Intermediate Technology Consultants Ltd

Final Report for WWF

The Mphanda Nkuwa Dam project: Is it the best option for Mozambique's energy needs?

June 2004

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Executive Summary

The proposed Mphanda Nkuwa hydropower scheme, 70 km down stream of the Cahora Bassa Dam in Mozambique is billed by the Government of Mozambique as one of the most competitive regional power projects in Southern Africa and a priority project for New Partnership for Africa's Development (NEPAD) . The Government of Mozambique is currently in the promotion phase of the project to attract potential investors from around the world.

Mphanda Nkuwa, selected from a range of several possible sites along the Zambezi is projected to generate 1300MW at a total cost of approximately $2.0 billion. The project was also selected on the basis of its low unit generation cost and its additional function to provide re-regulation for the Hydro Cahora Bassa (HCB). Development of Mphanda Nkuwa is supposed to enable Hydro Cahora Bassa to increase the value of the energy it produces by producing more during peak hours and less during low tariff periods. This is currently not possible due to the requirement to maintain a river level variation below a certain level.

The purpose of this report is to analyse the proposed Mphanda Nkuwa dam in terms of its technical, social, economic and environmental impacts and also in relation to alternative options for meeting Mozambique's energy and development priorities.

Mozambique has very low per capita and absolute consumption of electricity with 78kWh per capita per year and national demand of 350MW excluding the consumption by the aluminium smelter Mozal (which consumes 900 MW). It is a net exporter of electricity with the bulk of the surplus being consumed by South Africa and to a lesser extent Zimbabwe. Yet, only 4.7% of the population in Mozambique has access to electricity with 50% of these households in Maputo. The government with assistance from major donors are involved in extensive investment in improving access to electricity and other energy forms.

The government's decision to promote Mphanda Nkuwa has been premised on hydropower generation as an export industry on the available potential in the country, projected electricity demand in the Southern African region and infrastructure investment to support an economic plan based on primary resource extraction in minerals and other natural resources. Current excess capacity on the Southern African Power Pool (SAPP) is projected to run out by 2007. South Africa alone will require an additional 3000MW by 2010 after re-commissioning its mothballed thermal power plants. In Mozambique, several mega projects in mineral extraction and processing are planned with a projected total demand of approximately 2000MW by the same time horizon. It is this future market that Mphanda Nkuwa is poised to serve.

Mphanda Nkuwa is promoted as a private sector investment with minimal (5%) government shareholding to mitigate political risk. Attracting foreign direct investment into the electricity sector is also viewed as aiding the image of Mozambique as a competitive destination for foreign direct investment in resource extraction industries. Uncertainty however, persists over the net benefit to fiscal revenues and national development of such mega investment which have up to now been negotiated on the basis of wide tax breaks and very light handed regulation. Current experiences with Hydro Cahora Bassa and Mozal cast doubt over the real contribution of such mega projects and whether this is indeed the best development path for Mozambique.

Specific to the project, several socio-economic considerations are still to be addressed. The feasibility study was conducted shortly before the publication of the World Commission on Dams (WCD) Report and does not conform to some of the best practice recommendations. There is no evidence of a wide national or even local consultation to gain public acceptance as recommended by the WCD report. The government on its part is wary of a high visibility programme to discuss the project due to the political pressure that may result due to raised expectations. The only respite lies in that any developer who would consider investing $2.0 billion dollars would want to undertake a thorough and more detailed feasibility study of their own which would include gaining public acceptance. In reality however, developers may invest in curtailing public rejection rather than gaining its acceptance.

The project is proposed in a context with regulatory institutions whose capacity to enforce compliance against the larger multinational energy companies who have the resources to invest in such projects puts to doubt the extent to which negative impacts will be mitigated. The following considerations in particular still need clarification:

- The impact of hydropower operation on the shrimp industry in the Zambezi delta- Mphanda Nkuwa will perpetuate high base river flows and low seasonal variation which reduces shrimp populations and subsequent catch. The loss of income from Mphanda Nkuwa is estimated at $10 million per year.
- The project also has a recommendation for river levels to be allowed to vary by 1.5 metres threatening many flood fields (and hence floodplain agriculture) that have been the source of livelihood for thousands for families in the lower reaches of the Zambezi in the districts of Mutarara, Caia, Marromeu, Chemba and Tete.

- A framework for compensation for the 1400 people projected to be displaced by the project still remains hazy. The level of participation of the affected households given their low bargaining power needs the facilitation of external agencies especially civil society organizations and a strong regulator. Both are currently missing.
- The project falls into the Zambezi Valley Authority and is eligible for wide ranging investment incentives. The level of local industry stimulation and the downstream benefits are still to be clearly spelt out.
- Greater public discussion and debate on the project in view of the current high information asymmetries especially between a keen civil society and an over cautious government.
- In view of the low prices being fetched on HCB exports to South Africa (US$) compared against a unit generation cost of $0.027/kWh, energy pricing levels within the SAPP are likely to be the eventual determinant on whether Mphanda Nkuwa goes ahead or not.

On the whole, Mphanda Nkuwa will not directly benefit most of the Mozambican people in the short term, but has the potential to do so in the medium to long term contingent on the above mentioned issues being addressed. However, if these issues are not addressed then the project could result in an unequal distribution of costs and benefits alongside heavy social and environmental impacts.

1 General Background

1.1 Mozambique

Mozambique is a vast country with a diverse natural resource base. The country is enjoying relative peace and a nascent democracy is firmly taking root. This stability has given rise to above regional average economic performance with the national economic growth rate one of the highest in Sub-Saharan Africa.

Mozambique still has very poor infrastructure to support value adding economic activities. As such the country has focused its economic development policy around the exploitation of primary raw materials such as agricultural produce, mining and hydropower development.

Considerable international resources have been focused on Mozambique to support her economic rejuvenation. The energy sector has been one of the biggest recipients of international support, mainly from the Nordic Donors but also other multilaterals. The major donors are the Norwegian, Swedish and Danish Government Aid Agencies (NORAD, SIDA and DANIDA), the French Agency for Development, World Bank and African Development Bank (ADB). With the exception of DANIDA and the World Bank who have a broader energy sector investment which includes renewable and off grid energy solutions, all the donors have focused their investment in supporting rehabilitation and expansion of the electricity network in Mozambique after years of sabotage during the war, and on institutional capacity building. Substantial resources have been channelled into extending the reach of the centrally operated grid networks within the country. Mozambique does not have a central grid but rather three networks to cover the central region, northern and southern regions. It still is far from national coverage and there are wide regional disparities in access levels. The table below shows the percentage access by province for the whole of Mozambique.

Table 1.1: Access by Province, 2002

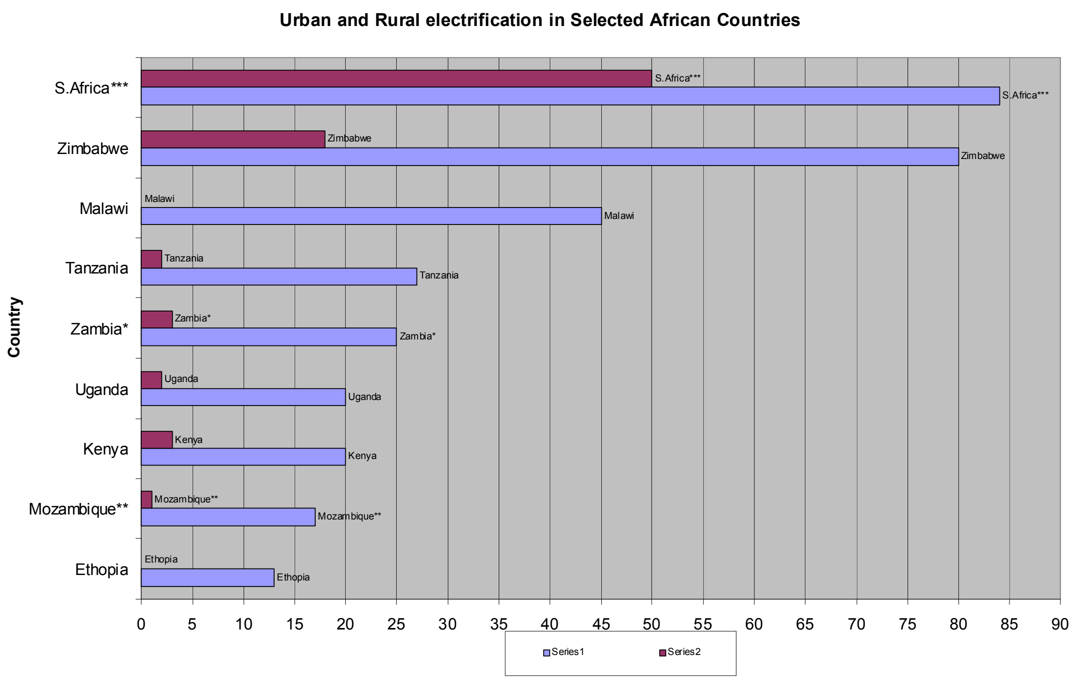
Province	Domestic Cons. EDM	Domestic Cons. Others	Total	Population by Province	Access by Province %
Cabo Delgado	3,721	1,476	5,197	1,525,634	1.4
Niassa	4,812	543	5,355	916,672	2.5
Nampula	24,088	800	25,888	3,410,141	3.1
Zambezia	11,431	579	12,010	3,476,484	1.5
Tete	7,527	2,230	9,757	1,388,205	3
Manica	5,985	1,596	7,581	1,207,332	2.6
Sofala	14,072	3,642	17,714	1,516,166	4.9
Inhambane	4,903	1,752	6,655	1,326,848	2.1
Gaza	11,356	457	11,813	1,266,431	3.9
Maputo	101,948	0	101,948	2,048,610	20.9
Total	**189,843**	**13,075**	**202,918**	**18,082,523**	**4.7**

Source: EdM Annual Statistical Yearbook 2002

Through the Energy Reform and Access Programme (ERAP) the Mozambique Government with financing from the World Bank is involved in a four year project that would result in 40,000 new electricity connections and 2,500 solar systems to supply power to education and health centres as well as households in rural areas. There is an additional component to promote the rehabilitation and setting up of new small-scale hydro systems (approximately 40 in total). The Council for Electricity Users (CNELEC) will be expanded and transformed into an electricity sector regulator during the same four year period to allow for wider private sector participation in all the phases of electricity supply industry. DANIDA is a supporting a renewable energy programme for rural areas initially focusing on the province of Sofala but not limited there. They are also making major investment in the expansion for the transmission and distribution networks where their efforts are strongly complimented by NORAD, SIDA and ADB.

1.2 Energy and Poverty Statistics

Mozambique has one of the lowest electrification rates (approximately 5%) in Southern Africa. However, the gross national electricity consumption has increased substantially as several mega projects have come on stream. The new aluminium smelter, Mozal, increased the national consumption three fold when it came on stream in 2002. However, annual domestic consumption still remains low at 78kWh per capita compared to 3,745kWh for South Africa (Human Development Indicators, 2000). Only 200,000 households are connected to the electricity network (EdM, Annual Statistical Report, 2002) due to very low per capita incomes for the majority of the population.



Source: Adapted from Energy Policy Vol 30, September 2002

1.3 Poverty context in Mozambique

One of the main priorities of the Government of Mozambique is to substantially reduce the levels of absolute poverty in Mozambique through the adoption of measures to improve the capacities of, and the opportunities available to all Mozambicans, especially the poor. The specific objective is to reduce the incidence of absolute poverty from 70% in 1997 to less than 60% by 2005 and less than 50% by the end of this decade.

The reduction and elimination of poverty is the principal objective of development policies in the medium and long term. However, in discussing poverty, it is essential to look at the different interpretations of its meaning. Poverty is a complex, multi-dimensional phenomenon with diverse characteristics. Poverty has usually been synonymous with the failure to secure a certain level of income. However, a broader definition of poverty could be based on the *consumption per capita* (the total consumption of the family household divided by the number of members) as the basic measure of individual well-being for the following reasons:

- Consumption is the most appropriate indicator or measure of actual well being (while income is a measure of potential well being given that it may or may not be used for consumption)
- Consumption is a more precise and stable indicator since it is less subject to fluctuations over time

Therefore, individuals are classified as poor or not poor in terms of a poverty line defined in terms of per capita consumption. (PARPA[1] 2001-5).

The Mozambican government has targeted poverty alleviation as its major priority with the highest concern being expenditure on health and education in order to improve human development. Significant investments were also made in rehabilitating basic infrastructure. Since 1987, the Government has adopted a stabilization and structural adjustment programme with the objective of re-establishing production and improving incomes through deep reforms aimed at creating an economy based on private initiatives and market forces.

Analysis of data from the Household Survey (IAF) of 1996/97 provided a detailed profile of poverty in Mozambique. Nearly 70% of the population lives in absolute poverty, and there are notable urban-rural and regional imbalances. The IAF data identified the main determinants of poverty in Mozambique:

- Slow growth of the economy until the beginning of the 1990s;

[1] PARPA is the action Plan for the Eradication of Poverty. It is the same as the Poverty Reduction Strategy Paper for English speaking countries.

