-cost unskilled labour	24
Regulations and legal framework governing FDI	22
Access to natural resources	21
Access to skilled labour	21
Investment incentives	21
Size of local market	17
Profitability of investment	16
Trade policy	14
Access to regional markets	13
Growth of local market	11

Source: ECA, from official sources.

Fig. (6.2):

Most attractive African countries for FDI as perceived by TNCs, 2000-2003
 (% share in overall responses)

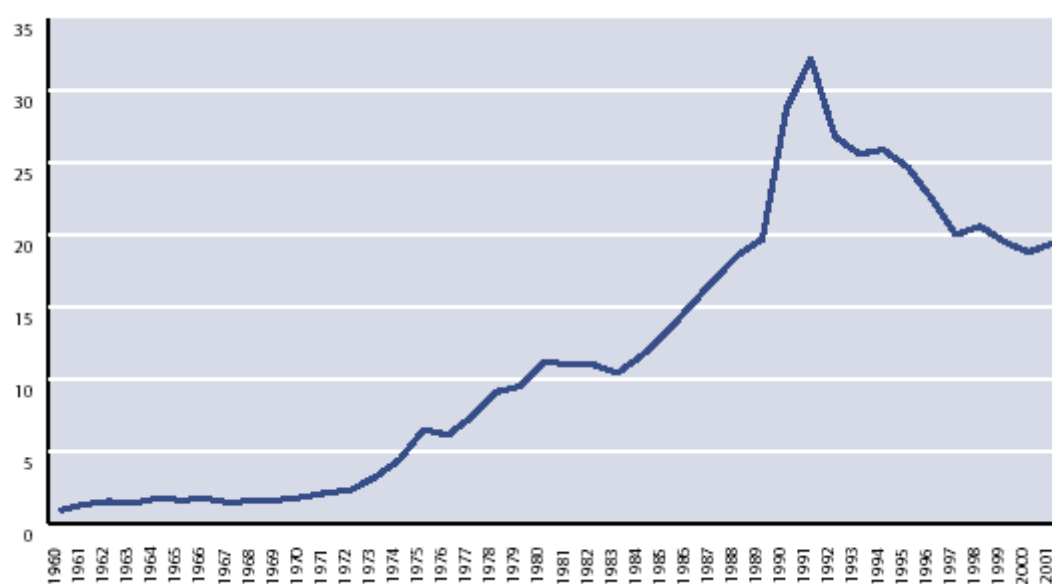


Source: ECA, from official sources

Overseas Development Assistance (ODA) can also contribute to improving infrastructure in Africa. After ODA flows to Africa in 2000, fell to US\$18.8 billion, they increased to US\$19.4 billion in 2001, ending a long period of decline that commenced in the early 1990s, Fig. (6.3). Africa is, however, designated to receive up to half of the additional funds that were pledged at the Monterrey Conference in 2002. In 2001, multilateral donor contributions to Africa improved with an increase of 32.7% over the previous year. The World Bank's International Development Association (IDA) is the biggest donor to Africa and has increased its contributions since 1999. In 2001, IDA flows totalled US\$2.3 billion, with most going to sub-Saharan Africa (SSA). On the bilateral side, the UK almost doubled its aid flows to Africa between 1995 and 2001; about 96% of its ODA to Africa was targeted to SSA in 2001. The US has also increased aid flows to SSA since 1996, although 32% of US net flows to Africa go to Egypt, on account of its important geo-strategic position⁷⁶. Most bilateral ODA flows to Africa in 2001 went to social sectors, ODA flows to transport, communications and energy have decreased by 48% since 1998. This trend is worrying given the crucial role of infrastructure in economic growth and poverty reduction, Fig. (6.4).

Fig. (6.3):

Recovering ODA flows: total flows to Africa, 1960-2001 (\$US billions)



Source: OECD, 2003b

In recent years, Africa has seen rising private and falling public investment, in terms of gross domestic product (GDP), Fig. (6.5). Private investment rose from 13.1% of GDP in 2000 to 15.3% of GDP in 2001, while public investment fell from 6.4% of GDP to 5% of GDP, in a continuation of trends seen through the 1980s and 1990s. The higher share of private investment in GDP shows that gradual progress is being made in the development of the private sector. However, barriers to private investment in Africa still include:

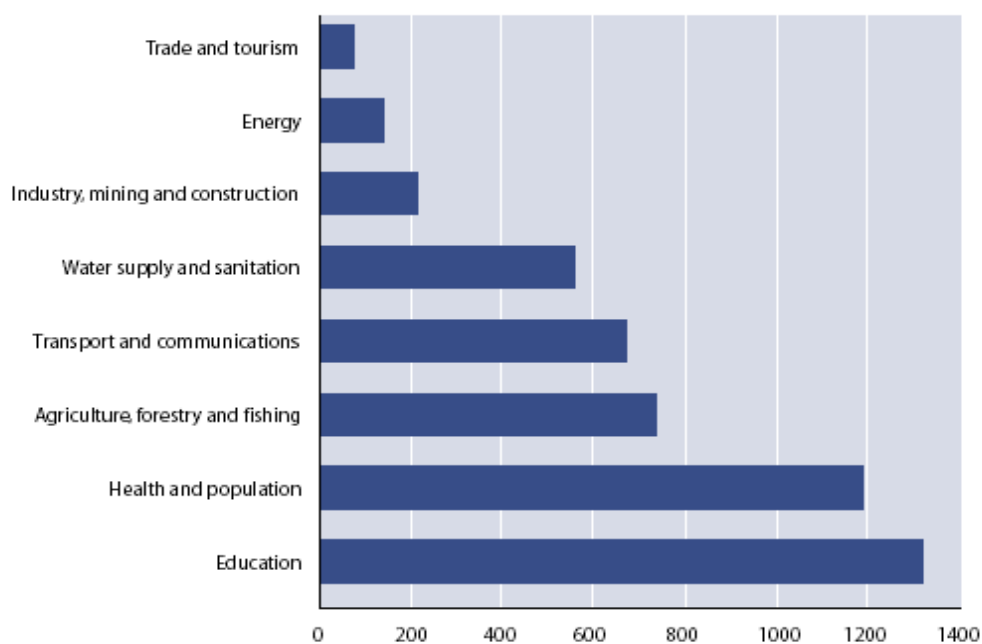
- Poor policies and inadequate regulations, which increase risks to private investors and increase business costs;
- High transaction (contracting and bidding) costs that can exceed 10% of project costs when the normal range is 3-5%;

⁷⁶ ECA, Economic Report on Africa 2004

- Expensive financing terms, due to high project risks and poorly defined project parameters;
- Weak domestic capital markets that are unable to provide long-term financing that have long 'pay back' times and earn little or no foreign currency;
- Low level of credit ratings among sovereign governments;
- Lack of local technical and managerial capacity.

Fig. (6.4):

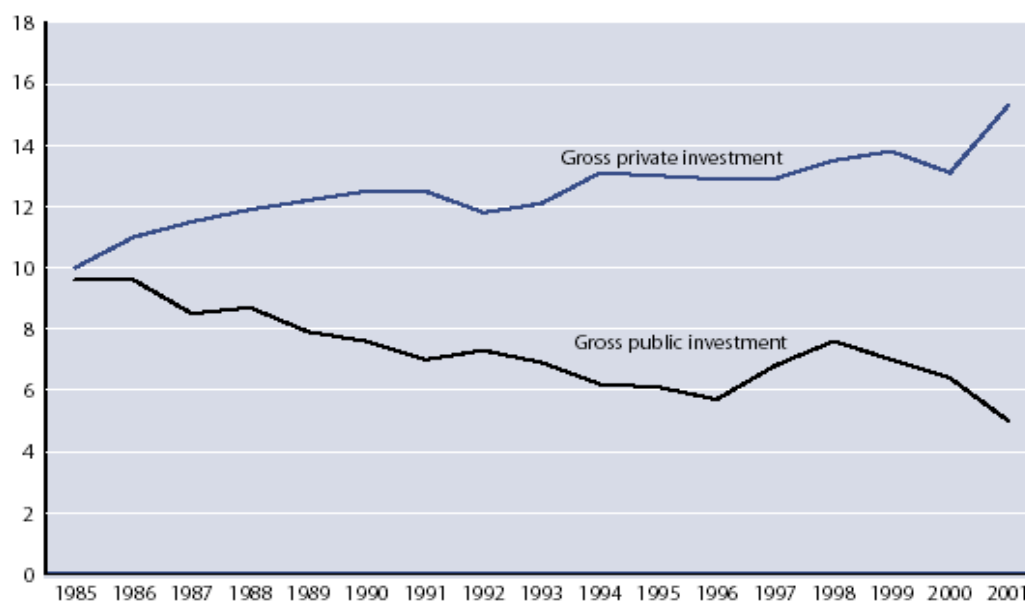
Bilateral ODA flows to Africa, by sector, 2001 (\$US millions)



Source: OECD 2003b

Fig (6.5)

Trends in private and public investment in Africa, 1985-2001 (% of GDP)



Source: ECA, from official sources

Based on this analysis, it is obvious that FDI has been recently playing the major role of financing the energy sector in Africa. Policies to attract private capital and remove legislative and regulatory barriers are essential to achieve long-term development objectives of the African power sector.

6.4.7. Safety and Security

One of the major causes of insecurity regarding infrastructure is political instability. Civil wars, social unrest and political instability make it very difficult to attract much needed investment for the development of infrastructure. For example, the DRC has enormous potential for the generation of hydroelectricity, but the lack of political stability within the country has meant that virtually no investments into the energy infrastructure have been made. On a similar level, the Cahora Bassa power station has been out of operation since 1983, as a result of the Mozambican civil war. After the civil war ended in 1996, the electricity generated at Cahora Bassa begun to flow again. On the other hand, the experience of SAPP has so far been positive. Despite the political instability in some SAPP member countries such as DRC, Angola and Zimbabwe, the SAPP operations have never been disrupted.

In general, regional economic integration is hampered by the effects of conflicts and political instability. FDI inflows to Africa have been hindered due to decades of political unrest. Investors are reluctant to invest in areas of high risks. Recently there were significant improvements in several places of political instability in Africa. Uganda and Rwanda withdrew from the DRC, setting the stage for reconciliation. Peaceful political transitions in Angola and the DRC are beginning to pay off. Angola attracted substantial FDI during 2003 with more in 2004 and grew by over 12%. The DRC is on a steady path to macroeconomic stability, with single-digit inflation in 2003 (down from more than 500% as recent as 2000), and economic growth above 5%. However, continuing political instability in both Zimbabwe and Côte d'Ivoire is a concern. In Zimbabwe, macroeconomic stability continued to deteriorate with inflation rising to 420% in 2003 and the economy contracting sharply.

6.4.8. Technical Capacity

The Lagos Plan of Action for the economic development of Africa (1980-2000) had recognised the shortage of different types and levels of trained manpower in Africa, the high level of adult illiteracy, the deficiencies in the educational system and the lack of coordinated policies and training programmes and the funding of training at the national level⁷⁷. It further called member states to give special priority to the development of scientific and technical expertise at all levels. The WEC Africa Regional Action Plan (2005 – 2007) identifies the lack of technical expertise as one of Africa's energy challenges⁷⁸.

Capacity gaps in institutional settings and human resources constitute a major barrier to development efforts that extends across most, if not all sectors. These capacity gaps can rarely be attributed to a single, or one-dimensional cause. On the contrary, they stem from various causes that include obvious factors such as, the lack of personal skills, equipment and financial resources. In addition, they also include less easily definable and quantifiable factors, such as the lack of staff motivation and career incentives, as well as deficiencies in the institutional infrastructure.

⁷⁷ OAU, The Lagos Plan of Action for the Economic Development of Africa 1980-2000, 1980

⁷⁸ WEC, Africa Regional Action Plan 2005 – 2007, 2005

Capacity building for the power sector is an important task. However Africa's governments are in most cases unable to mobilise the level of investment and commitment needed to develop and retain the wide array of skills needed by the power sector. This partly explains many of the difficulties that are faced by the region's electricity industry. Without a sufficient mass of trained and skilled professionals, infrastructure projects including power interconnections cannot be planned, implemented and maintained. Policies and strategies to promote capacity building are needed to ensure sustainability of cross-border electricity interconnections. These include: enhancement of investment in the social sectors, remuneration, support for information and communication technology, effective utilisation of existing capacity and the creation of a favourable environment for the attraction and retention of professionals⁷⁹.

According to South Africa's ESKOM, capacity building of power engineering skills is an on-going process and is required to ensure the long-term wellbeing of the business. Challenges, which need to be addressed in future, include:

- Development of global utilities;
- Changes in the utility structure;
- Changes in utility commercial practices;
- Changes in the drivers for utility technologies;
- Changes in technologies and development of new technologies.

The reality is that the market demand for experienced power engineering skills exceeds supply, as significant time is required to develop these skills⁸⁰. There is a need to train and develop human resources to manage and operate power pools. Training should include institutional capacity building, negotiating contracts, planning and foreign languages⁸¹.

On the other hand, to realise the potential for regional power integration, high-level and yet flexible institutions, capable of gaining confidence of international and regional actors in the energy field are required. However, in most African countries, the historically state-owned, vertically integrated electricity monopolies failed to adequately manage the electricity business, and the diverse technical and financial problems became endemic in the sector.

Technical issues that need to be addressed in the development of regional electricity trading can be categorised as planning issues, expansion planning and maintenance coordination, operational issues and connection issues. Operational issues include: the system security standards; the issuing of dispatch instructions for the transmission grid and connected generating facilities; the communication protocols between control areas or regions and the procedures employed during system emergencies. Most of these technical issues have been dealt with at national levels with different degrees of developments. This is more likely to be unique to the structural, political and legal characteristics of the particular countries involved in the development of the power interconnection and regional trade. To facilitate regional integration these issues have to be addressed at the regional level in a coordinated fashion. Thus, regional capacity building initiatives may be a viable strategy to achieve these goals in the long-run.

⁷⁹ <http://www.acbf-pact.org/inforResources/WorkshopReports/SummaryOfProceedings.pdf>

⁸⁰ John W Gosling, Technical Resource Development Manager, Eskom

⁸¹ ECOWAS, Ad Hoc Expert Group, Assessments of the Power Pooling Arrangements in Africa, 2003

6.5 The Algeria-Spain Electricity Connection

The new partnership for African development (NEPAD) was established in 2001. It was launched at the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002. The vision statement of NEPAD was adopted by the Organization of African Unity (OAU) Summit in Lusaka, Zambia, in July 2001. NEPAD is a commitment by African leaders to the people of Africa, it recognises that partnerships among African countries and their relationships with the international community are key elements of a shared vision to eradicate poverty. Furthermore, NEPAD aims to place the African countries, both individually and collectively, on a path of sustainable development. It contains a vision, objectives, goals, principles and priorities, as well as the outlines of major sectoral plans.

It is the timing, the vision and the detailed sectoral implementation plans, that give special significance to NEPAD. The combination of these factors makes the probability of success much greater. Different from all earlier economic action plans, NEPAD enjoys broad political support and commitment among the African leaders and within the international community.

Top priority NEPAD projects are contained in the Short-Term Action Plan (STAP), which includes projects selected following specific criteria. Priority had to be given to those projects that support both regional approach to infrastructure provision and regional integration. This includes the acceleration of the provision of key national and trans-boundary infrastructure covering energy, transport, water and sanitation and information and communications' technologies (ICT).

The Algerian gas-fired power station and Algeria-Spain interconnection, which entails developing a 2000 MW of gas turbine combined cycle power plant in Algeria is selected, for the purpose of this analysis, from the NEPAD short-term priority list to benefit from the previous SAPP lessons learned. From the 2000 MW electricity production, 40% of the electricity output will be used to meet Algerian domestic use and the balance of 1200 MW is for export to Europe through Spain.

6.6. Algeria's Electricity Sector

Algeria's electricity demand is growing at a high annual rate of 5-7% and will, according to Sonelgaz, require significant additional capacity - possibly 8,000 MW by 2010. Currently, Algeria has around 6,000 MW of installed power generating capacity, but this has not been sufficient to meet demand during peak cooling periods in the summer. Not surprisingly, Algeria is seeking to increase its use of gas in power generation, due to its plentiful gas resources and continued growth as new gas developments come on-stream. Natural gas already accounted for 3,152 MW of power generation in 2002 and that figure looks set to increase as further gas power projects are commissioned over the next few years. Algeria has already reduced its dependence on oil for power generation, in order to maximise the oil available for export and diesel has contributed just 175 MW to power generation in 2003.

In February 2002, legislation passed by Algeria's parliament ended Sonelgaz's monopoly over electric power generation, transmission, and distribution, it converted the company into a joint-stock company and cleared the way for Algeria's first independent power projects (IPP). In May 2001, Sonatrach and Sonelgaz established a joint venture, the Algerian Energy Company (AEC) to export electricity. In November

2001, Sonelgaz signed a similar deal with Spain's power group Red Electrica de Espana to build an underwater power line between Algeria and Spain⁸².

By signing the Agreement of Association with the European Union in December 2001, Algeria has committed itself to the Barcelona process and has taken all necessary measures to deregulate its market. At the institutional and statutory levels, it has undertaken major reforms in the energy sector. The foundation of these reforms is the establishment of an internal energy market that is free, open and transparent. To this end, Algeria has already put the necessary instruments in place through the law enacted in February 2002, on electricity and on gas distribution by pipeline. This law, which meets the requirements of an open and competitive market, gives freedom to import and export electricity. It also offers an appropriate legal framework within which to begin integrating Algeria's North African regional markets with those of Europe⁸³. Algeria has been struggling to meet domestic power needs and is unable to meet projected demand growth relying on state funding only. This encourages it to embrace far-reaching liberalisation in the energy sector to attract foreign investment. Several independent power projects (IPP) are in various stages of development, including the planned 2,000 MW power plant in Skikda, 1,200 MW of which is planned for export. The government is also keen to pursue regional grid links in both North Africa and Europe in order to increase revenues. Algeria already exports power to the Moroccan electricity grid and has been pushing for links with Italy and Spain to tap into the European market. The Algerian Energy Company (AEC) was formed in 2001 to invest locally and abroad in power generation, transmission and distribution, and the transport and distribution of gas. The energy sector is to be regulated by the independent Electricity and Gas Regulatory Commission (CREG) from 2005, which has been assigned to ensure competition, transparency and free access to the power and gas networks.