- Low levels of education of working age household members, particularly women;
- High dependency rates in households;
- Low productivity in the family agriculture sector;
- Lack of employment opportunities within and outside of the agricultural sector; and
- Poor infrastructure, especially in rural areas.

Box 1. What is poverty?

Definition in Mozambique: *"inability of individuals to ensure for themselves and their dependants a set of basic minimum conditions necessary for their subsistence and well-being in accordance with the norms of society."*[4]

Other definitions: "the lack of income necessary to satisfy basic food needs or minimum calorie requirements" *(Absolute or Extreme Poverty* in terms of income); "Lack of sufficient income to satisfy the basic essential food and non-food requirements given the average income of the country" (R*elative Poverty);* "Lack of basic human capacities, such as illiteracy, malnutrition, low life expectancy, poor maternal health, prevalence of preventable diseases, together with indirect measures such as access to the necessary goods, services and infrastructures necessary to achieve basic human capacities – sanitation, clean drinking water, education, communications, energy, etc.-" (*human poverty).*

The new PARPA (2001-2005) places emphasis on **social investment** to directly tackle poverty and on medium and long-term measures to fight poverty through policies to sustain rapid and broad-based economic growth.

Without growth, the objective of increasing the capacities and expanding the opportunities for the poor will continue to be severely constrained by the lack of public and private resources. Therefore, the strategy contains policies aimed at creating a favourable climate for stimulating investment and productivity, and achieving an average annual GDP growth rate of 8%.

The strategy is geared to ensure that growth is inclusive, so that the poor will benefit integrally. This should occur through greater access to assets (including improvements in human capacity) and the more efficient use of such assets by individuals, families and other institutions, especially in rural areas. The provision and access to sustainable energy services is central in stimulating economic activity. Energy is a key factor of production and its availability has a bearing on the pace of economic growth. Access to electricity stimulates the private sector to increase job creation and income generating opportunities.

In addition, the geographical distribution of poverty in Mozambique is a very politically sensitive issue. To that end the PARPA highlights the need to dissipate existing poverty asymmetries and strive for a better regional balance, with special attention given to regions with the greatest concentration of poor people.

In concrete terms, the poverty reduction strategy in Mozambique is based on **six priorities** aimed at promoting human development and creating a favourable environment for rapid, inclusive and broad-based growth. The fundamental areas of action are:

- Education,
- Health;
- Agriculture and rural development;
- Basic infrastructure;
- Good governance;
- Macro-economic and financial management.

1.4 Energy and cross-sectoral linkages to poverty

As stated above the Mozambican government has targeted the development of basic infrastructure as a priority area in reducing and eradicating poverty. Roads, electricity and water are some of the infrastructure services considered vital for improving the lives of people in Mozambique. Improvements in the road network will permit better access to markets and a reduction in costs, and will facilitate communication and mobility, especially for those who live in rural areas and depend on agriculture. In parallel, the provision of water and energy is fundamental to the development of human capital and the expansion of national output. Priority in the rehabilitation and construction of basic infrastructure will be given to those areas of the country with the largest populations and highest levels of poverty.

Education is a basic human right and has a fundamental role in poverty reduction. Access to education contributes directly to human development by improving the capacity and opportunities for the poor, promoting greater social, regional and gender equity. Education is also essential for rapid growth, as it expands the quantity and quality of human capital available for productive activities, and the ability of the nation to absorb new technologies. The main objectives, in Mozambique, in the area of education include achieving universal primary education, while rapidly expanding secondary education, informal education, and technical-vocational training. Access to electricity helps in improving adult education as well as technical and vocational training by enabling adults to learn during the evenings when they are free from their daily livelihood activities. The quality of education depends on access to current and up to date technologies such as information communication technologies, all of which operate on electricity.

The **health** sector also plays a fundamental role in directly improving the well being of the poor, while at the same time contributing to rapid economic growth by improving the quality of human capital. The main objectives in the field of health include an expansion of, and improvement in, the coverage of primary health care through special programmes geared towards target groups such as women and children, a campaign to reverse the current growth of the HIV/AIDS epidemic, and greater efforts in the fight against diseases such as malaria, diarrhea, tuberculosis and leprosy.

Energy (electricity) is vital as a factor of production as well as for human development. The social sectors of education and health are a top priority for the Mozambique government. From the foregoing description of the poverty and energy sector priorities for the government, it is clear that the proposed Mphanda Nkuwa project does very little to directly address these areas. There is a proposal to provide infrastructure for the 260 families that will be displaced by the development but in terms of increasing access to electricity directly to the poor, or the institutions that serve them, Mphanda Nkuwa will not have a direct impact.

1.5 Mozambique Electricity Sector

Three service providers dominate the electricity sector in Mozambique:

- Electricidade de Mozambique (EdM) which is the national power utility (wholly owned by the government of Mozambique) is involved in all stages of the electricity supply chain from generation through transmission and distribution to final supply and billing of consumers,
- Hidroelectrica de Cahora Bassa, is the company that manages and operates Cahora Bassa Hydro Electric Power Stations and associated transmission network to the Southern Africa Power Pool,
- MoTraCo is a joint venture between the power utilities of Mozambique, South Africa and Swaziland formulated to transport power from South Africa to the Mozal Plant in Maputo.

EdM has approximately 250,000 customers connected to its grid with 50% of the customers in Maputo. The electricity distribution is distorted with the bulk of the connections in urban areas and only a very small proportion of the consumers in rural areas. It is estimated that between 4 and 6% of Mozambicans have access to electricity, and most of these are in the urban areas.

The main objectives of the PARPA in the energy sector are to:

- Expand the population's access to energy sources;
- Reduce the environmental impact of using non-renewable sources;
- Contribute to the supply of sustainable energy in the main regions of the country, strengthening their economic growth and reducing regional imbalances;
- Promote the use of new and renewable energy sources in the electrification of remote areas;
- Electrification of districts with economic potential;
- Promote the participation of the private sector in the field of energy.

Other measures include supplying electricity to 60,000 new domestic consumers.

The Mphanda Nkuwa project does not directly address any of the energy sector objectives contained in the Action Plan for the Eradication of Absolute Poverty. As stated in other sections of this document, the current line of argument by the promoters is that this project supports poverty eradication through the promotion of private initiative and investment based on market imperatives. The problem is in determining the appropriate level of fiscal support to be given to such private initiatives that do not directly benefit the poor and whose activities may actually threaten the livelihood of the most vulnerable communities. The conundrum of how much public support and concessions should be given to private developers versus the assistance needed and socio-economic measures required to protect the interests of the poor with such a development is at the centre of the decision that the Government of Mozambique must make on Mphanda Nkuwa. It is essentially a choice of the development paradigm to be adopted between attraction of foreign direct investment into resource extraction and socio-economic development investment in basic infrastructure such as appropriate energy supplies to enable communities to improve their livelihoods. It would make sense for the government to concern itself primarily with the socio-economic investment to provide its people with a basic quality of life rather than the promotion of private investment per se. The converse is also valid in that there is need to promote private investment as a way of creating jobs and wealth in the country for long term sustainable poverty reduction. The issue then becomes one of balancing the short to medium term priorities and the long term development needs of the country. Mphanda Nkuwa may be evaluated to be a useful long term investment project to enable investors to tap the vast mineral and other natural resources available in Mozambique but only if its long term impacts on the livelihoods of communities in the lower Zambezi are also properly managed. This is discussed in greater detail in the following sections.

Of the current energy production in Mozambique 80% comes from the Cahora Bassa hydropower plant (HCB) with an installed capacity of 2075MW and the balance from small hydro and gas power stations. EdM expects to cover demand growth from additional power allocation from the HCB in the coming years with surplus still exported to South Africa, Zimbabwe and Malawi.

The major source of concern for private developers is linked to the price and security of payment for electricity from the project. Some of the regional utilities such as ZESA from Zimbabwe have been in arrears for prolonged periods under the current supply arrangements from Hydro Cahora Bassa and wheeling charges through EdM. An adverse power purchase agreement and ownership of the Hydro Cahora Bassa also raises fears from potential developers who are closely following the ongoing negotiations between the Governments of Mozambique, South Africa and Portugal.

The capacity of EdM still remains low with electrical energy distribution being contracted through third party control (Eskom of South Africa) even when the generation is Mozambican based and the power is to supply mega projects in Mozambique, as has happened with Mozal which requires that its electricity supply comes from Eskom.

Demand growth is expected mainly from a number of energy intensive primary extraction industrial projects which are at different stages of development. The table below summarizes these projects and their projected electricity demand.

Table 1.2: Proposed Projects in Mozambique and their Energy Requirements

Project	Maximum Demand (MW)	Annual Energy (GWh/y)
Mozal Phase 1	460	4,000
Mozal Phase 1 and 2	895	7,500

Maputo Iron and Steel Plant	850	5,000
Kaiser Aluminium Smelter, Beira	625	5,000
Nacala Titanium Smelter	150	1,000
Chibuto Corridor Heavy Sands Project	150	1,000

The total demand of these major projects would be some 3,000MW with annual energy demand of over 20,000GWh/year. This would outstrip the current installed generation capacity of 2,385MW.

2 Regional Electricity Market

This section provides a review of the regional electricity market into which the output of the Mphanda Nkuwa could be sold. In particular, it focuses on the market for power in South Africa which would represent the best opportunity for any exports from Mozambique.

2.1 Southern Africa Power Pool

The Southern African Power Pool (SAPP) was established in 1995 through an Inter-Utility Memorandum of Understanding signed by representatives of the governments of the Southern African Development Community (SADC).

In terms of its constitution only utilities (and not individual power stations) are allowed to join the SAPP. At present its members are the utilities and Ministries involved in energy usage in Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zaire, Zimbabwe and South Africa[2]. The SAPP region is shown in Figure 2.1 In terms of electricity supply and demand, the SAPP is dominated by the South African utility, Eskom, which accounts for over 80% of the demand in Southern Africa.

The SAPP is based on co-operative principles, i.e. the utilities coordinate and cooperate in the planning and operation of their systems in order to minimise cost and maintain power system reliability. It works on the principle of full recovery of costs and equitable sharing of trading benefits.

From the SAPP's original primary objective to provide reliable and economic electricity supply to the consumers of each member, the SAPP has evolved into a very loose cooperative pool. The short-term trade prices in the SAPP are theoretically based on short-run marginal costs (with provision for a mark-up). This is the maximum price at which short-term trade may take place. Long-term trades can include a capacity component in the pricing. A short-term energy market (STEM), which started live trading in April 2001, utilizes the Internet to conduct trades.

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[2] Botswana Power Corporation (BPC); Electricidade de Mocambique(EDM); Angola's Empresa Nacional de Electricidade (ENE); Electricity Supply Commission of Malawi (Escom); South Africa's Eskom; Lesotho Electricity Corporation (LEC); Namibia's NamPower; Swaziland Electricity Board (SEB); the Democratic Republic of Congo's (DRC) Societe Nationale d'Electricite (SNEL); Tanzania Electric Supply Company (Tanesco); Zimbabwe Electricity Supply Authority (ZESA) and Zambia Electricity Supply Corporation (ZESCO).

The SAPP sets out certain rights and obligations to member utilities covering aspects of quality, capacity, operations and access.

Figure 2.1: The Southern African Power Pool (Source: www.sapp.co.zw)

Eskom's sales (GWh) to SAPP members between 2000 and 2002 are shown in Table 2.1. Eskom also imports over 1000MW base load from the Cahora Bassa hydroelectric power plant in Mozambique.