6.6.1. Energy Sector Reform in Algeria

Algeria leapt ahead of other regional players, in terms of privatisation with its 2002 electricity and gas law, which was part of a wider programme of economic reforms within efforts to join the World Trade Organization (WTO). Private investments have already been welcomed into new electricity generation projects.

The main objectives of this policy are: (i) improve efficiency in the sectors of energy and mines whilst securing an adequate supply of energy to the economy; (ii) enable market forces to play their role; (iii) increase revenues by greater development of un-utilised resources; (iv) address environmental concerns; (v) encourage efficient use of resources and safeguard public interests, and (vi) lessen the financial burden on public finance of the energy and mines sectors.

The landmark legislation of 2002 was passed to break up Sonelgaz's monopoly on electricity distribution and generation and the sector is still in a three-year transitional period to more open competition. As part of this process, Sonelgaz is set to be reformed into two shareholding companies - one to cover electricity generation and supply, the other responsible for gas distribution, in which private investors will be able to take a minority stake. The state will retain control over the transport of gas and electricity through two dedicated Sonelgaz subsidiaries.

⁸² US Energy Information Administration, Feb. 2004

⁸³ Speech by HE Mr. Chakib Khelil, Minister of Energy and Mining, Rome, 1- 2 December 2003

The Commission of Regulation of Electricity and Gas (CREG) is responsible for overseeing the competitive and transparency functioning of the electricity market (art. 113 of the law), in the interests of consumers and operators. Its role is fundamental to the organisation and functioning of the electricity sector. Eventually, Algeria aims to open up domestic and cross-border power trading to all participants. Rules of access and pricing will be set by the CREG and companies will have to sign up to a number of public service obligations.

On the other side of the Mediterranean, the liberalisation of the electricity markets, covered by the EC Directives 96/92 and 03/54, paves the way for opening up these markets to competition by laying down the ground rules for their operation. This depends on two factors: the expansion of electricity production, distribution and transportation to competition by setting up a system for access to the networks by third parties and also the legal separation of networks management operators.

These two unprecedented regulatory steps on both sides of the Mediterranean would have long-term implications for the Euro-Mediterranean electricity market. However, both initiatives are still in the early stages.

6.6.2. Harmonisation of the Legal Frameworks

Successful integration of electricity systems requires a framework for transactions to take place, harmonised arrangements for system operations, a system of tariffs for use of transmission infrastructure, and agreed principles and procedures for dispute resolution. It is important that arrangements be established to remove barriers to trade, while at the same time creating systems that reward transmission operators and create appropriate incentives to invest in transmission capacity expansion. Different legal, regulatory and licensing systems existed in Algeria, Spain and the planned European integrated energy market, necessitating complex international agreements and arrangements. Currently, the two systems of Algeria and Spain could be viewed as being in transition toward liberalisation. Though Algeria has had some experience from cross-border interconnection with Morocco, this experience was gained in the context of a traditional state-owned vertically integrated utility. Therefore, the new national-level regulatory statutes should be carefully drafted, so that the regulatory agency's jurisdictions are properly defined, directed and restrained, in order to avoid regulatory barriers to cross-border trade. The role of regional institutions should be enhanced, these institutions could coordinate capacity building programmes; information and experience sharing among regulators; coordination of regional policy/strategy/legislation, with a view to harmonising regulatory frameworks, that will enhance regional electricity trade and facilitate regional integration. It is anticipated that the Mediterranean Power Pool (MPP), which would link the power grids of North Africa (Algeria, Egypt, Libya, Morocco and Tunisia), Spain and the Middle East (Jordan, Syria, Turkey and Iraq), would be completed by 2015. The interconnection between Libya, Tunisia, Algeria and Morocco will be upgraded from 220 kV to 400 kV; this initiative is part of the energy priority projects of NEPAD. Morocco and Algeria will be connected to Spain, while Egypt will be connected to the Middle East via Jordan. In addition, the Euro-Med Energy Forum in April 2003 identified the need to upgrade the Maghreb and Mashrek sub-rings, to develop a new South-North interconnection, including an Algeria-Spain interconnection and Italy-Tunisia interconnection, and to extend integration between the Euro-Mediterranean electricity markets and the South-Eastern European market (currently being developed.).

6.6.3. Role of Regional Institutions

Though the Algeria-Spain interconnection project is listed in the NEPAD's short-term priority list, neither Union du Maghreb Arabe (UMA) otherwise known as the Arab Maghreb Union nor the African Energy Commission (AFREC) have had any role to play in the project development. The reality has been that, since NEPAD's inception, institutional roles and responsibilities are not well defined, and lines of communication between countries, NEPAD secretariat and regional economic commissions are non-existent or unclear. UMA as a regional economic community is, similar to other regional institutions in Africa, suffering from a chronic shortage in human and financial resources⁸⁴. Thus it is clear, that it is too early for NEPAD's regional institutions to develop such capabilities that are parallel to those that already exist in the EU market. Much more needs to be done to empower these institutions to be able to take an active role in Africa's economic integration in general, and in particular, energy projects.

6.6.4. Investment Environment

The electricity interconnection between Algeria and Spain has been evaluated in the technical and economic feasibility studies supported by Algerian and Spanish funding. These studies demonstrated the advantages of the interconnection, both in terms of security of supply and of European-North African market integration through the creation of a genuine sub-regional market between Algeria, Morocco and Spain. This interconnection, which is part of the process of meeting the objectives of North African-European market integration, has not yet secured funding. Algeria's investment climate has recently been improving and now is among the top ten most attractive African countries to foreign investors. Algeria is also the second largest supplier of gas to Europe and a leading exporter of gas to the US, and already accounts for a quarter of all gas consumed in Europe. Finally, Algeria possesses a world-class oil and gas infrastructure⁸⁵. Sonatrach's facilities include an extensive network of pipelines linking oil and gas fields to major distribution centres; two export pipelines under the Mediterranean Sea to Europe; gasification plants; modern LNG transportation capability; refineries, etc.

The investments plan for the electricity and gas sector in Algeria aims at investing US\$12.2 billion between 2000 and 2010. Sonatrach has invested nearly US\$3 billion a year during the last four years. In an interview concerning the attractiveness of direct foreign investment (DFI) in the company, published in the "Nouvelle République", HE Mr Chakib Khelil, Algerian Minister of Energy and Mines said, "Sonatrach attracted some US\$8 billion in the same period for the whole of the hydrocarbons sector"⁸⁶.

6.6.5. Safety and Security

FDI inflows to Algeria have been hindered for decades, owing to political unrest and border conflicts. In addition, the safety and security of the undersea transmission line should be thoroughly secured. This specific security measure should be addressed in a more regional context of the Euro-Mediterranean partnership.

⁸⁴ ADB, NEPAD Infrastructure Short-term Action Plan, Review of Implementation Progress and the Way Forward, 2003

⁸⁵ David Nagel, President and CEO BP-Algeria, Corporate Council on Africa Business Summit, 2003

⁸⁶ Energy and Mines, April 2004

6.6.6. Capacity Building

As previously stated, without the necessary capacity to plan, build, operate and manage cross-border electricity interconnections, system efficiency and reliability cannot be sustained. Algeria has had a long history of interconnection with Tunisia and Morocco. A skilful workforce capable of performing numerous functions of the power industry is reasonably available. However, the main capacity building activities should be targeting the issue of harmonisation, as the Algerian power sector is moving towards more regional and global integration. In addition, the NEPAD supporting regional institutions should be a major source of any capacity building efforts. Capacity building of these institutions would help them play their vital role in facilitating regional integration, mobilise resources, monitor NEPAD activities and facilitate information exchange and knowledge sharing. Capacity building in a broader sense would include, but not limited to, budgetary reforms, streamlining the organisational structure, staff hiring, and using modern information and communication technology.

6.6.7. Infrastructure

Development of the existing infrastructure is a major driving force for electricity interconnection. The SAPP experience proves that the lack of high voltage power lines could be a real bottleneck to flows of electricity from points of surplus capacity to necessary demand centres. Moreover, without adequate and reliable infrastructure there will be no trade. Many issues would affect future expansion of the current infrastructure to support cross-border interconnection. Among these issues are investment climate, long-term visibility and transparency of the regulatory regime, harmonisation of procedures across the borders, higher rate of return on investments, and the availability of capital. Attracting foreign capital has become necessary and creating an enabling environment is therefore, essential.

6.6.8. Coordination of Expansion Plans

Future increases in domestic demand for energy in Algeria needed to support growth, could make it difficult to guarantee contractual amounts of electricity for Spain. To be more effective, bilateral agreements should be supplemented by other pooling arrangements such as coordination in planning and operations of the interconnected systems. This is even more important, given the European energy integration plans that are currently underway. Coordination of expansion plans at the regional levels proves to be a viable option to ensure sustainability of the interconnected power systems.

Chapter 7: Assessment of the African Experience in the Cross-border Gas Projects

7.1 Introduction

Demand for natural gas is increasing worldwide; and it is expected to grow at a higher rate than oil over the next two decades. This is driven partly by the availability of gas and its environmental benefits. Natural gas is a relatively, clean fuel that will play a significant role in the future world energy mix. Africa is no exception, and changes in reserves' locations and energy demand patterns across the African continent entail the growth of cross-border gas trade. For natural gas, only two transport options are available: pipelines and liquefied natural gas (LNG). The latter is extremely expensive and only cost-effective when transporting gas over long distances. In developing countries, in particular in Africa, the development of gas markets has been very slow, mainly due to a lack of capital-intensive infrastructure and of regulatory and legal frameworks conducive to attracting foreign direct investments (FDI). Cross-border gas pipelines have a long history of vulnerability to disruption and conflicts. These conflicts are often political, technical and financial in nature.

The Algerian gas pipeline to Italy via Tunisia, called Transmed, was formally inaugurated in 1983. By 2001, the Transmed delivered approximately 21.85 bcm to Italy and 1.2 bcm to Tunisia. This accounted for 34% of Italy's gas consumption and all of Tunisia's consumption.

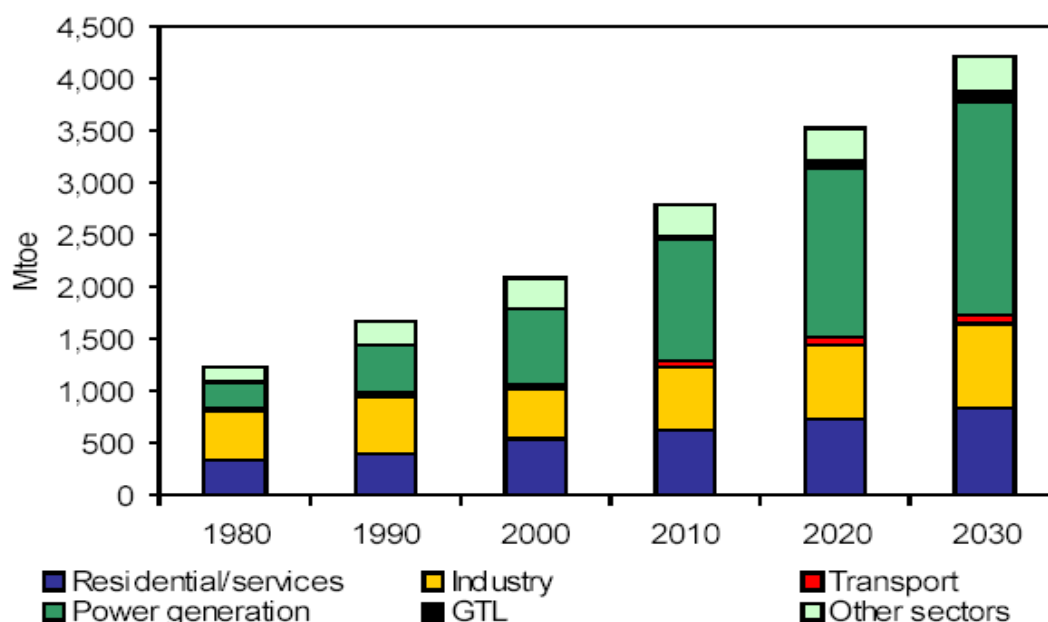
This chapter examines issues relevant to cross-border gas trade. The Algeria-Tunisia-Italy gas pipeline (Transmed) was selected, since it connects Africa to the EU market across the Mediterranean. Therefore, it is not only a regional (North African) gas connection but it is also an intercontinental gas link that would facilitate integrating Africa into the global markets. The aim is to draw some lessons that could be learned from and applied to the planned African regional gas trade especially within the NEPAD priority list. The planned West Africa Gas Pipeline (WAGP) has been selected as a potential beneficiary from the experiences of Transmed.

7.2. Historical Background

During the last three decades, a number of drivers have led to a global shift towards natural gas utilisation. These driving forces include energy security policies of the Organisation for Economic Co-Operation and Development (OECD) countries calling for a reduction on the dependence on imported oil supplies through, for example, diversification of energy resources, the environmental merits of natural gas as a clean easy-to-use fuel in industrial, residential and commercial sectors, and the technological advancement in electric power industry leading to the increased usage of more efficient combined cycle gas turbines (CCGTs). Currently, a shift is taking place from the historical world of regionally isolated markets to an international, interdependent, market of global gas. A series of developments including: increasing demand especially for power generation (gas to power), Fig. (7.1); technological advances in gas technologies; cost reductions in producing and delivering liquefied natural gas (LNG) to markets, Table (7.1); environmental concerns regarding greenhouse gas (GHG) effects and market liberalisation is spurring this integration of natural gas markets. Such market interconnections will have huge ramifications for both large gas consumers and producers. However, the construction of the

transportation infrastructure is currently the major barrier to increased world natural gas consumption. Cumulative investments in the global natural gas supply chain of US\$3.1 trillion, or US\$105 billion per year, will be needed to meet rising demand for gas between 2001 and 2030, according to the International Energy Agency (IEA)⁸⁷.

Fig. (7.1): World Gas Demand (1980-2030)



Source: IEA, *World Energy Outlook, 2003*

Table (7.1): Trends of Cost Reduction of LNG

	<i>Qatargas 1996 grassroots</i>	<i>T&T 1999 grassroots</i>	<i>Oman LNG 2000 grassroots</i>	<i>Qatar 2000 expansion</i>	<i>T&T 2002/03 expansion</i>
Number of trains	3	1	2	2	2
Capacity (Mt/y)	7.2	3.2	6.6	8	6.6
Cost (US\$ bn 1999)	2.85	0.82	1.8	1.571	1.1
\$/t/y	396	256	273	196	167
Cost index	100	64	67	49	42

Source: IEA, 2002

Africa has had experience of cross-border gas projects. In November 1998, BP-Amoco signed agreements with Egypt and Jordan to build a natural gas pipeline across the Sinai and under the Gulf of Aqaba to Amman, Jordan and possibly beyond. Under this agreement, gas from Egypt's Nile Delta is currently flowing to fuel power plants in Jordan.

⁸⁷ Amy Jaffe and David Victor, *Geopolitics of Gas Working Paper Series, 2004*

Natural gas from Namibia's offshore Kudu field is expected to be a fuel source for power and industrial projects in Namibia and South Africa. A 440-mile (700 km) pipeline would deliver gas to power a new 1,000-MW power generating facility in Cape Town, South Africa and provide fuel for industrial projects in Saldanha and Cape Town.

An agreement to supply natural gas from the Temane gas fields in southern Mozambique to South Africa's Gauteng region is expected to be completed soon. The gas would be transported to South Africa by a 580-mile (925 km) pipeline.

Cote d'Ivoire and Ghana have signed an agreement for a feasibility study on the construction of a natural gas pipeline to supply Ivorian gas to Ghana, for power generation.

Nigeria and Algeria continue to discuss the possibility of constructing a "Trans-Saharan Gas Pipeline". The 2,500-mile (4,000 km) pipeline would carry gas from oil fields in Nigeria's Delta region via Niger to Algeria's Beni Saf export terminal on the Mediterranean Sea⁸⁸.

Tunisia has committed to purchase a further 14 bcf/y of Algerian gas (via the Transmed pipeline) until 2020, under a deal signed in March 1997. Tunisia consumes approximately 25 bcf/y of gas from Algeria, which is bought on a spot-basis and received in lieu of transit fees from the Transmed pipeline.

7.3. The Algerian Gas Sector

Natural gas markets in North Africa are dominated by Algeria, although there have been substantial gas discoveries in Tunisia and off the coast of Egypt. Much of the Algerian gas production is linked to markets in Southern Europe.

Algeria has proven gas reserves of over 4.0 trillion cubic meters (tcm), making it the fifth largest gas producer in the world. Natural gas accounted for about 60% of Algeria's total hydrocarbons production in 1999. Algeria is the second largest supplier of gas to Europe and a leading exporter of gas to the US. Algerian gas currently represents 30% of Europe's gas supplies⁸⁹, and it will account for half of Italy's projected 30bn m3 of new gas demand requirements by 2010.

Algeria's largest gas field is the giant Hassi R'Mel, which initially held proven reserves of approximately 85 tcf. Hassi R'Mel production is around 1.35 billion cubic feet (bcf) per day, or about a quarter of Algeria's total dry gas production. The remainder of Algeria's gas reserves are located in associated and non-associated fields in the southeast, and in non-associated reservoirs in the In Salah region of southern Algeria.

Algeria's oil and gas giant, Sonatrach is one of the largest companies on the African continent. It is ranked the 12th largest petroleum company in the world, the world's second largest exporter of liquid petroleum gas (LPG) and the third largest exporter of natural gas.

⁸⁸ <http://www.eia.doe.gov/emeu/cabs/nigeria.html>

⁸⁹ Marie-Françoise Chabrelie Cedigaz, *The Dynamics of the World Gas Trade*, 2003

Algeria's natural gas pipeline export capacity includes 850 bcf/y via the 667-mile Trans-Mediterranean (Transmed, renamed Enrico Mattei) line from Hassi R'Mel via Tunisia and Sicily to mainland Italy, and 285 bcf/y via the 1,013-mile Maghreb-Europe Gas (MEG, renamed Pedro Duran Farell) line via Morocco to Cordoba, Spain, where it ties into the Spanish and Portuguese gas transmission networks.⁹⁰ With EU natural gas demand growing rapidly, Algeria has plans to increase its natural gas export capacity significantly in the coming years. In late July 2001, Spain and Algeria agreed to implement a new natural gas pipeline (Medgaz) linking Algeria directly to Europe via Spain. The 350-530 bcf/yr Medgaz pipeline is likely to link Hassi R'Mel, through the port of Arzew to Almeira in Spain. In December 2001, Sonatrach also signed a deal with Italy's Enel and Germany's Wintershall on a feasibility study of another new natural gas pipeline, from Algeria under the Mediterranean Sea to Sicily and onwards to mainland Italy and France.