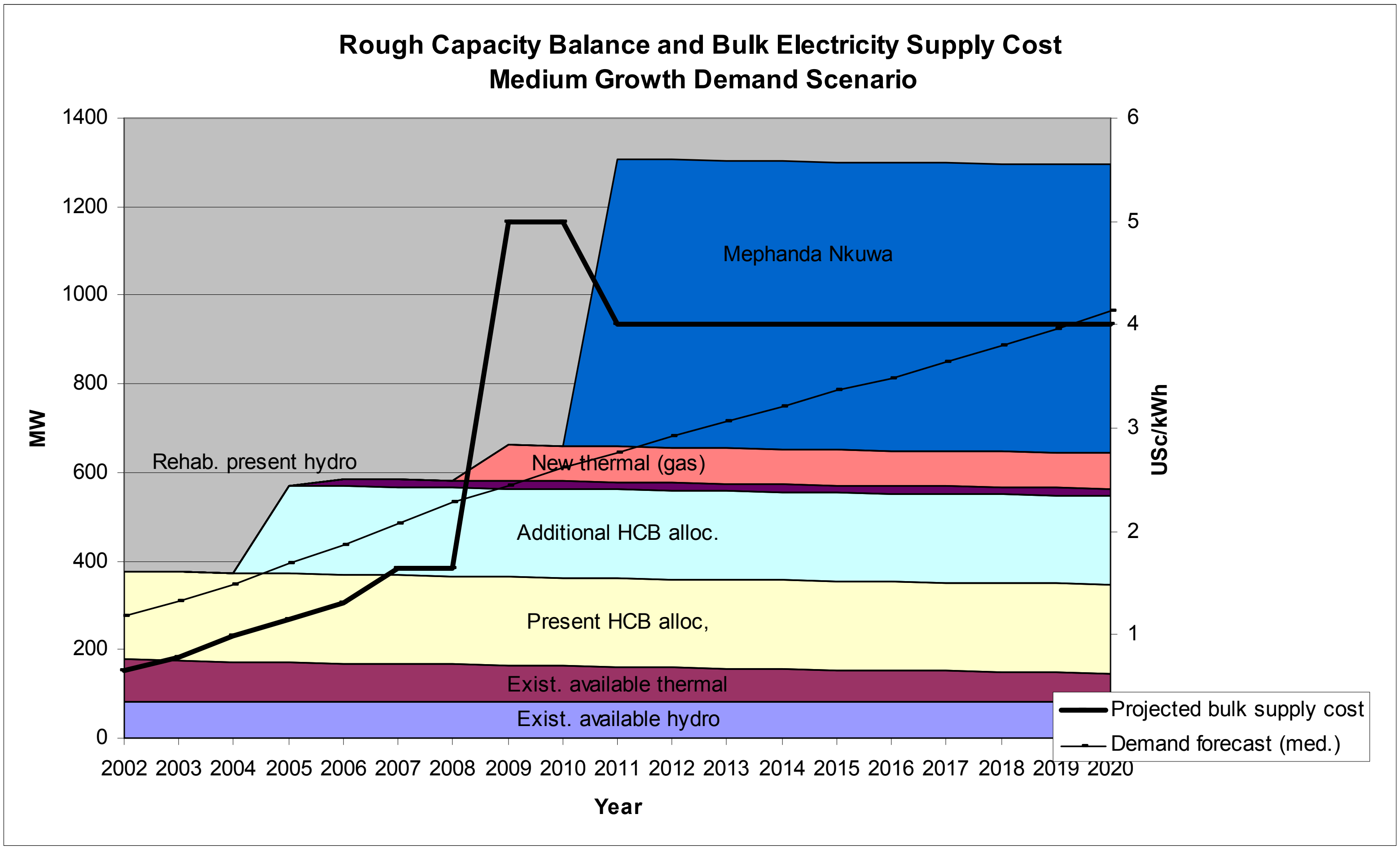
Table 2.1 Eskom's sales to countries in Southern Africa

Eskom's sales to countries in Southern Africa (GWh)			
	2002	**2001**	**2000**
Botswana	1,124	1,183	986
Mozambique	3,907	3,899	1,331
Namibia	598	578	640
Zimbabwe	298	371	788
Lesotho	16	40	12
Swaziland	799	639	115
Zambia	103	-	-

3 Energy Needs

3.1 Load Forecasts

Mozambique has a projected energy demand forecast shown below (EdM statistics):



3.2 Planned Generation

Mozambique has several options for hydropower generation on the Zambezi River and on several other smaller rivers. A study by the Technical Unit for the Implementation of Hydropower (UTIP) has identified 60 potential hydro sites in the country excluding the micro hydro sites (<500kW). The total combined generation potential is estimated at some 12GW.

Mphanda Nkuwa was selected among the various options along the Zambezi. It is not the biggest scheme. There is larger capacity at Boroma and Cambewe Foz (the other potential sites) but one of the reasons it was selected was because it can be combined with the construction of Cahora Bassa North. Mphanda Nkuwa is therefore currently proposed together with Cahora Bassa North. Besides hydro generation there are plans for gas turbines to utilize gas from the Temane and Pande gas fields for electricity generation. The third generation option is dependent on the re-commissioning of the Moatize Coal Fields in Tete where a coal fired thermal power station has been planned since colonial times.

Regionally, South Africa has three major coal power stations that are in storage or "mothballed" status with a combined capacity of 3,556MW. It is foreseen that as demand on the South African and SAPP rises, these power stations will come back on stream. South Africa has no significant untapped hydropower potential and future energy demand will have to be met from thermal and or nuclear generation. The country has limited potential for offshore wind generation as well as abundant solar radiation. The country is also developing portable and smaller nuclear Pebble-Bed Modular Reactor (PBMR) which can generate 110MW for electricity production.

Zimbabwe is already experiencing a deficit on its domestic demand with imports from the SAPP supplying up to 60% of peak demand. The country has no immediate generation projects planned but the potential is in additional generation at Kariba hydro plant and the suspended Gokwe North Thermal Power Stations.

There are other planned hydropower stations in the region at various levels of planning. Judging from the fact that many of the commissioning dates are now in the past, it is difficult to determine what capacity will come on stream. Demand growth however can be more reliably projected. Table 3.1 shows the planned generation plants within the region.

The 1775 megawatts (MW) Inga hydroelectric facility in the Democratic Republic of Congo (DRC) currently comprises a 351MW plant (Inga 1), commissioned in 1972, and a 1424MW plant (Inga 2) which has been in operation since 1982. Inga provides power to the Republic of Congo and also exports power to Southern Africa countries including Zambia, Zimbabwe and South Africa. There are plans for a significant expansion of the capacity at Inga - the proposed Inga 3 development would add 3500MW while the Grand Inga scheme would increase the capacity at Inga to 39,000MW. The Grand Inga scheme would require very significant investment and for a new transmission infrastructure to be in place to enable the output to be delivered to load centres. It is unlikely to proceed in the near future.

In April 2000, Angola and Namibia signed a bilateral cooperation energy agreement. The two countries are considering the development of a hydroelectric facility on the Kunene (Cunene) River that would provide electricity to both countries. The proposed facility would have a generating capacity of 360MW and provide power to the Angolan, Namibian and South African grids. There are also various Angolan power plants that have fallen into disrepair after the war but could be rehabilitated.

In April 2002, the Maguga Dam in Swaziland was inaugurated. The dam will provide power from a 19MW hydroelectric plant which could meet 50% of Swaziland's electricity needs. This would lessen Swaziland's dependency on South Africa, where 90% of the country's electricity is imported from Eskom. The Maguga is the first of four projected dams intended to harness the Komati River, which flows into Swaziland's northwest sector from South Africa.

The Kafue Gorge Lower (KGL) hydroelectric station, south of the Zambian capital Lusaka, is expected to have a capacity of 660MW. The Zambian government plans to export the vast majority of the power produced to Zimbabwe, Botswana and DRC. Kafue Gorge Lower will be the second-largest generating facility in Zambia. The existing Kafue Gorge Upper power plant currently has a generation capacity of 900MW. There are also plans for a 120MW peaking plant at the Itezhi-tezhi reservoir upstream on the Kafue River.

There are thus a variety of hydroelectric projects under consideration within the SAPP region including Mphanda Nkuwa. The viability of any given project will be contingent upon there being sufficient demand for its output and the majority of demand in the SAPP region is in South Africa.

Table 3.1: New generating plant

NEW GENERATING PLANT

Year	Country	Power Station	Number of Units	Units Size (MW)	Total Added (MW)	Cost US$ million	Type T/H
1996	South Africa	Majuba 1	1	612	612	430	T
1996	South Africa	Arnot 3 Recommission	1	330	330		T
1997	South Africa	Majuba 2	1	612	612	430	T
1997	South Africa	Arnot 4 Recommission	1	330	330		T
2000	Tanzania	Ubungo	1	34	34	18	T
1998	Tanzania	IPTL	10	10	100	150	T
1998	Lesotho	Muela	3	24	72		H
1998	South Africa	Majuba 3	1	612	612	430	T
1998	South Africa	Arnot 5 Recommission	1	330	330	237	H
2000	Tanzania	Kihansi	3	60	180	237	H
1999	South Africa	Majuba 4	1	670	670	430	T
1999	South Africa	Arnot 6 Recommission	1	330	330		T
1999	Malawi	Kaphichira Phase 1	2	32	64	129	H
2000	Angola	Capanda	2	130	260		H
2000	South Africa	Majuba 5	1	670	670	430	T
2001	Zimbabwe	Hwange Upgrade	1	84	84	130	T
2001	Zimbabwe	Hwange 7	1	330	330	271	T
2001	South Africa	Majuba 6	1	670	670	430	T
2001	Zambia	Itezhi-Tezhi	1	80	80	63	H
2002	Zambia	Kafue Lower	1	200	200	520	H
2002	Tanzania	Da-es-Salaam	1	50	50	24	T
2002	Malawi	Kaphichira Phase 2	2	32	64	38	H
2002	Namibia	Kudu	1	750	750		T
2003	Zimbabwe	Hwange 8	1	330	330	271	T
2003	Zambia	Kafue Lower	2	200	400		H
2003	Malawi	Lower Fufu	1	45	45	59	H
2003	Mozambique	Mepanda Uncua	5	400	2 000	1 500	H
2004	Angola	Capanda	4	130	260		H
2004	Tanzania	Rumakali	4	51	204	405	H
2004	Malawi	Lower Fungu	1	45	45	59	H
2005	Namibia	Kudu	1	750	750		T
2004	Zimbabwe	Gokwe North	3	350	1050	771	T
2006	Zimbabwe	Gokwe North	1	350	350	257	T
2006	Tanzania	Mpanga	1	40	160	300	H
2007	South Africa	Camden 1 and 2	2	190	380		T
2008	South Africa	Camden 3 and 4	2	190	380		T
2008	Zimbabwe	Batoka	1	200	200	275	H
2009	South Africa	Camden 5 and 6	2	190	380		T
2010	South Africa	Camden 7 and 8	2	190	380		T
2010	South Africa	Grootvlei 1 and 2	2	190	380		T
2010	Zimbabwe	Batoka	1	200	200	275	H
2011	Zimbabwe	Batoka	1	200	200	275	H
2012	Zimbabwe	Batoka	1	200	200	275	H
2013	Zimbabwe	Kariba South Extension	1	150	150	100	H
2014	Zimbabwe	Kariba South Extension	1	150	150	100	H

The Mphanda Nkuwa project has been framed to support any demand increases on the Mozambique grid due to the foreseen mega projects as well as the projected deficit on the SAPP by 2007. The economic option assessment for this report therefore will be based on those that would meet the same objective and cover the same market.

3.3 The Market for Power in SAPP

Figure 3.1[3] shows Eskom's sales (GWh) by category for the period 1993 to 2002. The average growth rate in energy sales over this period is a little over 3% per annum. Eskom's sales are dominated by the mining and industrial sectors and sales to municipalities.

Figure 3.1

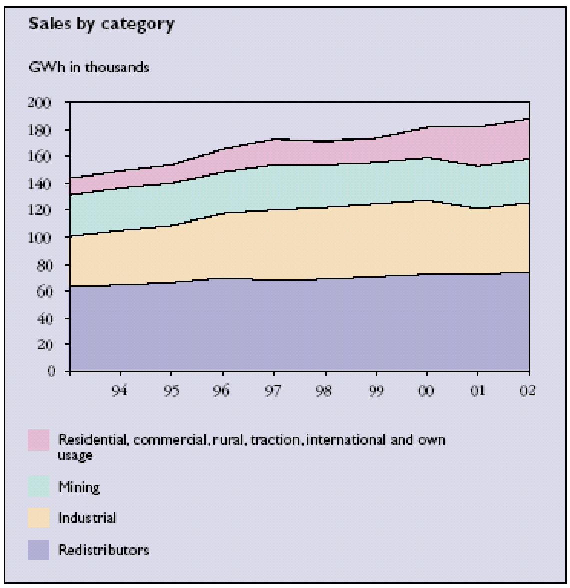


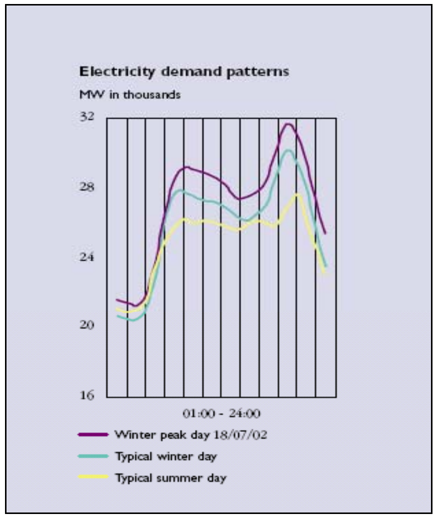
Figure 3.2[4] shows the demand patterns on Eskom's integrated system. This figure clearly illustrates that:

- The system peak is during the winter months (June/July)
- That the system peaks are of a relatively short duration (approximately 4 hours)
- That the winter peaks are significantly higher than those in the summer (by approximately 6000MW).

[3] Source Eskom annual report 2002
[4] Source Eskom annual report 2002

The system load factor in South Africa is high by international standards with a figure of 74% reported for 2002.

Figure 3.2



The total installed capacity on Eskom's system is 42,000MW of which 36,200MW was available to meet a 2002 system peak demand of 31,621MW[5]. Three coal stations (Camden, Grotvlei and Komati) totalling 3800MW are currently mothballed (reserve storage). In addition to its own sources of generation, Eskom imports over 1000MW from Cahora Bassa. Some municipalities in South Africa also own generating plants.