7.4. The Algeria-Tunisia-Italy Gas Pipeline

The Transmed line (Fig 7.2 and Table 7.2) has a nameplate capacity of 24 bcm/yr but its actual output will exceed 30 bcm/yr in 2005 and links the Hassi R'Mel gas field to Mazzara del Vallo in Sicily. The 667-mile Transmed goes through Algeria, Tunisia and under the Mediterranean Sea to Sicily. An extension of the Transmed pipeline delivers Algerian gas to Slovenia. Most of the gas from this line is taken by Italy's main gas utility Snam, which is under contract to buy 680 bcf/yr from 1997 until 2018. Tunisia purchases about 39 bcf/yr, with 14 bcf/yr committed until 2020 under a deal signed in March 1997, and the rest bought on a spot-basis, in lieu of transit fees.

Fig. (7.2): Map of the Transmed gas pipeline



⁹⁰ EIA

Table (7.2): Transmed technical details

Segment	Length	No. of Pipes Diameter (inches)	No. of Compressors	Maximum Depth
Algeria	550 km	1 x 48"	1	n/a
Tunisia	370 km	1 x 48"	3	n/a
Sicilian Channel	155 km	3 x 20"	n/a	610 m
Italian Section				
Sicily Overland	340 km	1 x 48"	1	n/a
Straits of Messina	15 km	3 x 20"	n/a	270 m
Italian Mainland	1055 km	1 x 42–48"	4	n/a
TOTAL	2,485 km		9	

Source: Sonatrach, SNAM

7.5. Potential Risks for Cross-border Gas Projects

The expansion of cross-border gas trade depends enormously on investor confidence and the availability of vast financial and intellectual capital. Although global gas resources are abundant, the majority of these reserves are in countries that have traditionally been unattractive for private investors. The capital-intensive nature of the gas infrastructure and the long payback periods typical of gas projects, 15 to 20 years or longer for some of the more complex projects, make investors especially wary. In addition, plans to expand cross-border gas projects may face difficulties in locating major gas infrastructures, especially in areas of political instability and amid emerging worries about terrorism. Building cross-border gas infrastructure involves many risks. Once an investment is made, it becomes a “sunk cost.” The original balance of bargaining power that existed at the time of contract negotiation shifts in favour of off-takers or regulators. At least five factors can explain the risks involved in cross-border gas transport projects⁹¹:

- The investment climate in source, transit and “off-take” countries may be unattractive to investors due to poor “rule of law”, unpredictable tax codes, exposure to foreign exchange risk and peculiar regulatory practices;
- Many pipeline routes involve one or more transit countries, which complicates negotiations and management, creating additional risks for investors;
- Many “off-take” markets presently have little or no gas consumption, which creates risk in the “off-take” quantity for new pipelines. Success in introducing large quantities of gas into immature “off-take” markets depends on large complementary investments in gas-use technologies;
- Inexperience with regulating gas markets and the fact that gas is often more expensive than the incumbent fuels—especially when competing against

⁹¹ Mark H. Hayes & David G. Victor, Factors that Explain Investment in Cross- Border Natural Gas Transport Infrastructures: A Research Protocol for Historical Case Studies, 2004

“paid-off” coal and hydroelectric generating stations—may also create risk in the “off-take” price;

- Finally, many of these gas transport routes would link countries that presently have few or no international institutional links. Many problems concerning international coordination of investments can be eased when multilateral cooperative institutions and development agencies are in place. These institutions can mobilise more financial resources, help reduce transaction costs and ease the enforcement of contracts. The absence of institutions can be both the ‘symptom’ and ‘cause’ of the inability to secure investments in regional infrastructures.

7.6. Cross-border Gas Trade Issues

A two-year study by Stanford University-Baker Institute uses seven case studies, including the Transmed pipeline from Algeria to Europe, to identify the challenges of investing in large-scale, long-distance gas production and transportation infrastructures. These case studies focus on countries that do not have the stable legal and political environments that are often necessary to attract private investors. This is largely because the growing role of gas as a global fuel depends on success in attracting investment within such political, institutional and economical environments.

The study findings highlight four broad conclusions:

- (1) An integrated global gas market is emerging where events in any individual region or country will affect all regions.
- (2) The role of governments in natural gas market development will change dramatically in the coming decades.
- (3) The rising geopolitical importance of natural gas implies growing attention to supply security.
- (4) The speed of the shift to a global gas market depends to a large extent on whether the investors have confidence in deploying vast sums of financial and intellectual capital; it requires finding solutions to the adverse social and political consequences of developing natural resources in countries where governance is weak; and it assumes a continued pull from the growing world electricity sector.

Some of these issues affecting investment decisions in cross-border gas pipelines have been identified and discussed here, in connection with the geopolitical and economical contexts of the Transmed pipeline.

7.6.1. Political Contexts and the Role of Governments

With regards to the Transmed pipeline, the variation in the outcomes of the two proposed projects to pipe gas across the Mediterranean through Spain and Italy in the late 1970s, was due to the different roles that the Italian and Spanish governments took towards the prospects of starting to import large volumes of gas. Italy was actively seeking gas imports and was willing to mobilise significant government funding to secure new energy supplies. Through its own export credit agencies, the government provided the bulk of financing for the Transmed pipeline project. The state-owned ENI was also positioned, at that time, to orchestrate the pipeline project

as well as the development of Italy's domestic gas transmission grid. State backing allowed ENI to invest with confidence and provided cover for international lending.

Spain, on the other hand, did not have supporting policies in place, and thus could not lead a successful development of a major gas import project during the same period. Hence, the case study findings sound caution about visions of rapidly switching to gas in markets where gas delivery and domestic market infrastructure do not already exist and where the state is not prepared to support the creation of the gas delivery infrastructure. Obviously, state intervention is usually not the most economically efficient or the only way to create a market, but these case studies suggest that state intervention accounts for much of the observed variation in initial gas projects.

On the supply side, the role of government has been equally important. Even where private firms have made the investments in developing gas fields and in building the transmission infrastructure, governments have been the guarantors of long-term contracts that, historically, have underpinned most large-scale gas infrastructure investment. In the past, investor risk has been mitigated by "take-or-pay" contracts, but new, more flexible contracting is being urged by the industry as gas markets become more global. Gas-on-gas competition, new gas resale contract clauses and joint investor/host country spot-marketing strategies are creating new uncertainties that are creating a new market structure for gas.

The role of governments in the gas sector goes beyond market regulation and licensing. It includes: setting health, safety and environmental standards, taxation policy related to gas and other energy alternatives, and power sector regulation in the case of gas to power. Furthermore, bilateral cross-border gas deals need policy coordination between the countries involved. This would necessitate clear rules for each country before trying to harmonise such rules at the regional level.

The Transmed case shows no evidence of direct dispute between Italy or Algeria and Tunisia. Tunisia proved to be a reliable partner in this project, in spite of the attempt by Tunisia to earn more transit fees. This does not exclude the potential risks imposed by transit countries both for security of supply and negotiating gas prices. Based on the geopolitical context for a given project or a region, re-routing a cross-border gas pipeline to minimise or avoid passing through a transit country might be an option to mitigate such transit risks.

While the role of the state weakens, the key anchoring role for gas projects is shifting to the private sector. Recently, a few large energy companies are taking over the role as creator and guarantor of the implementation process. These players are largely private, but they also include national energy companies that are now playing a larger role in the international marketplace, such as ENI, PetroChina, Petrobras, Sonatrach and others. This shift to large energy companies, however, is likely to lead to infrastructure development being increasingly driven by commercial interests rather than national energy security objectives

7.6.2. Institutional, Legal, and Regulatory Framework

The "rule of law" in the upstream, downstream and transit countries (where relevant) is vital. This includes factors such as commercial laws and level of enforcement, historical track record on upholding contractual agreements, the role and independence of the judiciary system in resolving disputes and the abilities of governments to implement long-term strategies, are important, because costly

infrastructure such as cross-border gas pipelines have high “sunk cost.” Once the capital is deployed, the investor is in a weak position to assure that the contractual terms are met for the decades required to recoup the initial investment and secure a profit. In some circumstances, illegal practices (e.g., corruption, joint ventures with politically connected local firms, joint ventures with politically powerful foreign entities), should be investigated and considered as a measure of the unfavourable climate for such massive capital projects. The issue of “sunk cost” has been avoided in the case of the Transmed, through sharing risks between the two major players, Sonatrach and ENI.

Another important issue is market regulation, in particular, in the case of state monopolies operating under political directives. Relevant information would include any laws governing the price and quantity of gas sales in the market outside of the project in question. ENI, as a state owned monopoly, historically has not faced with such problems in the Italian market. Within the new European Union (EU) open market, many emerging issues have to be resolved that are not within the scope of this study.

‘Right-of-way’ legislation in a host country is another important issue for infrastructure projects. Many countries do not have the laws that facilitate the acquisition of land for project construction. Environmental legislation and laws concerning indigenous peoples and protected lands are also critical issues for siting, constructing and operating a gas pipeline. Any particular social and environmental problems deemed potential obstacles in the construction and operation of the projects should be explored beforehand.

Proposed regulatory reforms, if any, and historical and prospective progress in carrying out these reforms should also be considered. In some cases legislative changes may be required, as found in ‘right-of-way’ issues. Other examples, negotiations with native groups or non-governmental organisations can produce non-regulatory solutions to social and environmental conflicts.

7.6.3. Market Forces

There are differences between those mature markets that involve extensions of existing gas infrastructures upstream and downstream, and those immature markets where “first gas projects” are implemented. When the Transmed was built, the “off-take” Italian market was immature at the time. Italy has a policy of promoting natural gas as a viable alternative to imported coal, and a gas distribution network linked to its major industrial users.

By 1965, Italy was the largest gas producer and consumer in Western Europe⁹². In the early 1970s, Italy secured gas imports from the Soviet Union and the Netherlands. In 1973, Italy was 79% dependent on imported oil, and seeking to diversify its rapidly growing gas imports. The economics of a long distance (2,000 to 2,500 km) large diameter (40 to 48”) gas transmission line are dependent on a minimum pipeline throughout to enjoy economies of scale. Regarding gas-pricing risks, ENI as the monopoly gas importer and seller, was relatively protected by price risks in its domestic market. Consumer prices were set by the company, overseen by the Ministry of Industry.

⁹² Darmstadter, J., P. D. Teitelbaum, et al. Energy in the World Economy: A Statistical Review of Trends in Output, Trade, and Consumption since 1925, 1971

On the supply side, the Hassi R'Mel field has been a massive resource, backed by political support that secures long-term gas supply to the Italian market. This is crucial not only for security of supply, but also to repay the massive capital investments.

7.6.4. Power Sector Policies

Since the beginning of the 1990s, much of the global demand for natural gas has depended on the electricity market. Experience in the power sectors of England and the United States, and several other markets proved gas to be a favoured option. This has been mainly due to tighter environmental regulations, technological advancements leading to increased efficiencies of combined cycles gas turbines (CCGT), and their decreasing costs. In addition, restructuring of the power sector has created additional economic pressure to select the least-cost generation options. Therefore, close attention must be given to markets where gas-fired generation is not the least marginal cost supplier or where electricity demand might be constrained by other factors. Thus, an integrated energy policy framework would be necessary to assess the different policy alternatives pertinent to electricity power, domestic gas use and cross-border gas trade.

7.6.5. Financing Cross-border Gas Projects

From the financing perspective, cross-border gas projects have many special features⁹³:

- (1) Discrepancies of laws and regulations among suppliers, transit countries and off-takers may impact on the economic viability of the project.
- (2) A high vulnerability to any changes in the geopolitical contexts and bilateral relationships between participating countries.
- (3) Lack of flexibility and efficiency of the gas market, similar to the oil markets.
- (4) Need for distribution network infrastructure for end use customers (power generators, industrial clients or residential customers)

7.6.6. Issues related to Opening of Gas Markets

These emerging issues should be carefully examined for those cross-border gas projects linked to global gas markets. Historically, cross-border trade has been the exclusive domain of the vertically integrated natural gas companies undertaken with the objective of securing their gas import requirements. This has been the case of the Transmed pipeline supplying Algerian gas to the Italian market. As markets become more integrated, the trade pattern will change, and the flow of gas will become more diversified. Cross-border trade takes on a new dimension in which coherent technical, as well as commercial trading rules for operation of gas networks will become an important condition for the proper functioning of an open gas market.

Compatibility of gas network systems is an important technical condition for facilitating gas trade. But obstacles to cross-border trade are not exclusively of a technical nature. Legal and commercial aspects such as capacity bottlenecks and

⁹³ Hervé Collin, Vice President - ABN AMRO Bank, Latin American Conference On Cross-Border Gas Trade, 2002

cross-border access charges, which, if not streamlined, may also risk hampering cross-border trade and the functioning of the open gas markets.

7.6.6.1. Compatibility of Gas Networks

Compatibility of different national gas systems is essential for the proper functioning of an open market for natural gas. Technical discrepancies in the gas networks of individual gas suppliers and consumers may pose a potential obstacle for integration, trade and competition of the gas markets. A harmonised set of technical rules; design and operational requirements for connection to a gas system should be developed and made public to other potential trade partners.

7.6.6.2. Gas Quality

One of the critical aspects for network compatibility is the existence of different gas qualities, due to the variety of different gas sources when supplying to one network such as in the EU market. Two main gas quality categories prevail in the European market: high-calorific gas (H-gas), which dominates the supply chain throughout the EU and low-calorific gas (L-gas) which is principally of Dutch and German origin and supplied only in five member states.

Defining a single convertible gas quality is in practice not a realistic option. However, defining a standard range of high-calorific gas specification as a common convertible gas quality in the medium-term may be beneficial and should therefore be further investigated. Technological developments in relation to the range of gas qualities, which burner installations may cover, should also be assessed.

7.6.6.3. Network Specifications

When building gas pipelines and related facilities, certain codes and standards for design and construction are followed. These codes and standards differ between different gas suppliers. Technical discrepancies between network specifications such as different design philosophies, pressure ratings, material grades of interconnected systems and specifications for welding and testing have the potential to create obstacles to network compatibility. A move towards harmonised standards for gas pipelines and related facilities is the only option in the long-term to remove such potential barriers to trade. National codes and standards should gradually converge and eventually be replaced by a common set of standards. Some initiatives to harmonise the respective technical standards are undertaken within the European Committee for Standardisation.

7.6.6.4. Capacity Constraints

Cross-border interconnections are the bridges between national gas network systems. They are of critical importance, as the capacity of these interconnections may be insufficient for the expected increase in gas trade. Possible solutions to overcome capacity bottlenecks, involve enhancement of existing capacity and other appropriate alternatives that are common practice between gas companies, to optimise transportation and to avoid costly transmission over long distances. Integrating natural gas policies in a national integrated energy framework is another viable option to secure long-term sustainability of the energy sector. In addition, creating an enabling environment to attract private capital would secure inflow of investments needed for removing capacity bottlenecks.

7.6.6.5. Costs and Transmission Tariffs

The costs incurred in building and running the infrastructure required for the cross-border transportation of large volumes of gas is high. This cost includes cost of gas supply, capital costs of the cross-border pipeline infrastructure and the transit fees. Transit fees are paid to each transit country, and could represent a significant part of the total transmission cost of gas, and therefore become one of the determining factors of the economic feasibility of cross-border gas projects. These transit fees would further increase if the pipeline crosses the borders of several countries, as in the case of WAGP. However, in this specific situation, the WAGP is not planning to allow for third party access, neither would it reach to markets opened to other gas suppliers.

A key issue for providing effective competition will be to ensure fair and non-discriminatory conditions, especially on charges for access to a gas system, if such a system is opened to different gas suppliers. The question of access charges is equally important to gas pipeline operators as to eligible customers. For the gas company, third party access charges may become a significant source of revenue, whilst for the customer, or any network user, the access charge may constitute an important element of the overall gas supply costs and is therefore crucial in relation to the choice of supplier, thus, affecting competitiveness of different suppliers.

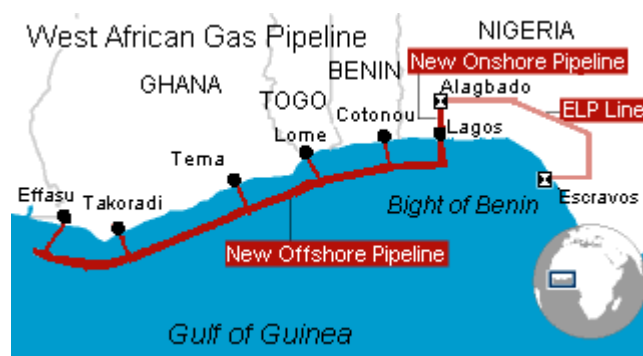
Due to the commercial importance of access charges and their crucial role in relation to actual market entry, it seems appropriate to further develop certain basic criteria (such as objectivity, non-discrimination, cost-reflectivity and transparency), which fair access charges should fulfil. For these reasons, the EU recently launched a study on "Methodologies for establishing national and cross-border systems of pricing of access to the gas system" which seeks to identify possible approaches, methodologies and general guiding principles for ensuring workable, fair and non-discriminatory systems of access pricing across the EU, with a view to facilitate competition and third-party access. Member states, the gas industry, gas consumers, regulators and other interested parties will be invited to contribute to the study.