Figure 3.3[6] shows Eskom's projections of the supply/demand balance going forward. Three load forecast scenarios are considered in this figure:

- High forecast
- Moderate forecast
- Low forecast

For all three forecasts a 10% reserve margin is assumed.

[5] The reserve margin decreased from 22% to 17% during 2002 - see p57 of annual report
[6] Source Eskom annual report 2002.

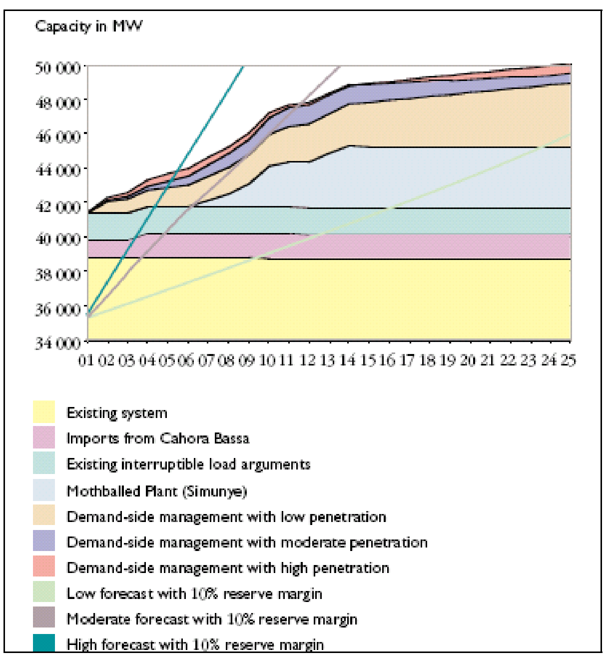
The moderate growth scenario is in line with historic growth rates (see Figure 3.1) and thus can be considered a central case scenario. The high growth scenario would involve growth rates significantly above those experienced over the past ten years.

Figure 3.3 indicates that in the moderate forecast, load growth can be accommodated until 2011 by employing the following supply and demand side options:

- Return to service of the mothballed coal stations (Simunye)
- Increased imports from Cahora Bassa
- Moderate penetration of demand side measures
- Maintaining the existing interruptible load arrangements

The low load growth scenario can be accommodated until well beyond 2025 with the above supply and demand side options in place. The low growth scenario thus represents a potential risk to any new build power plant including Mphanda Nkuwa.

Figure 3.3



For the period beyond 2010, Eskom are investigating a number of supply side options[7] including:

- Conventional pulverised coal stations
- Pumped storage schemes
- Pebble bed modular reactors (PBMR nuclear option)
- Fluidised bed combustion coal plant
- Renewable energy technologies.

Of these options, the PBMR nuclear option is at the research and development stage. Some wind generators are currently operational but renewable generation is not expected to make a significant contribution to South Africa's energy requirements in the medium term. Feasibility studies have been undertaken for two pumped storage stations (Braamhoek and Steelport) with commissioning of Braamhoek planned for 2012. The addition of these two pumped storage plants is likely to defer the need for further new capacity until 2013.

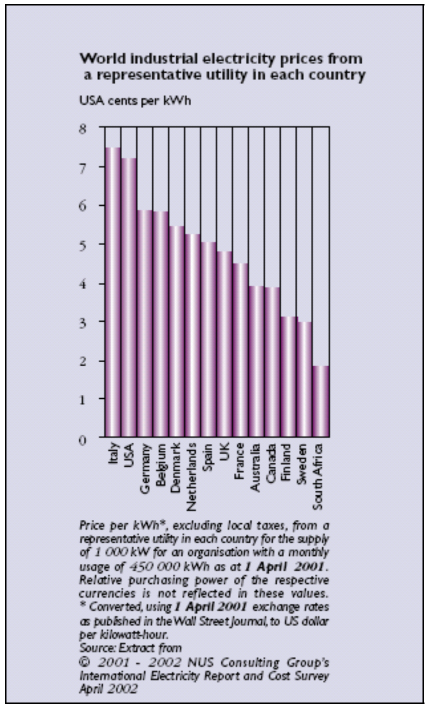
Current industrial electricity prices in South Africa are amongst the lowest in the world and average less than 2 US cents per kWh as illustrated in Figure 3.4. This price compares with the market prices for energy delivered to the power purchaser which are assumed in the UTIP report[8] on Mphanda Nkuwa that are listed in Table 3.2

Table 3.2 Market Prices for Energy Assumed in the UTIP Report

Category	Euro c/kWh	$ c/kWh[9]
Peak	8.0	9.4
1st mid merit	6.0	7.1
2nd mid merit	5.0	5.9
Base	3.8	4.5
Secondary	0.6	0.7

[7] see page 59 of Eskom's annual report
[8] Mphanda Nkuwa Hydropower Project Feasibility Study see section 14 of the executive summary.
[9] Using an exchange rate of 0.85 Euros/$

Figure 3.4



3.4 Market Options for the Export of Power from Mphanda Nkuwa

South Africa represents the best prospect for exports of the output from Mphanda Nkuwa due to the size of its market and the financial robustness of its power sector.

Assuming Eskom's moderate load growth scenario and that two new pumped storage plants are built in South Africa, there is unlikely to be a requirement for new imports of power before 2013. The introduction of additional pumped storage capacity into the market would also tend to depress any premium that could be attributable to the peaking capability proposed for Mphanda Nkuwa.

In order to be attractive to Eskom, any power imports would need to demonstrate clear economic benefits compared with indigenous supply side options. The economics of alternative supply side options are discussed in Section 4.

4 Economic Option Assessment of Mphanda Nkuwa

In this section, the economic costs of generating and transmitting power from the proposed Mphanda Nkuwa project are compared with the alternatives of generating power from either gas or coal fired thermal plants, in the region.

In addition, the cost of new generation sources is compared with the market prices which were assumed in the UTIP feasibility study of the Mphanda Nkuwa project.

4.1 The Dollar – Euro Exchange Rate

The financial analysis in the UTIP report (released in February 2003) is undertaken in euros. Since the middle of 2001, there has been a dramatic change in the euro/dollar exchange rate from a peak of 1.16 Euro/Dollar in mid 2001 to a low of 0.81 Euro/Dollar at the end of 2003. This represents a fall in the value of the dollar relative to the euro of over 40% over this period. A less dramatic adjustment in the dollar/sterling rate has also been experienced with the rate moving from a high of 1.4 dollar/pound a low of 1.77 dollar/pound over the same period.

Most internationally traded fuels are priced in US dollars and thus the analysis in this report, which assesses the economics of thermal power plant to compare with those of Mphanda Nkuwa, is undertaken in dollars. The change in exchange rates has pushed up the dollar price of oil and is also increasing the dollar prices for gas and coal. The recent changes in the exchange rates will have a significant effect on any comparison of prices denominated in dollars and euros. Footnotes to the tables used in this report indicate the exchange rates that have been used in the economic analysis.

4.2 The Economics of Combined Cycle Gas Turbine Plant

The Pande and Temane gas fields, located near the coast in central Mozambique are currently being developed. We understand that the proven[10] gas reserves at these two fields are a little over 2 trillion cubic feet (TCF). In February 2004, Sasol commenced gas exports to South Africa over a new dedicated gas pipeline.

[10] If probable and possible reserves are included this figure rises to a little over 5 TCF

An alternative generation option to Mphanda Nkuwa would be to build combined cycle gas turbine plant (CCGT). A 750MW CCGT running at a 90% load factor on gas with a calorific value of 41GJ per cubic metre will consume around 0.04 TCF per annum and thus 1 TCF over a 25-year lifetime. This would account for 50% of the current proven gas reserves in Mozambique.

Such a power plant could either be built in Mozambique with a proportion of the power generated being exported to South Africa. Alternatively, or the station could be built in South Africa with the gas being exported from Mozambique.
The following assumptions have been made regarding a typical CCGT plant:

- A capital cost including a transmission connection of $600/kW
- An operating life of 25 years
- A thermal efficiency 50%
- A delivered gas price of $2.5/GJ
- Operating and maintenance costs of $4.2/MWh for base load operation

This yields a total production cost from a new CCGT plant of $32.0/MWh as detailed in Table 4.1.

Table 4.1 Cost of New CCGT Plant

Cost of New CCGT Plant ($/MWh)	
Annual capital cost[11]	9.7
Fuel	18.0
Operation and maintenance	4.2
Total production cost	32.0

If the delivered gas price were to be increased by 20% to $3.0/GJ, the fuel component for a CCGT would rise to $21.7/MWh and the total production cost would rise to $35.6/MWh.

4.3 The Economics of Coal Fired Power Plant

Another alternative to meeting increased demand in South Africa by importing power from Mphanda Nkuwa is to build and operate a new coal fired plant sited on the coalfields in the north east of South Africa.

[11] Using a discount rate of 12%

Making the following assumptions regarding a conventional coal fired power plant:

- A capital cost including a transmission connection of $1,500/kW
- An operating life of 35 years
- A thermal efficiency of 37.5%
- A mine head coal price of $0.5/GJ[12].
- Operating and maintenance costs of $5.9/MWh for base load operation

This yields a total production cost from a new coal plant of $34.3/MWh as detailed in Table 4.2

Table 4.2 Cost of New Coal Fired Plant

Cost of New Coal Fired Plant ($/MWh)	
Annual capital cost[13]	25.3
Fuel	4.8
Operation and maintenance	5.9
Total production cost	34.3

If coal prices were increased by 40% to 0.7$/GJ, the fuel component would rise to $6.7/MWh and the total production cost of a coal power station would rise to $36.2/MWh.

4.4 The Economics of Mphanda Nkuwa

The proposed Mphanda Nkuwa hydroelectric project would comprise a powerhouse with an installed capacity of 1300MW (four 325MW units) 61km downstream of the existing Cahora Bassa dam. Power would be transmitted to Maputo over a 1600km transmission system comprising two 400kV circuits on separate towers.

The economic justification of the Mphanda Nkuwa project presented in the UTIP report[14] is based upon the assumptions of market prices for the energy delivered to the power purchaser

[12] Eskom burns low-grade coal in power plants located on the coalfields. Coal for export is currently traded at around $1.34/GJ at Richard's Bay. Traded coal is significantly better quality than that burnt at the power plants and it requires transportation from the coal mine to Richard's Bay. Eskom's annual report indicates that the operating costs for primary energy are 6,199mRand for 193,642GWh of thermal production (coal plus nuclear) yielding an operating cost of 32Rand/MWh.

[13] Using a discount rate of 12%

[14] Mphanda Nkuwa Hydropower Project Feasibility Study

that are listed in Table 4.3. However, at present no freely traded long-term power market exists in the region. The Southern African Power Pool enables national power utilities to optimise their regional energy resources with the trading arrangements based upon intergovernmental agreements. Utilities in the region enter into long term bilateral agreements for buying and selling electrical power. In 2001, a day ahead short-term energy market (STEM) was created within SAPP but, to be viable, the output of Mphanda Nkuwa would need to be sold under the terms of a long term Power Purchase Agreement. Without such an agreement in place, it would not be possible to attract investors in the project.

As the only likely buyer of the output from Mphanda Nkuwa, Eskom will be in a powerful position in any negotiations over the price of its output. It is well known, for example, that Eskom currently purchases the output of Cahora Bassa at very favourable prices due, in part, to the lack of any alternative markets. In the absence of any other potential buyers it may well be optimistic to assume that Mphanda Nkuwa could achieve a “fair” market price for its output.

Table 4.3 also shows the Euro prices converted to dollar levels at the exchange rate prevailing in December 2003 and December 2002 respectively. The change in exchange rates discussed in section 4.1 above results in very different dollar figure over this 12-month period.

Table 4.3 Market prices for energy which are assumed in the UTIP report

Market prices for energy which are assumed in the UTIP report			
Category	Euro c/kWh	$ /MWh[15]	$ /MWh[16]
Peak	8.0	94	76
1st mid merit	6.0	71	57
2nd mid merit	5.0	59	48
Base	3.8	45	36
Secondary	0.6	7	6

A purchaser in a power market would be expected to offer the lowest possible price that can be achieved in any long term off take contract. In assessing the alternatives to purchasing the output of Mphanda Nkuwa a purchaser would assess the options for buying for the output from thermal power plant.

[15] Using an exchange rate of 0.85 Euros/$, 1MWh equals 1000kWh
[16] Using an exchange rate of 1.05 Euros/$

In a market, peaking capability will command some premium over base load energy, with the premium being dependant upon the alternatives available. There are currently three pumped storage stations[17], two conventional hydroelectric plants and two open cycle gas turbines in South Africa all with a capability to deliver energy at times of peak demand. In addition, Eskom has undertaken feasibility studies for building a further two pumped storage stations.

The ability of Mphanda Nkuwa to operate in a mid merit or peaking mode would offer greater flexibility to the system than the competing thermal options providing that sufficient transmission capability is available for operating in this manner.

The estimated capital costs comprising both the generation and transmission components for the Mphanda Nkuwa project are given in Table 4.4[18] and these have been adjusted to 2003 price levels and converted to a cost per kW in Table 4.5. In table 2.5 two different dollar-to-Euro conversion rates have been used, the first (0.85 Euros/$) reflects exchange rate subsequent to the fall in the value of the dollar in the course of 2003 while the second (1.11 Euros/$) reflects exchange rates prevailing at the time the UTIP report was written. In subsequent tables an exchange rate of 0.85 Euros/$ has been used in the analysis. It is noted that while the capital cost per kW installed of the power plant is low; the cost of the transmission facilities from Mphanda Nkuwa to Maputo exceeds the cost of the power plant.

The projections of firm energy and annual average energy for the project together with estimates of the delivered energy to a purchaser once transmission losses have been taken into account are given in Table 4.6. Table 4.5 provides an estimate of the total cost of production ($/MWh). This total includes an estimate of the operating costs for the power plant and the associated 1,400km of transmission facilities. In table 4.5 the euro/dollar exchange rates at both December 2002 and December 2003 levels have been used. These figures demonstrate the difficulty in converting the costs assumed for Mphanda Nkuwa to dollars given the dramatic change in the value of the euro relative to the dollar since the UTIP report was written.

[17] Two of these are owned by Eskom and one by the Municipality of Cape town
[18] Source UTIP Mphanda Nkuwa Hydropower Project Feasibility Study

Table 4.4 Estimated Capital Cost

Estimated Capital Cost (millions of Euro[19])		
Generation	Transmission	Total
887	953	1,841

Table 4.5 Cost per kW at two Euro/$ exchange rates

Cost per kW at two Euro/$ exchange rates			
	Euro/kW[20]	$/kW[21]	$/kW[22]
Capital cost	1,500	1,773	1,353
Annualised cost[23]	181	213	163

Table 4.6 Energy Production

Energy Production (GWh/annum)		
	Firm Energy	Average energy
Energy production	7,253	9,070
Energy delivered[24]	6,890	8,617

Using the December 2003 euro/dollar exchange rate, the total cost of energy production from Mphanda Nkuwa is given in Table 4.5.

Table 4.7 Cost of Delivered Energy

Cost of Delivered Energy ($/MWh)[25]	
Annual capital cost	32.2
Operation and maintenance[26]	5
Total	37.2

[19] At 2001 price levels
[20] Adjusted to 2003 price levels using an inflation rate of 3%/annum
[21] Using an exchange rate of 0.85 Euros/$
[22] Using an exchange rate of 1.11 Euros/$
[23] Using a discount rate of 12% and a lifetime of 50 years
[24] Assuming 5% losses to transmit energy to Maputo. Additional losses would be incurred in South Africa
[25] Using an exchange rate of 0.85 Euros/$ and with costs adjusted to take account of estimated transmission losses
[26] Estimate of the operation and maintenance cost of Mphanda Nkuwa and the associated transmission lines

If the capital costs were to be 10% above those estimated in the UTIP report, the cost of delivered power would rise to $40.3/MWh.

If the euro/dollar exchange rate that prevailed in December 2002 is used to convert capital costs for the project to dollars, the total cost falls to $34.2/MWh.

4.5 The South Africa National Integrated Resource Plan

At the end of February 2004, the National Electricity Regulator (NER) published its National Integrated Resource Plan (NIRP) for South Africa. This document is an independent source of information for stakeholders and decision makers for the purposes of ensuring security of supply in South Africa. In early 2003, NER established an IRP advisory and review committee to provide wide stakeholders' contribution to the NIRP process. The most recent NIRP has been generated under the review of this committee which comprises Eskom's Resource and Strategy Group, the Energy Research Institute of University of Cape Town (UCT) and the NER.

The conclusions of the NIRP included the following:

- New base load generation is required for commercial operation from 2010
- Pulverised fuel coal fired, fluidised bed combustion coal plant and CCGT are the available options for this role
- Fluidised bed combustion coal plant is the most economic option followed by conventional coal fired plant and CCGT plant fuelled on LNG
- It would be difficult to justify fuel diversification on economic grounds

Imports from the Southern African region were not considered as supply options for the purposes of the NIRP.

4.6 Economic Analysis Summary

New generating capacity is expected to be required for the South African system from 2010 onwards. There are limited realistic options available for the provision of base load and mid merit generating capacity for South Africa. These options include:

- New coal fired capacity
- New CCGT capacity

- Increased imports from hydro electric capacity

While CCGT capacity may be attractive on economic and environmental grounds, at present proven gas reserves in Mozambique and South Africa are limited and thus natural gas may not be available in sufficient quantities as a fuel for large-scale power generation. An alternative option is to import LNG to fuel CCGT plants located at the coast. While LNG will tend to be more expensive than natural gas, this option has the attraction of enabling power plant to be located in the Cape region where there is a current deficit of generating capability

As South Africa has abundant supplies of low cost coal, new coal-fired capacity is an economically viable option for new base load capacity. Because of the costs associated with transporting low grade coal, new coal stations are likely to be located in the north east of the country.

There are a number of major hydroelectric projects that are under active discussion across Southern Africa including the Mphanda Nkuwa scheme. The most likely market for the majority of the output of such projects is in South Africa. However, there are a number of risks associated to South Africa with these including:

- The country risk and potential for Government interference.
- Delays in project completion
- Delays in completion of transmission facilities from the new projects to the load centres in South Africa.

Based upon the above analysis in sections 4.2 to 4.4, Table 4.8 shows the comparison of the economic costs of:

- The proposed hydroelectric development at Mphanda Nkuwa;
- A new combined cycle gas turbine plant; and
- A new coal fired generating plant.

Table 4.8 Comparative Costs of New Generation Options

Comparative Costs of New Generation Options ($/MWh)	
Mphanda Nkuwa[27]	28.4 -34.2
CCGT	32.0 – 35.6
Coal Fired Plant	34.3 – 36.2

Using the current $/Euro exchange rate the economics of the Mphanda Nkuwa project are broadly comparable to coal or gas fired plant as a supply option for South Africa. If the exchange rate that prevailed when the UTIP report was written, the Mphanda Nkuwa project would be a lower cost option than either gas or coal fired plant, In addition, Mphanda Nkuwa would offer diversity of fuel supply and may offer operational benefits due to its flexibility. Careful consideration would, however, be required of the transmission costs of transporting the imported power to the load centres within South Africa.

The estimated project construction phase for the Mphanda Nkuwa project is 6.5 years[28]. Construction would only commence after the chosen developer had achieved financial closure. The longer the lead time for the project, the more significant the associated risks become. An additional risk for Mphanda Nkuwa is that its output will be dependent upon the flows in the Zambezi River which have reduced significantly during drought years. Given these risk factors, the Mphanda Nkuwa project would need to demonstrate real benefits relative to thermal generation options to make it attractive to a developer.

The existing wholesale power prices in South Africa are well below those required to finance a new power plant. As new capacity is required over the next few years some rises in wholesale prices will be inevitable. The extent of such price rises will be contingent upon the evolution of the power market in South Africa.

[27] The range in cost for Mphanda Nkuwa is wide because of the uncertainty resulting from the significant change in the dollar/euro exchange rate since the UTIP report was issued

[28] See section 17 of the executive summary of UTIP report.

5 Environmental and Social Options Assessment

Mphanda Nkuwa has been proposed as an energy source for the SAPP as well as augment national supplies in Mozambique. The previous section looked at the economic justification of different scenarios to meet the additional demand for power and energy. This section looks at the environmental, technical and social issues of the different options.

Mphanda Nkuwa is part of the hydroelectricity export industry for Mozambique. It is also planned as a private sector investment and therefore has to be of an attractive scale and mode. The development aspects of Mphanda Nkuwa therefore are analysed for a private sector investment angle as opposed to socio-economic investment by government to meet broad development objectives. Its contribution to development is envisaged through tax contribution, employment creation as well as availability of cheap and reliable power supply for resource extraction industries especially in minerals such as heavy metals (titanium at Chibuto) and aluminium through Mozal.

This approach to development has raised more questions than answers in Mozambique based on experience with similar mega projects that have often been developed on the basis of wide ranging tax and fiscal concessions and a very light handed regulatory environment.

The options assessment was carried out on the following range of available generating sources that were selected as being able to supply the same market as Mphanda Nkuwa:

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1) Mphanda Nkuwa
2) Kudu Gas fired CC power station (750MW)
3) Decentralized local generation using different energy sources
4) Intensive Demand Side Management coupled with lower additional generation capacity
5) Coal based generation in South Africa

A summary table of this analysis is shown in Table 5.1

Table 5.1: Options Assessment

Option	Environmental considerations	Technical capacity	Economic consideration	Social considerations
Mphanda Nkuwa	The impact of regulation on fish stocks and fishing in the lower Zambezi. Designed as a run of river scheme therefore minimizes environmental impact (it will have impacts but certainly far less than a fully dammed scheme) Net reduction in greenhouse gas emissions Operation will permanently flood some floodplain irrigation fields High risk of default on environmental management plan Reduced sediment transportation and hence deepening of river channel The impacts of climate change might adversely affect the ability of the	1300MW installed capacity Will allow for the development of Cahora Bassa North Bank (850 MW) as the development of Mphanda Nkuwa is coupled with the Cahora Bassa North in the proposed implementation. Will allow Cahora Bassa South to generate in mid merit and increase the value of energy generated	In a global economy emphasizing liberalization, GoM will benefit from a positive outlook for opening up to international investment in the electricity sector Internalization of costs of the reduction in fish and shrimp catch would increase the unit generation cost The implementation of the project will allow generating capacity for future economic expansion There will be economic opportunities availed through support services during the implementation of the project Local infrastructure development in the form of proposed school, hospital and other social facilities	Communities living below the dam will have to change their traditional uses of flood plain agriculture with some moving away from the regulated channels There is risk of loss of livestock due to floods There are food security risks as a result of loss of floodplain agriculture

	project to produce at full capacity in years to come			
Kudu CCGT (Namibia)	Natural gas is a finite resource that will run out at some point in the future. CO_2 emissions	750MW Conflicting reports on available resource and generating capacity	Finite resource and will run out at some point. Conflicting reports on available resources and feasibility of resources for power export. Pulling out of initial promoters Eskom and Shell casts doubts over feasibility of the project Unit cost of generation is higher at 7.2USc/kWh	Offshore gas reserves with little impact on human settlements
Decentralized Generation	Renewable energy technologies with net positive environmental benefits Run of the river systems with little disruption of river systems Solar PV systems with minimal environmental impact.	Increased reliability Distances to load centres may exacerbate transmission costs and losses Both micro hydro and solar technology are now well proven and their availability and support well matured	Micro Hydro generation at US$2400/kW installed capacity will be very high for grid connected systems Solar PV systems at the moment produce electricity at a cost of USc 35/kWh which makes them highly unsuitable for plugging the demand gap projected on the SAPP	Help develop local management skills Offer a chance for local empowerment through equity and employment creation Decentralized generation offers an opportunity for distributed socio-economic benefits as it can be done in different locations

DSM with lower generation	Demand side management offers the chance to reduce the negative impacts of current generating systems especially for South Africa with a large coal based generating capacity	Technologies for demand side management have matured and there is considerable potential for DSM measures in South Africa and the rest of SAPP	Electricity prices are still low and therefore discourage any meaningful DSM strategies from being implemented Energy intensity per capita is very low so limiting the scope of possible savings even under the most optimal conditions (Southern Africa per capita electricity consumption fell from 909 kWh per capita per year (1980) to 889kWh (2000)).	DSM measures yield the greatest savings in the industrial and commercial sectors In the household sector the upfront costs in energy saving devices is usually out of sync with earning and expenditure patterns of most households. Requires the cooperation and involvement of many players well outside the influence of the proponents of Mphanda Nkuwa
Coal Based Generation in South Africa	High greenhouse gas emissions Environmental impacts of coal mining	Equal capacity of 1300MW will be attainable	Economically viable as the technology is well proven and in use for many decades	There are health problems associated with coal mining and burning.

6 Option Selection

6.1 Factors

The feasibility study for Mphanda Nkuwa shows that in Mozambique the project is the most economically viable among the currently available options along the Zambezi River. Coal based generation at Moatize and possible gas fired generation using gas from the Temane and Pande fields were not analysed as the amount of reserves and their lifespan were not fully known at the time of this study.

On a regional scale, the parameters for comparison and recommending of one option over the other become more complex as political and other non-conventional factors affect the assessment. Although countries jointly subscribe to supplying power to each other at reasonable price and reliability, recent political events in Zimbabwe and their impact on national and international relations point to security of supply being guaranteed only when the source of power is physically within a government's control.

Some of the alternative electricity options on a regional scale will have differences in appeal to electricity users and power producers. Demand side management is highly unlikely to be attained in Zimbabwe where electricity prices are still very low and price adjustments carry a heavy political penalty. Generally across the region, per capita consumption of electricity at approximately 900kWh per year is very low to provide meaningful savings from demand side management.

Decentralized generation while a very attractive proposal will be severely limited by the differing government policies and absence of a mature regulatory capacity for such options in the country. This is in view of the short horizon between now and when power deficits are projected to set in.

After considering all the above factors, Mphanda Nkuwa is viewed as a technically viable proposition. That is not to suggest that it is without serious problems. The scheme, despite 100km^2 of inundated area[29], will be managed as a run of river scheme, as there will be insufficient storage in the reservoir to alter seasonal flow patterns, so daily outflow should equal

[29] The existing river channel of the Zambezi between Mphanda Nkuwa and Cahora Bassa, and on the Luia river from its confluence for about 18 km upstream would be inundated by impoundment. These sections constitute almost all the remaining bedrock gorge sections of the middle Zambezi river and its perennial tributaries. *(MN EIA, Impacts of Impoundment)*

daily inflow. Normally a run of river scheme means that environmental impacts are limited, but in this case there is the potential for environmental problems, given the size of the inundated area and the existing streamflow problems created by Cahora Bassa.

A major problem is that the project is proposed in a context where large hydro is generally perceived to have delivered national benefits, whilst communities and some industries have paid the price of adverse environmental impacts, such as the fishing and shrimp industry in the Zambezi Delta. To that end the key concerns are not around its technical feasibility but rather how its socio-economic and environmental implications fit in the described national context as well as a global context where major funders and civil society are generally sceptical of its impacts and their management.

7 Key Issues to be addressed on Mphanda Nkuwa

7.1 Technical Issues

Cahora Bassa is currently operating in base load only and therefore not providing optimal returns for the investors. This is a requirement induced by the need to control water level fluctuations and daily floods downstream of the scheme. The implementation of Mphanda Nkuwa should allow for greater regulation of river flow between Cahora Bassa and Mphanda Nkuwa enabling HCB to operate in mid merit and peak mode. This will enhance the value of the energy generated from Cahora Bassa South. It is estimated that about 20% of the benefits from the development of Mphanda Nkuwa derive from uplift in the value of energy generated at Cahora Bassa South rather than generation at Mphanda Nkuwa itself, as shown in Table 7.1. It will then also allow the development of Cahora Bassa North at an additional capacity of 850MW.

Table 7.1: Financial Parameters for Mphanda Nkuwa

Item	Mphanda Nkuwa [1300MW]	Cahora Bassa North [850MW]
NPV of Benefits (Euro Million)	212	-45
NPV of Benefits arising at Cahora Bassa South due to changed flow regime(Euro Million)	55	
NPV Total Benefits Euro Million	263	-45
Cost Euro Million (2001 projection)	1841	829

Source: Mphanda Nkuwa and Cahora Bassa North Project Feasibility Study, LI-EDF-KP, 2002

7.2 Social Issues

The project has the following implications in terms of social impacts:

- The proposed project will displace 260 households comprising of about 1400 people in the area to be impounded. The relocation and fair compensation of these groups is still a controversial issue. With the differences in bargaining power and resource leverage it is unlikely that those relocated will have a strong voice in demanding their rights and entitlements. It is important that the resettlement is the outcome of a process of negotiated agreements and commitments but the feasibility report does not indicate any attempt to have informed and negotiated settlements. The logic seems to be that detailed studies will be made once the government gives its approval and identified a potential investor who will then undertake their own assessment and consultation process. The issue of fair compensation for the displaced communities will be a determinant on public opinion. It will be a lot easier to gain investor confidence if the project has widespread public good will and acceptance. This requires a wide consultation process through which the pros and cons of the project are publicly debated, social mitigation measures devised and a monitoring framework developed. The government is wary of the high expectations such a process might generate and the ensuing political pressure. It is highly unlikely that this would be done in the immediate future or until after the elections in the last quarter of 2004. The lack of such a wide consultation process may induce potential developers to invest in abetting public rejection rather than gaining genuine acceptance.

- For decades the livelihood security for the people in the lower Zambezi has consisted of a dual agricultural system in which the highland area is utilized for rain fed agriculture and the lower flood plains are cultivated in the dry season to supplement the summer produce especially in drought years when the highland crop has failed. Recent events in 2000 showed that the people in the lower Zambezi valley are vulnerable to large floods that are not helped by dams. River regulation since the construction of the Cahora Bassa has apparently encouraged settlement on floodplains, and has also reduced the productivity of these areas. Flood recession farming was especially important in drought years when upland crops failed. With regulation, high land on the floodplain is now rarely flooded and soil fertility has declined, while low-lying areas are permanently inundated and can no longer be farmed. In addition, fish stocks are no longer concentrated by low base flows at the end of the dry season so that fishing at certain times is less productive. The chronic food insecurity that now afflicts tens of thousands of people living in the riparian districts of Morrumbala, Mopeia, Mutarara, Caia and Chinde may be the outcome. Mphanda Nkuwa will further complicate this, as the communities that are within a 70km radius downstream of the dam, will be subject to increased river levels of up to half a metre which will permanently flood some of the currently cultivated flood plain plots.

- The process followed so far in the feasibility study has been criticised for lack of meaningful engagement with the groups affected. Although in general many organizations that have interacted with the people have indicated that an overwhelming majority supports the project, no sufficient effort has been made to incorporate the lessons from the implementation of Cahora Bassa and its associated social problems. This is more pertinent in the Mozambican case where institutional will and capacity to enforce such settlements have been proven to be very weak.

- The feasibility report recognises the need for a suitable communication system that warns the operator of Mphanda Nkuwa of releases from Kariba and Cahora Bassa, as well as people downstream of planned releases from Mphanda Nkuwa. Procedures are needed for informing residents of the lower reaches of the Zambezi downstream of Mphanda Nkuwa of releases ahead of time to avoid unnecessary human loss. This is crucial if the concept of environmental flows is taken up and enforced for rejuvenation of biodiversity in the lower Zambezi.

- As far as large hydro projects go, Mphanda Nkuwa has favourable ratios in terms of number people displaced per MW installed, as shown in Table 7.2. This provides a good opportunity for minimizing the disruptions to human life as well as making it a lot easier to involve those to be displaced by the project.

Table 7.2: Number of Displaced people by dams per MW produced in Africa

Project	Country	Power Output (MW)	Reservoir Volume (Mm3)	Reservoir Area (Ha)	Number of Oustees	Reservoir Area/ Power Output ha/MW	Oustees /MW
Aswan	Egypt	1,815	162,000	650,000	100,000	358	55
Kariba	Zambia/Zim	1,320	180,600	510,000	57,000	386	43
Cahora Bassa	Mozambique	2,075	51,700	266,500	25,000	128	12
Manantali	Mali	200	11,300	47,700	10,000	239	50
Kainji	Nigeria	760	15,000	127,000	44,000	167	58
Mphanda Nkuwa	Mozambique	1,300	2,324	9,650	1,400	7	1,1
Akasombo	Ghana	833	150,000	848,200	84,000	1018	101
Nangbeto	Togo/Benin	65	1,715	18,000	10,600	277	163
Gariep	South Africa	360	5,670	36,000	n/a	100	n/a
Vanderkloof	South Africa	240	3,237	13,800	n/a	58	n/a
Masinga	Kenya	40	1,560	12,000	5,000	300	125
Kiambere	Kenya	140	585	2,500	7,000	18	50
Kamburu	Kenya	84	123	2,000	n/a	24	n/a
Turkwel	Kenya	106	1,641	6,600	n/a	62	n/a
Gitaru	Kenya	216	20	310	n/a	1.4	n/a
Bujagali	Uganda	250	54	452	387	1.8	1.5

n/a: not available

Source: Mphanda Nkuwa and Cahora Bassa North Project Feasibility Study, LI-EDF-KP, 2002

7.3 Environmental Issues

Mphanda Nkuwa is projected as a run of the river scheme with little retention of water. Key environmental issues to be addressed on the project include:

- Mphanda Nkuwa is currently proposed to generate with an allowance for a 0.5m daily river level fluctuation. This has the effect of flooding some floodplain "paddies" currently used for small scale subsistence agriculture during the dry season.
- There is overwhelming evidence that the absence of environmental flow releases from the Cahora Bassa Dam has seriously affected the biodiversity and productivity of the Zambezi Delta. The effect of river regulation on fish and shrimp production and catches on the lower Zambezi has been adverse. The implementation of the project will see even lower peak floods and higher base flows in the lower Zambezi seriously affecting the habitat patterns for riverine production systems especially fish and shrimp.

The impact of regulation on fish stocks and fishing in the lower Zambezi valley is unknown. Floodplain fisheries comprise some of the most productive available but are dependent upon the annual flood and drawdown for their maintenance. There can be little doubt that, with reduced flooding and higher base flows, the fisheries of the lower Zambezi river would have declined.

Similarly, the shrimp catch on the Sofala Bank, off the Zambezi river mouth, is related to river discharge. The number caught per hour is positively correlated with monthly discharge at Tete, as is annual catch with annual runoff. Catches declined from 10,000 – 12,000 tons in 1974-76 to 8000 tons in 1983 and 7900 tons in 1998. By redistributing discharge from Cahora Bassa to increase flows in the period December – March, Gammelsrød (1992) estimated that the catch per unit effort could be increased by about 20%, or 1 500 tonnes per year. The catch is mainly comprised of three species – Penaeus indicus (48 %), Metapenaeus monocerus (42 %) and Penaeus monodon (10 %). Present market values in Mozambique range from 5.1 – 8.7, 2.5 – 4.8, and 8.7 – 12.7 USD/kg respectively, depending on the size of shrimp (pers. com. Entroposto Frigorifico de Pesca de Mozambique Lda.). Assuming mid-price values for each species and an overall value based on the proportion of species in the total catch, shrimp is worth about 6 USD/kg, or 6.7 EUR/kg. The annual benefit from improving river flows could therefore be in the order of 9 million USD (10 million EUR).

Source: Mphanda Nkuwa and Cahora Bassa North Project Feasibility Study, LI-EDF-KP, 2002

The contradiction in the excerpt above shows perhaps the reluctance by the proponents to admit the impacts of the proposed project. The report starts by stating that " the impacts of river regulation are unknown.." and then immediately afterwards details the evidence of reduction in fish and shrimp catch as being directly affected by levels of river discharge.

- Implementation of Mphanda Nkuwa offers an opportunity for greater regulation to mimic natural flow patterns and rejuvenate the delta. However this is only true if the current environmental enforcement rules begin to function fully with clear penalties for default. The excerpt above shows the need for stronger environmental enforcement and compliance.
- Reduced sediment transport is responsible for decline in mangrove growth in the delta.
- Construction of Mphanda Nkuwa will retain more sediment and dam management will need to take this into consideration.

It is important to note that the majority of the environmental impacts raised above are reversible or avoidable in the long term if a strict dam management regime is followed. To that end it is difficult to determine beforehand what the true environmental cost of this intervention will be as it depends mostly on the will of the developer to implement mitigation measures as well as the government capacity to apply and enforce the necessary regulations.

Hydropower sales from Cahora Bassa South are currently valued at about 200 million USD per year (215 million EUR) (EIA Working Document 7). The cost of an 8 % loss in hydropower sales due to an environmental flow release would be in the order of 16 million USD per year (17 million EUR). The benefit to poverty alleviation through improved food security in the lower Zambezi valley, and from increased export sales of shrimp, could well exceed this figure. Investment in either Mphanda Nkuwa or Cahora Bassa North would increase the costs and reduce the likelihood of environmental flow releases in future.

Source: Mphanda Nkuwa and Cahora Bassa North Project Feasibility Study, LI-EDF-KP, 2002

The above excerpt is key for all the environmental arguments for more caution and control if the project is to be implemented. For environmental concerns to be assuaged, the developers of Mphanda Nkuwa have to forego 17 million Euros per year in possible income! This is the core of why it is perhaps unlikely that investors would do this. What will be the penalty for not abiding with this requirement? It will certainly not be in the same order of magnitude. It is therefore within reason to expect that the operator will do a cost benefit analysis and if the direct cost of compliance is higher than non-compliance then the chances get even slimmer for the environmental concerns to be addressed.

Although the feasibility report concedes that these costs may very well be outweighed by the economic benefits of poverty alleviation that would accrue if the proper practice is followed, there is no firm commitment towards enforcing this particular requirement. This is the weakest point in the project design. It requires a strong and functional regulatory function to be able to enforce the desired results on poverty alleviation. The failure to enforce many of the agreed environmental management measures for Cahora Bassa throws into doubt any suggestions that the government will be able to enforce rules on the developers for the Mphanda Nkuwa project.

To illustrate this point the report mentions a short survey to gauge the attitudes of the local population to these river flow conditions which indicated " broad approval amongst the population of river conditions". The survey was limited to a 60 km stretch between Mphanda Nkuwa and Tete City despite the fact that the effects of diurnal river level variation are estimated to have an impact for as long as 300km. The report does accept that there is need for a more detailed survey of attitudes for the whole stretch of the river, and on the impacts the river variations will have on river based and river bank activities. Although positive in its outlook, the recommendation is likely to be overlooked by the fact that the consultants have already recommended to the government an operation regime based on the 0.5m river fluctuation at Tete and all economic calculation is based on this. Any consultation at any stage after this is unlikely to be objective as the main motive would be to "authenticate" a proposed position rather than seek the best solution. This is because the chances are very slim that the decision or recommendation of a 0.5m river ripple would be reversed after a survey of attitudes. The idea that the government of Mozambique equity will be financed from part of the benefits accruing from allowing a new river regulation regime (0.5m fluctuation at Tete) looks more like an attempt to ensure that this condition is adopted without much consideration.

In summary, with no major changes to the regulatory environment in Mozambique, it is unlikely that the environmental management measures would be adhered to, as there is no precedent to support that. Negotiation of environmental management requirements as part of the licensing and financing package may help but it still requires a strong, competent regulator to be able to challenge bad practice and enforce performance. It is likely that Mphanda Nkuwa will be developed by large multinational energy companies whose annual budget may equal or even dwarf the national budget for Mozambique. This power imbalance may militate against impartial regulation of the operation of the scheme.

7.3.1 Greenhouse Gas Emissions

The carbon emissions that would occur as a result of implementing the Mphanda Nkuwa hydropower project are a key factor in determining its environmental impact and benefit, compared to the energy alternatives.

Below is an extract from the Mphanda Nkuwa EIA.

The World Bank recommends adopting a stock- rather than a flow approach when annual carbon flux data are not available and the timing of CO_2 impacts is not important. The stock approach assumes that any change in terrestrial carbon stocks represents an equal and opposite change in atmospheric carbon, in the form of CO_2.
Carbon stocks in the reservoir area are likely to change with or without the project. By measuring the difference between the with- and without project options at the end of the accounting period, the project's total CO_2 impact can be measured.
At present, about 80 % of the land outside the river channel in the reservoir area (i.e. 56 km^2) is woodland and 20 % (i.e. 14 km^2) is cultivated or recent fallow land. The river channel extends to about 30 km^2. Total system carbon in miombo woodland in Zimbabwe and dry thorn savanna in South Africa is estimated to be in the range 7.6 - 9.7 kg m^{-2} (Woomer and Swift, 1994). Most is found in the soil. The conversion of woodland to dryland farming reduces the amount of carbon in the system by perhaps half. A value of 8 kg C /m^2 is therefore assumed for the woodland, and 4 kg C /m^2 for cropped and fallow areas. Total carbon in the reservoir area at present is therefore estimated to be about 504,000 t.
In the absence of the project, the reservoir area would continue to be subject to a regime of shifting cultivation. Trends in carbon stocks are unknown and as no data exists it is assumed that stocks would remain constant over the next 100 years with the no-project option.
With the project, it is assumed that carbon sequestration would end with inundation of the reservoir area and that by the end of the accounting period no carbon stock would remain. As

some carbon would inevitably remain in sediment, undecomposed wood and phytoplankton, this assumption exaggerates the global warming potential of Mphanda Nkuwa.

Source: Mphanda Nkuwa and Cahora Bassa North Project Feasibility Study, LI-EDF-KP, 2002

Table 7.3 shows the different Global Warming Potentials of Mphanda Nkuwa and other power generation options in the region.

Table 7.3: Factors used to compare the Global Warming Potential of Mphanda Nkuwa and alternative power generation options.

Factor	Value	Units	Source
Common Factors			
Project duration	100	Y	This study
Carbon dioxide/carbon conversion factor	44/12		World Bank, 1998
Carbon dioxide/ carbohydrate biomass conversion factor	44/28		World Bank, 1998
Methane/carbon conversion factor	16/12		World Bank, 1998
Density of methane	0.72	kg /m^3	World Bank, 1998
Global warming potential of CH_4:CO_2	21		World Bank, 1998
Global warming potential of N_2O:CO_2	310		World Bank, 1998
Mphanda Nkuwa			
Land inundated by reservoir	70	km^2	This study
Woodland area	80	%	This study
Farm and fallow area	20	%	This study
Total system carbon - woodland	8,000	t C /km^2	Woomer and Swift, 1994
Total system carbon - cropland	4,000	t C /km^2	Woomer and Swift, 1994
Alternative Project: coal-fired steam turbine			
Fuel conversion efficiency	34.4	%	Eskom, 2001
Net calorific value: hard coal, South Africa	25.09	TJ /kt	World Bank, 1998
Average carbon content of coal	25.8	t C /TJ	World Bank, 1998
Plant combustion efficiency	98	%	World Bank, 1998
Nitrous oxide emission rate	1.4	kg /TJ	IPCC, 1996
Methane emissions per tonne of coal mined underground in South Africa	3.8	Kg	Derived from Saghafi et al., 1997
Methane emissions per tonne of coal mined in South Africa	4.6-13.1	Kg	USEPA, 1994
Methane emissions per tonne of coal mined	5	Kg	Assumed
Total CO_2 and CO_2-equivalents produced per 1000 GWh	1.019	Mt	This study
Alternative Project: gas-fired combined or open cycle turbine			
Thermal efficiency of combined cycle gas turbine	60	%	Anex, R., et al., 2001
Thermal efficiency of open cycle gas turbine	40	%	Anex, R., et al., 2001
Thermal efficiency of alternative project	58	%	Assumed

Net calorific value of natural gas	34.8	MJ /m^3	World Bank, 1998
Average carbon content	15.3	t C /TJ	World Bank, 1998
Combustion efficiency	0.995		World Bank, 1998
CH_4 emission factor	0.0061	t /TJ	World Bank, 1998
CO_2 emission factor	56	t /TJ	World Bank, 1998
Total CO_2 and CO_2-equivalents produced per 1000 GWh	0.348	Mt	This study

The carbon would be emitted as either carbon dioxide or methane, depending upon decomposition processes. However the proportions of CO_2 and CH_4 are unknown and both extreme cases are therefore examined. These assume on the one hand, that all carbon in the reservoir area is emitted as CO_2 and on the other, that all carbon is emitted as CH_4.

If the total carbon of the reservoir area is emitted as carbon dioxide there would be an emission of 1.85 Mt over the life-time of the project, or an average of 0.0185 Mt /y. If the total carbon is emitted as methane there would be an emission equivalent to 14 Mt of CO_2 over the life-time of the project, or an annual average of 0.14 Mt /y (Table 7.4). The firm energy expected from Mphanda Nkuwa is above 7,000 GWh a year so would give a carbon equivalent emission of either 0.00026 Mt (if emitted as CO_2) or 0.02 Mt (if emitted as methane) per 1000 GWh. This is considerable less that the equivalent coal or gas alternatives (Table 7.3)

Table 7.4: Summary of Global Warming Potential of the reservoir at Mphanda Nkuwa.

Source	*Emission*	*Annual output (Mt)*	*Project life-time output (Mt)*
Reservoir	*CO_2*	*0.0185*	*1.85*
Reservoir	*CH_4 (CO_2-equivalent)*	*0.1410*	*14.10*
	Mean	*0.0800*	*8.00*

Source: Mphanda Nkuwa and Cahora Bassa North Project Feasibility Study, LI-EDF-KP, 2002

Besides emitting some GHG emissions, hydropower stations themselves are likely to suffer from the impacts of climate change as some river basins suffer from reduced precipitation and increased evaporation rates. Mphanda Nkuwa is being proposed in the Zambezi Basin which is projected globally to be the most severely affected from reduced precipitation. Table 7.5 shows the projected figures for the major basins in Africa.

Table 7.5: Projections of climate change impacts on river flows and precipitation to 2100

***Table 10-1**: Estimates of ranges of percentage changes in precipitation, potential evaporation, and runoff in African river basins, constructed from Figure 3 of Arnell (1999). In some basins, estimates given by HadCM3 simulation have been excluded where they appear to be outliers.*

Basin	Change in Precipitation (%)	Change in Potential Evaporation (%)	Change in Runoff (%)
Nile	10	10	0
Niger	10	10	10
Volta	0	4 to -5	0 to -15
Schebeli	-5 to 18	10 to 15	-10 to 40
Zaire	10	10 to 18	10 to 15
Ogooue	-2 to 20	10	-20 to 25
Rufiji	-10 to 10	20	-10 to 10
Zambezi	-10 to -20	10 to 25	-26 to -40
Ruvuma	-10 to 5	25	-30 to -40
Limpopo	-5 to -15	5 to 20	-25 to -35
Orange	-5 to 5	4 to 10	-10 to 10

Source: Climate Change Adaptation in Africa, IPCC, 2000

The Zambezi River is the worst affected with a projected 26 to 40% decline in runoff. This will affect the reliability of hydropower stations on the Zambezi to start with but will also increase the pressure for environmental flow releases to support downstream ecosystems as well as agricultural and subsistence activities on the lower reaches of the river. If the Mphanda Nkuwa is implemented it will be the last regulating station on the river and therefore the demands for a more sensitive operation regime would be greater. This is a very significant threat for both the promoters of the project if it goes through but also the communities below the dam that may have their lifestyles permanently and irreversibly changed due to the combined effects of climate change and Mphanda Nkuwa. The projected reduction in surface runoff will mean a gradual reduction in river discharge and a threat to the riparian communities whose livelihood relies on the Zambezi river.

7.4 Political issues

Mphanda Nkuwa is promoted as a private sector development with government offering fiscal incentives and light handed regulation to promote investment. Specific project development companies are envisaged for the implementation of the project. Separate entities are proposed for the generation and transmission components of the project.

The Government of Mozambique will retain nominal shareholding to mitigate political risk.

There is little room envisaged for local community involvement but the feasibility report recognises the need for compensation to be based on four principles:

- Recognition of rights of affected parties
- Entitlements of affected parties should be mutually agreed
- Standard of living of resettled must improve
- Livelihood options should be available and sustainable

There is need for an explicit role for civil society involvement in negotiating the compensation packages for the displaced communities. While the principles sound plausible experience suggests that there is need for a stronger representation if these principles are to be applied.

7.5 Economic Issues

A financial analysis has already been discussed in previous sections but there are some other economic issues that have a bearing on this project. The project comes under the Zambezi Valley Authority which offers an incentive package for investing in the valley as an economic corridor (as outlined in the Government Decree No 16/98). The decree gives exemption and reduction of import duties and taxation for specific sectors of economic activity, which include production, transportation and distribution of electric power. The decree establishes a special fiscal and customs regime until 2025 and, for projects that are established while the special regime is in force will benefit for at least 10 years after this. It also exempts import duties, circulation taxes and provides for a five year corporate tax exemption from start of operations and an

80% reduction in corporate profit tax starting from the sixth year of operation. Flexibility in foreign dividend repatriation is also guaranteed.

The Government of Mozambique therefore will get its revenues from the proposed development through corporate income tax and water rights.

The total project cost estimated at about $2 billion is a very significant investment that will send a message about the competitiveness of Mozambique as an investment destination. In this perceived strength lies the weak point for the government. Previous experience with such mega investments indicates that they have done little to improve the fiscal resources. It is the structuring of the agreements at inception that requires careful scrutiny, and for which the capacity to do this in Mozambique is still in its infancy.

With these incentives and past experience (especially with the Hydro Cahora Bassa), the main economic issue to be addressed is what will be the net benefit to Mozambique of this intervention. There is no doubt that it will stimulate economic activity especially during its construction phase through services and products from support industries and labour demands. However this must be considered alongside the current discussion on HCB that shows that Mozambique is not benefiting at all in real terms from electricity exports to South Africa mainly due to an unfavourable power purchase agreement.

7.6 Net Benefit Analysis

Several studies have been conducted on the loss of revenue due to declining fish and shrimp catches on the lower Zambezi. Some current arguments are that these are the effects of HCB and therefore external to the analysis of the impact of Mphanda Nkuwa. If the current flow release patterns continue, the loss of income from shrimp industry is estimated at 250 million euro over the next 30 years (Hoguane, The role of Zambezi runoff in the shrimp abundance in Sofala Bank). There is no information currently available about the economic value lost due to loss of flood plain irrigation.

The net benefit of the project to Mozambique is a complicated parameter to determine but there are some indicators that are useful. Cases in Mozambique such as Mozal and Hydro Cahora Bassa are showing that such mega projects give little overall economic contribution to Mozambique. In a meeting on the Poverty Reduction Strategy Paper (PRSP) review the government decided to develop a framework for future mega projects to increase social and economic benefits. The agreed position by major donors including the World Bank is that the mega projects have had low positive net benefit to the country.

Clearly the implementation of this project is as much a statement of the government's commitment to attract foreign direct investment as it is about meeting the regional energy demands. This further complicates the analysis. As part of the support to Mozambican government, the World Bank will provide funds for the development of an analytical framework for the assessment of the net benefits of mega projects.

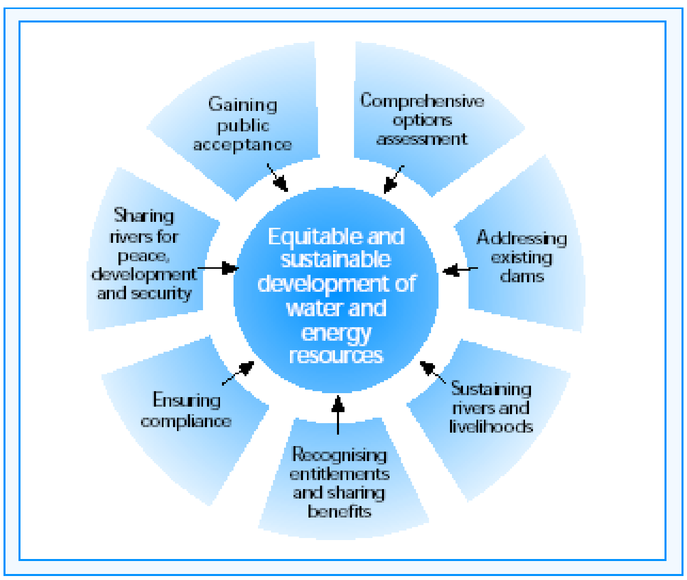
8 Mphanda Nkuwa and the World Commission on Dams Guidelines

The World Commission on Dams (WCD) published its findings during the feasibility study of the Mphanda Nkuwa project. The feasibility study therefore had not been structured specifically to follow the WCD recommendations, in terms of its strategic priorities and policy principles. The feasibility report alludes to this fact and emphasises that where possible the guidelines were generally followed.

This section of the report is a short assessment of how the feasibility study conformed to the WCD recommendations (in retrospect).

The WCD has a set of seven key parameters for ensuring that large dams minimize their impacts and are sustainable in the long term.

Figure 8.1 The WCD's seven strategic priorities



8.1 Needs Assessment

The WCD calls for a "needs assessment" as part of the options assessment to validate the requirements for electricity or water at a local, regional and national level. This is to be achieved through an open and participatory process: "*In countries where a large proportion of the population does not have access to basic services, a key* *parameter in the validation process should be the extent to which basic human needs will be met*."

In the case of Mphanda Nkuwa, public verification of the needs for energy services at the national or local level is not known to have taken place. Currently there is no national need for so much grid-based power (the dam is expected to produce 1300MW). The Mphanda Nkuwa Feasibility Study touches on the needs for electricity at the local level through its description of the area's economic and social situation. The situation in Mozambique is that less than 5% of the population has access to electricity, and most of those without access are rural people far from the national grid. It is clear the Mozambique needs to prioritise decentralized rural electrification rather than large-scale grid-based power.

Various organizations and sector specialists (Dr Hoguane, Professor Cuamba, Livaningo personal communication during interviews) in Mozambique agree that the project will not address the basic needs of people in the short term. Unrelated to the specific project, several studies have shown that food security is the primary need of many poor households in Mozambique, not electricity. What energy projects can do is to help establish a firm base for supporting future economic growth. There is however no pretence on the part of the promoters that the project will address basic needs. It is clearly a project with an export orientation designed to take advantage of the country's natural resources, the regions projected energy scenarios in the near future and as part of a process of regional economic cooperation.

8.2 Comprehensive Options assessment

Comprehensive Options Assessment

Key Message

Alternatives to dams do often exist. To explore these alternatives, needs for water, food and energy are assessed and objectives clearly defined. The appropriate development response is identified from a range of possible options. The selection is based on a comprehensive and participatory assessment of the full range of policy, institutional, and technical options. In the assessment process social and environmental aspects have the same significance as economic and financial factors. The options assessment process continues through all stages of planning, project development and operations.

Effective implementation of this strategic priority depends on applying these policy principles:

2.1 Development needs and objectives are clearly formulated through an open and participatory process before the identification and assessment of options for water and energy resource development.

2.2 Planning approaches that take into account the full range of development objectives are used to assess all policy, institutional, management, and technical options before the decision is made to proceed with any programme or project.

2.3 Social and environmental aspects are given the same significance as technical, economic and financial factors in assessing options.

2.4 Increasing the effectiveness and sustainability of existing water, irrigation, and energy systems are given priority in the options assessment process.

2.5 If a dam is selected through such a comprehensive options assessment process, social and environmental principles are applied in the review and selection of options throughout the detailed planning, design, construction, and operation phases.

Options assessment for the proposed Mphanda Nkuwa Project did not necessarily follow the WCD recommendations as these were only published after the feasibility study had already commenced. An analysis of the available literature on the project provided the following insights regarding options assessment.

"Development needs objectives are clearly formulated through an open and participatory process before the identification and assessment of options for water and energy resource development." (WCD 6.1.1)

In the Mozambican case development needs at a national and provincial scale are well documented. These have been arrived at through research, surveys and consultations. The government of Mozambique believes that the hydropower potential on the Zambezi river is a vital resource for meeting future national energy needs as well as export to regional markets.

"Planning approaches that take into account the full range of development objectives are used to assess all policy, institutional, management and technical options before the decision is made to proceed with any programme or project." (WCD 6.1.2)

The WCD states, "*a multi-criteria assessment should be used to screen and select preferred options from the full range of identified alternatives*". The project should also "*ensure that available alternatives, their relevant consequences and uncertainties are given full consideration*" and that the "*rejection of any options was explained in an open and timely manner*". The WCD also recommends inclusion of demand-side management within the options assessed and the possible effects of flawed demand forecast for the sector. Cumulative impacts and the application of the precautionary approach are also considered vital.

Although there are strong views to the contrary, for the scale and target market concerned, alternatives had to be evaluated on both a national and regional scale. A key fact of this assessment therefore is that decentralized energy solutions were therefore not competitive.

Given that the project is being promoted as a private sector investment with the government retaining a minimal shareholding to mitigate political and market risk, the range of options to supply the same scale of energy was also significantly reduced.

There are wide ranging criticisms of the project formulation process and its outcomes so far. These have emerged from environmental NGOs and other sector specialists. Below is a summary of the key concerns and our analysis of the substance of each.

"Even the operational options assessment is controversial with the selection of mid-merit energy production, which causes daily mini floods and underplays the cumulative impacts. The options assessments were not conducted in a multi-stakeholder manner and options chosen were done solely by the project proponents". (Livaningo, local environmental NGO)

8.3 Gaining Public Acceptance

The project feasibility has been largely restricted to the technical fraternity. For those outside the technical circles, there is a high degree of misinformation that exists which results in limited knowledge being passed onto the wider public. An inundated area of 100km^2 is very conservative for hydropower generation of the scale proposed for Mphanda Nkuwa. There are several documents in circulation stating that this will be one of the largest dams in Africa, whereas the Kariba scheme is of similar capacity, a slightly bigger dam height but actually has a reservoir area that is about 58 times bigger. There are several other cases which point to a lack of understanding of the technical issues surrounding the proposed plant that are being used to campaign against the implementation of the project. It is this lack of factual information that weakens lobbying on genuine issues pertaining to mega projects in Mozambique.

The lack of public engagement on the proposed project may result in low public opinion and acceptance. WCD guidelines were published after the feasibility study had commenced but there is an opportunity to retrace some of the important consultation steps to gain public acceptance of the project.

8.4 Address Existing Dams

The WCD states that problems with existing dams must be addressed: "*Outstanding social issues associated with existing large dams are identified and assessed; processes and mechanisms are developed with affected communities to remedy them".* Furthermore, WCD states *"opportunities to improve the efficiency, environmental and social performances of existing dams and optimise their benefits must be taken*."

Addressing existing dams in Mozambique necessarily means a long discussion around Cahora Bassa Dam and its effect on the Zambezi river. The impacts of Cahora Bassa are now well documented but little seems to be changing in the operation regime of the dam. Mphanda Nkuwa is closely linked to Cahora Bassa to the extent that 20% of the benefits of the project will come from a change in operation mode for Cahora Bassa South. There will be greater river level variation between Cahora Bassa and Mphanda Nkuwa as the former switches to mid merit operation.

The effects of current river regulation will entail HCB foregoing approximately US$16 million in income with the figure projected to rise for the two combined. The feasibility report states that implementation of Mphanda Nkuwa will make addressing of the current river regulation regime more unlikely as it will entail heavier financial opportunity cost for the operators.

The excerpt below shows the summary of projected impacts that will affect the inhabitants of the lower Zambezi and the eco-system as a whole. While some might argue that these impacts are external to the decision to build Mphanda Nkuwa, it is important to note that Mphanda Nkuwa will actually reduce the chances of redressing these effects.

Before the dam was completed in 1975, South African river ecologist Dr. Bryan Davies warned of the dam's severe consequences in a pre-project assessment: "Reduced artisanal fisheries and shrimp industry productivity, reduced silt deposition and nutrient availability, severe coastal erosion, soil salinisation, salt water intrusion, replacement of wetland vegetation by invasive upland species, reduction in coastal mangroves, failure of vegetation to recover from grazing, and disrupted or mistimed reproductive patterns for wildlife species." Just ten years later, deleterious changes to the Zambezi's riverine, wetland, deltaic and coastal ecosystems were already apparent.

Source: Can this river be saved?, International Rivers Network Website

In the context of addressing existing dams therefore it is true to say that Mphanda Nkuwa is currently being promoted as an independent plant with little connection to the existing Cahora Bassa scheme. This approach heightens fears among environmentalists and civil society generally on the apparent lack of commitment to right the negative effects of HCB before promoting Mphanda Nkuwa.

8.5 Sustaining Rivers and Livelihoods

The project does have a direct and primary effect on the livelihoods of approximately a million people who live in the Zambezi Valley below Mphanda Nkuwa. Hydro Cahora Bassa has significantly changed the lifestyles of peasants along the lower Zambezi. It has disrupted a way of life that had evolved over many years to meet basic needs. In a survey, Belfuiss et al state that:

"From the interviews it became clear that the utilization of river–fed fields was an integral part of a complex and highly adaptive indigenous agronomic system, which dated back over several centuries. Drawing on rich repertoire of farming practices, born out of years of trial and error and detailed micro-ecological knowledge, local communities creatively adapted to the uneven soil quality, fluctuations of rainfall, and challenges of flooding. The oral accounts further highlight three important dimensions of the indigenous agronomic system. First, and foremost, the food production system of the local peasant communities co-evolved with the seasonal cycle of the river's flooding patterns. Decisions regarding the spatial and temporal patterns of food production- including selection of the most appropriate crops and amounts planted, with reference to the season and location – were finely tuned to changes in the river's discharge rates."

Source: The Impact Of Hydrological Changes On Subsistence Production Systems And Socio-Cultural Values In The Lower Zambezi Valley (Beilfuss et al, 2002)

The feasibility report did not detail the extent of livelihood changes that implementing the project will bring for communities downstream of Mphanda Nkuwa. This is a shortcoming that the report recommends further investigation. The government on their part have stated that there are serious political risks of raising expectations through a process of wide consultation before a financier and developer have been secured. Some middle ground surely has to be attained between wide consultation with consequent expectations and minimal consultation and the risk that social issues that affect the livelihoods of hundreds of thousands of people will be overlooked.

9 Recommendations for better decision making on Mphanda Nkuwa

The current debate on Mphanda Nkuwa has been characterised by fears emanating from the effects and failures of Cahora Bassa. Information asymmetry between project proponents and civic organizations has polarized relations around the project. Some local NGOs have had to petition parliament to have access to some of the feasibility reports and working papers on the project. On the part of civil society there are varying levels of information and knowledge on the project so it is difficult to arrive at a coherent and consistent civil society position.

There is a role to enhance public and civil society participation in the different stages of the project.

- Current fear by the government of Mozambique is that such an extensive process will raise expectation unnecessarily and the consequent political pressure.
- There is no doubt that although the broad empowering framework exists for the management of water resources, especially on the Zambezi, detailed instruments and institutional capacity to ensure compliance at the operational level has been glaringly absent. This may not have much to do with the efficacy of Mphanda Nkuwa as a project but is a problem to do with the effects and management of Cahora Bassa.

These are the factors generally driving the various opinions held by the different key stakeholders. There is a need for an intermediary to create and foster dialogue over both Mphanda Nkuwa and Cahora Bassa, as the two are generally synonymous in the view of many institutions.

Consultative meetings have been held but not as broad as to reflect the range and spectrum of contending interests on the project.

The need for wider public and stakeholder engagement is crucial. The findings of this study have shown that the Mphanda Nkuwa hydropower scheme does have potential to be a successful export commodity for Mozambique and to send out signals to the investment sector that could see a boost in Mozambique's economy in the future.

However what it will not do is increase access to electricity for the rural communities, although there are other government initiatives such as the Energy Rural Access Programme that is promoting and funding de-centralised energy options. The technical and economic impacts of Mphanda Nkuwa depend on a good regulatory and fiscal regime which is not apparent in Mozambique at the moment. The social and environmental impacts of Mphanda Nkuwa depend on a transparent process of consultation and dialogue with a wide range of stakeholders. Evidence of such stakeholder dialogue happening in Mozambique does not seem to be very high.

In conclusion, Mphanda Nkuwa will not directly benefit the Mozambican people in the short term. It may do so in the medium to long term if the above issues are addressed, through an improved macro economy. However, if the social and environmental issues are not addressed then the result could be heavy social, economic and environmental costs for the Mozambique rural population.