7.7. West Africa Gas Pipeline (WAGP)

A feasibility report, prepared for the World Bank in the early 1990s, concluded that a pipeline to transport Nigerian natural gas to Benin, Togo and Ghana was commercially viable. In September 1995, the governments of the four nations signed a Heads of Agreement (HOA) pertaining to the pipeline project. The HOA broadly outlined the principles of the pipeline development. In August 1998, a consortium of companies signed an agreement commissioning a feasibility study on the West Africa Gas Pipeline (WAGP). The study that the commercial and technical viability of the WAGP, and projected that it could be operational as early as 2002. In 1999, a Memorandum of Understanding (MOU) was signed by the four countries and the consortium established the legal framework for the WAGP. In February 2000, an Inter-Governmental Agreement (IGA) was signed, which established the framework for realising the pipeline venture. The IGA includes the government's commitments to the pipeline owners and gas distributors on the conditions for the development, construction and operation of the WAGP, as well as fiscal and customs policies for the venture. The project has received administrative support from the Economic Community of West African States (ECOWAS) Secretariat and technical assistance (US\$1.55 million) from the United States Agency for International Development (USAID). In February 2003, the four nations signed an agreement on the implementation of the WAGP. The treaty, which lasts for a 20-year period, provides

for a comprehensive legal, fiscal and regulatory framework, as well as a single authority for the implementation of the project. The WAGP partners are: Chevron Texaco with 36.7%, Nigerian National Petroleum Corporation (NNPC) with 25%, Shell with 18%, Ghana's Volta River Authority (VRA) with 16.3% and SoBeGaz and SoToGaz each with a 2% interest⁹⁴. The initial capacity of the WAGP will be 200 mcf/d, with the capability to expand to 600 mcf/d as demand grows. The US\$500-million WAGP will initially transport 120 mcf/d of gas to Ghana, Benin and Togo beginning in June 2005. Gas deliveries are expected to increase to 150 mcf/d in 2007, to 210 mcf/d in 7 years and to be at 400 mcf/d when the pipeline is functioning at its full capacity, Fig. (7.3).

Fig. (7.3): West Africa Gas Pipeline project



It is also possible that the WAGP will be extended to markets in Cote d'Ivoire. There is speculation that the WAGP would eventually terminate in Senegal, but the current regional stability problems in several countries (Cote d'Ivoire, Liberia and Sierra Leone) that lie on the way to Senegal, will hinder any further extension of the WAGP.

Nigeria has an estimated 159 trillion cubic feet (tcf) of proven natural gas reserves, giving the country one of the top ten natural gas endowments in the world. Due to a lack of utilisation infrastructure, Nigeria still flares about 40% of the natural gas it produces and re-injects 12% to enhance oil recovery. Official Nigerian policy is to end gas flaring completely by 2008. The World Bank estimates that Nigeria accounts for 12.5% of the world's total gas flaring. Shell estimates that about half of the 2 bcf/d of associated gaseous by-products of oil extraction is flared in Nigeria annually. The new industry strategy is to collect the associated gas and process it into liquefied natural gas (LNG), greatly enhancing Nigerian natural gas revenues while simultaneously reducing carbon dioxide emissions. One of the major environmental and economic benefits of the WAGP is that it will export the currently flared gas to West African countries where some 70% of their population still uses fuel wood to meet their basic energy needs. Nigerian natural gas would thus be exported to Benin, Togo and Ghana to provide modern energy services and stimulate economic development.

⁹⁴ <http://www.eia.doe.gov/emeu/cabs/wagp.html>

7.7.1. Political Commitments and Role of Governments

The governments participating in the WAGP (Nigeria, Benin, Togo and Ghana) have played critical roles in supporting the pipeline project. The project is also listed in the short-term priority list of the NEPAD, initially decided upon by the African leaders.

7.7.2. Role of Regional Institutions

The Economic Community of West African States (ECOWAS) has been playing an active role in monitoring NEPAD projects including the WAGP. This is demonstrated by the creation of a NEPAD focal point within the ECOWAS secretariat, calling its member countries to create NEPAD focal points, and forming an ad-hoc inter-ministerial committee to oversee the implementation of the NEPAD programme.

7.7.3. Harmonisation of the Regulatory Framework

Cross-border gas pipelines require a framework for transactions to take place, harmonised arrangements for operations, a system of tariffs for use of the pipeline, gas pricing, and agreed principles and procedures for dispute resolution. It is also important that arrangements be established to remove barriers to trade. In the case of WAGP, the pipeline will be extended to new markets with almost no past experience in the gas industry.⁹⁵

7.7.4. Integrated Energy Policy Framework

The increasing use of natural gas for power generation is mainly attributed to the technological advances of combined cycle gas turbines (CCGT) resulting in improved efficiency, and reduced costs. Natural gas is an environmentally sound fuel producing the least amount of toxic emissions and greenhouse gases (GHG) amongst other fossil fuels and it has also become one of the most viable options for many countries to improve local air quality. In addition, many industrialised countries have planned to rely on natural gas to meet their commitments under the Kyoto protocol. Power expansion plans are essential to gas policies. Therefore, it is important to have an integrated energy framework at the national level, where natural gas policies are coordinated with the power sector and other wider energy forms.

7.7.5. Markets

Market drivers such as supply, demand and prices are determining factors in cross-border gas trade. Differences between mature gas markets, as is the case of "Transmed", and immature gas markets in the WAGP countries are very important. Much needs to be done to develop end-use markets, including the development of distribution networks, natural gas technologies in industrial, commercial and residential sectors and gas usage in the private sector. Other policies to develop gas markets include building local capacity in various aspects of gas industry, establishing capable institutions, setting up efficient energy pricing mechanisms, tightening environmental regulations and creating favourable investment climates. The role of government is either in creating market for gas demand or regulating immature gas markets. Other major players instrumental in developing gas markets include: gas companies, providers of gas technology, international organisations and environmental organisations.

⁹⁵ ADB, NEPAD Infrastructure Short Term Action Plan, Review of Implementation Progress and the Way Forward, 2003

Chapter 8: Conclusions & Recommendations

The fragmentation of Africa, after political independence, into many states with limited economic coherence, led African leaders to embrace regional integration as a central element of their development strategy. There has been increased awareness among African countries, that progressive integration holds great potential for minimising the costs of market fragmentation and thus, represents a precondition for integrating African economies into the global economy. Regional cooperation and integration is also necessary to improve Africa's competitiveness and position it to maximise the benefits of globalisation. Enhancing Africa's access to global markets, especially the markets of industrialised countries, is an essential factor, alongside debt relief and renewed official development aid for sustaining economic and social growth.

Energy services are indispensable for sustainable development. Reliable energy supply is an absolute prerequisite to economic growth; jobs creation; enhancement of value-added economic activities and support of income-earning activities; especially in rural areas, thus improving living standards.

Regional energy cooperation and integration is one of the most promising and cost-effective options for Africa, to further the development of its energy sector, in order to gain the environmental, social and economic benefits accruing from a more efficient use of resources. Four major benefits are associated with regional energy integration:

- (1) Improved security of supply;
- (2) Better economic efficiency;
- (3) Enhanced environmental quality; and
- (4) Development of renewable resources.

Historically, the first two factors have been the driving forces behind power interconnections and regional energy trading throughout the world. However, there is increasing awareness of the need to integrate environmental considerations in development. Power and natural gas interconnections are being viewed as a means to promote alternative clean or more environmentally sound energy resources. The current low rate of electricity access creates opportunities for hydropower development in Africa. It would be more beneficial to develop such resources as regional rather than national projects. This would help expand energy markets in these regions, and secure energy supply to those who presently have no access.

A crucial issue is the need to facilitate the formation and expansion of interconnected systems and power pools and development of regional transmission infrastructure for power transmission and market expansion. In addition, Africa holds about 8% of the world's natural gas resources. Due to domestic market limitations related to their size and credit-worthiness, and because of the significant investments and sizable minimum reserves required to support export projects, natural gas has been substantially under utilised or wasted in many African countries, where very large quantities of natural gas associated with oil production are being flared, wasting the resource and causing significant environmental damage. Although gas markets are being established on a country-by-country basis, regional development is also considered an equally important medium and long-term goal.

Integrating natural gas markets in Africa will achieve significant rewards including:

- A cleaner environment, where natural gas is exported instead of being flared, as in the case of the planned WAGP from Nigeria to Togo, Benin and Ghana;
- Economic benefits through job creation, attracting more investments and improving local economies; and
- Improved regional cooperation where regional gas projects such as the West Africa Gas Pipeline (WAGP) would distribute economic and political benefits to several nations.

A number of lessons can be drawn from the African regional energy integration experience. Obviously, there are some differences between issues related to cross-border natural gas projects, and those related to electricity interconnections. However, some key interdependent factors appear to be common to both. Among those common factors are: the geopolitical contexts and political commitments, the investment climate, the regulatory regime, the infrastructure, and the technical and managerial capacity.

- ***Geopolitical Context and Political Commitment***

Geopolitical contexts include the regional state of affairs and the status of security and stability in the region. The absence of political disputes and social unrest is an important prerequisite to regional energy integration. Geography also plays a facilitating role in the establishment of the regional energy integration infrastructure; this would include proximity of the demand centres to energy resources, and the effects of topography and terrain, in routing the gas pipelines or power transmission lines. It should be noted that the world is currently shifting from geopolitics to globalisation, where markets would be increasingly integrated in the medium to long-term. Political commitment and government support have proved to be a successful factor in Africa's regional energy integration experience. Although the role of governments is changing due to energy sector reform, they are instrumental in setting up the institutional and regulatory frameworks that will create an enabling environment to attract private capital and develop energy markets.

- ***Investment Climate***

Africa's unfavourable investment climate has led to high transaction costs, expensive financing terms, weak domestic capital markets, low sovereign credit ratings, and a lack of local technical and managerial capacity. However, in recent years, Africa has seen rising private investment and falling public investment as a percentage of GDP in a continuation of trends seen through the 1980s and 1990s. The higher share of private investment shows that gradual progress is being made in the development of the private sector. However, barriers to private investment are still plentiful and constantly need to be overcome. In view of the shortage in public finance, the global competition for Foreign Direct Investment (FDI), the capital-intensive nature of cross-border energy projects and its long payback periods and lead times, an investment climate conducive to attracting private capital would be indispensable.

- ***Regulatory Regime***

Successful integration of energy systems requires a framework for transactions to take place, harmonised arrangements for systems operations, a system of tariffs, and agreed principles and procedures for dispute resolution. Different legal, regulatory and licensing systems existing in different countries need to be harmonised to ensure smooth transactions, and minimise the likelihood of future disputes. Harmonisation of

the statutes of the national regulatory bodies, when they exist, would facilitate cross-border trade. The role of regional institutions cannot be dismissed, in addition to securing political support; these institutions could also coordinate capacity building, information and experience sharing among regulators, if their institutional and human capacity is reinforced. The difficulty in coordinating international investments can be eased when multilateral development agencies participate. These institutions can mobilise more financial resources, help reduce transaction costs and ease the enforcement of contracts. The absence of these institutions can be both a symptom and cause of the inability to secure investments in regional infrastructure.

Three major drivers are envisioned for the future growth in electricity demand in Africa: economic growth, population growth, and the lower rates of electrification and energy accessibility. Thus, future increases in domestic electricity demand at the national level are projected to be high. For interconnected electricity systems, it would be difficult for national utilities to continue to guarantee contractual amounts of electricity to the other partners. To be more effective, bilateral agreements should be supplemented by other pooling arrangements that allow coordination in the planning and operation of the interconnected systems. Coordination of expansion plans within regional pools proved to be more effective in ensuring the sustainability of the interconnected power systems.

Many “off-take” gas markets presently have little or no gas consumption, which creates risk in the “off-take” quantity for new pipelines. Success in introducing large quantities of gas into immature “off-take” markets depends, to a large extent, on complementary investments in gas-use technologies. As the world shifts increasingly towards natural gas for its energy needs, the share of gas in the energy mix has been increasing worldwide. However, there will be a difference between those mature markets that involve extensions of existing gas infrastructures, and those immature markets where “first gas projects” are introduced. More needs to be done to develop such end-use markets, including the development of distribution networks, promoting natural gas technologies in the industrial, commercial, and residential sectors, and gas usage in electricity generation. Other policies to develop gas markets including building local capacity on various aspects of the gas industry, creating capable institutions, establishing efficient energy pricing and taxation schemes and tightening environmental regulations. The role of government either in developing immature gas markets or in regulating such markets is inevitable. Other major players in developing gas markets include international organisations, financing institutions, gas companies, providers of gas technologies, and environmental organisations. Thus, aggressive public-private partnership might be a promising policy alternative in this regard.

In addition to the issues discussed, and to facilitate the successful implementation of the NEPAD short-term priority projects, a number of recommendations have been developed. These recommendations are mainly meant to strengthen the institutional and human capacity set-up. The role of the African regional economic commissions such as UMA, ECOWAS and SADC, amongst others, in promoting, coordinating and monitoring the NEPAD projects should be reinforced. These institutions can play a central role in coordinating and harmonising regulatory frameworks across Africa’s economic borders, with a view to achieving a unified African regulatory framework in the longer-term. To strengthen such roles, the institutional and human capacity of those institutions needs to be developed.

The newly established African Energy Commission (AFREC) could be a potential means to promote Africa's regional energy integration, information exchange and capacity building. The NEPAD secretariat and the African Development Bank should seek to strengthen the role of AFREC in promoting NEPAD's energy projects.

Although it is advisable to strengthen the role of the African Development Bank as a lead agency in mobilising financial resources for NEPAD's priority projects, it is necessary to explore the viability of devising new and innovative financing schemes to promote African regional energy integration and the general integrating of Africa into the global economy.

Recommendations

The primary objective of this study is to develop a set of recommendations for facilitating better planning and implementation of a few selected projects listed in the NEPAD's short-term priority list. Based on the lessons learned from the SAPP and Transmed projects, it is advisable to take into consideration, the following set of recommendations, as appropriate, when planning the implementation and operation of the proposed Algeria-Spain electricity interconnection and the West African Gas Pipeline (WAGP). It should be noted, that these projects do not aim primarily at Africa's regional energy integration; neither could they be considered as forming a power pool. The projects are aimed mainly at making use of the enormous natural gas resources available in these countries. Furthermore, they can benefit from the new evolution of the open access to the European energy market, and at the same time promote Africa's integration into the global economy. It is also worth mentioning, that the parties concerned might have already considered some of these recommendations.

- Strengthen the role of the African Energy Commission (AFREC) in promoting NEPAD's energy projects. This is to enhance regional energy integration in Africa and between Africa and other energy markets.
- Strengthen the role of NEPAD's supporting regional institutions in promoting and coordinating regional energy integration projects.
- Strengthen the role of the African Development Bank (ADB) as a leading agency in mobilising financial resources for NEPAD's priority projects.
- Explore the viability of devising new financing schemes to promote regional energy integration and integrating Africa into the global economy. For example a Euro-African investment bank, or a Euro-Mediterranean Bank.
- Enhance mechanisms for commercial dispute resolution in Africa within NEPAD and African Union (AU).
- The regulatory statutes for cross-border trade should be carefully drafted to be specifically compatible with those of potential trade partners.
- Build the capacity of the energy sector on issues of harmonised rules and procedures of interconnected power systems.

- Coordinate national development plans with potential trade partners.
- Coordinate and harmonise regulatory frameworks across economic regions with a view to achieving a unified African regulatory framework in the long term.
- Develop local gas market in ‘off-take’ countries.

WEC through its Regional Action Plan for Africa is willing to support the implementation of the NEPAD priority projects and other efforts aimed at providing access to energy for Africa’s energy poor population.

ANNEX A**BIBLIOGRAPHY**

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ANNEX B

List of Abbreviations/Acronyms

1995US\$	in 1995 United States dollars
ADB	African Development Bank
AEC	Algerian Energy Company
AFREC	African Energy Commission
AU	African Union
bcf	billion cubic feet
bcm	billion cubic meters
BP	British Petroleum (Southern Africa)
CCGT	Combined Cycle Gas Turbines
CEB	Communauté Electrique du Benin
CIE	Compagnie Ivoirienne d'Electricite
CNG	Compressed Natural Gas
CO ₂	Carbon Dioxide
CREG	Electricity and Gas Regulatory Commission (Algeria)
DOE	Department of Energy
DRC	Democratic Republic of Congo
ECA	United Nations' Economic Commission for Africa
ECOWAS	Economic Community of West African States
EGAS	Egyptian Natural Gas Holding Company
EGPC	Egyptian General Petroleum Company
ESMAP	Energy Sector Management Assistance Programme
EU	European Union
FDI	Foreign Direct Investment
HSE	health, safety and environmental standards
GdF	Gaz de France
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gases
GNP	Gross National Product
GW	gigawatt
H-gas	high-calorific gas
HOA	Heads of Agreement
HV	high voltage
ICT	information and communications technologies
IEA/OECD	International Energy Agency/Organisation for Economic Co-operation and Development
IGA	Inter-Governmental Agreement
IHA	International Hydropower Association
IOC	International Oil Company
IPP	Independent Power Producer
ITP	Independent Transmission Project
km	kilometre
kV	kilovolt
kWh	kilowatt hour
L-gas	low-calorific gas
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas

mcf	million cubic feet
MDG	Millennium Development Goal (United Nations)
MEG	Maghreb-Europe Gas Project
MOU	Memorandum of Understanding
MPP	Mediterranean Power Pool
mtoe	million of tonnes oil equivalent
MW	megawatt
NEPAD	New Partnership for Africa's Development
NNPC	Nigerian National Petroleum Corporation
NO _x	Nitrogen Oxide
OAU	Organization of African Unity
ODA	Overseas Development Assistance
OECD	Organisation for Economic Co-Operation and Development
p.a.	per annum
PSC	Planning Sub-Committee (South African Power Pool)
PV	Photovoltaic
RERA	Regional Electricity Regulatory Association
R/P	Reserve to Production Ratio
SADC	Southern African Development Community
SAPP	South African Power Pool
SO ₂	Sulphur Dioxide
SSA	Sub-Saharan Africa
STAP	Short-Term Action Plan
STEM	Short-Term Energy Market
tcf	trillion cubic feet
tcm	trillion cubic meters
toe	tonnes oil equivalent
Transmed	Algerian-Tunisia-Italy pipeline
TWh	terrawatthours
UMA	Union du Maghreb Arabe (Arab Maghreb Union)
UN	United Nations
UNDP	United Nations Development Programme
US\$	United States dollar
USAID	United States Agency for International Development
VRA	Ghana's Volta River Authority
WAGP	West Africa Gas Pipeline
WAPP	West African Power Pool
WCD	World Commission on Dams
WEC	World Energy Council
WEHAB	Water, Energy, Health, Agriculture and Biodiversity
WLGP	Western Libyan Gas Project
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization