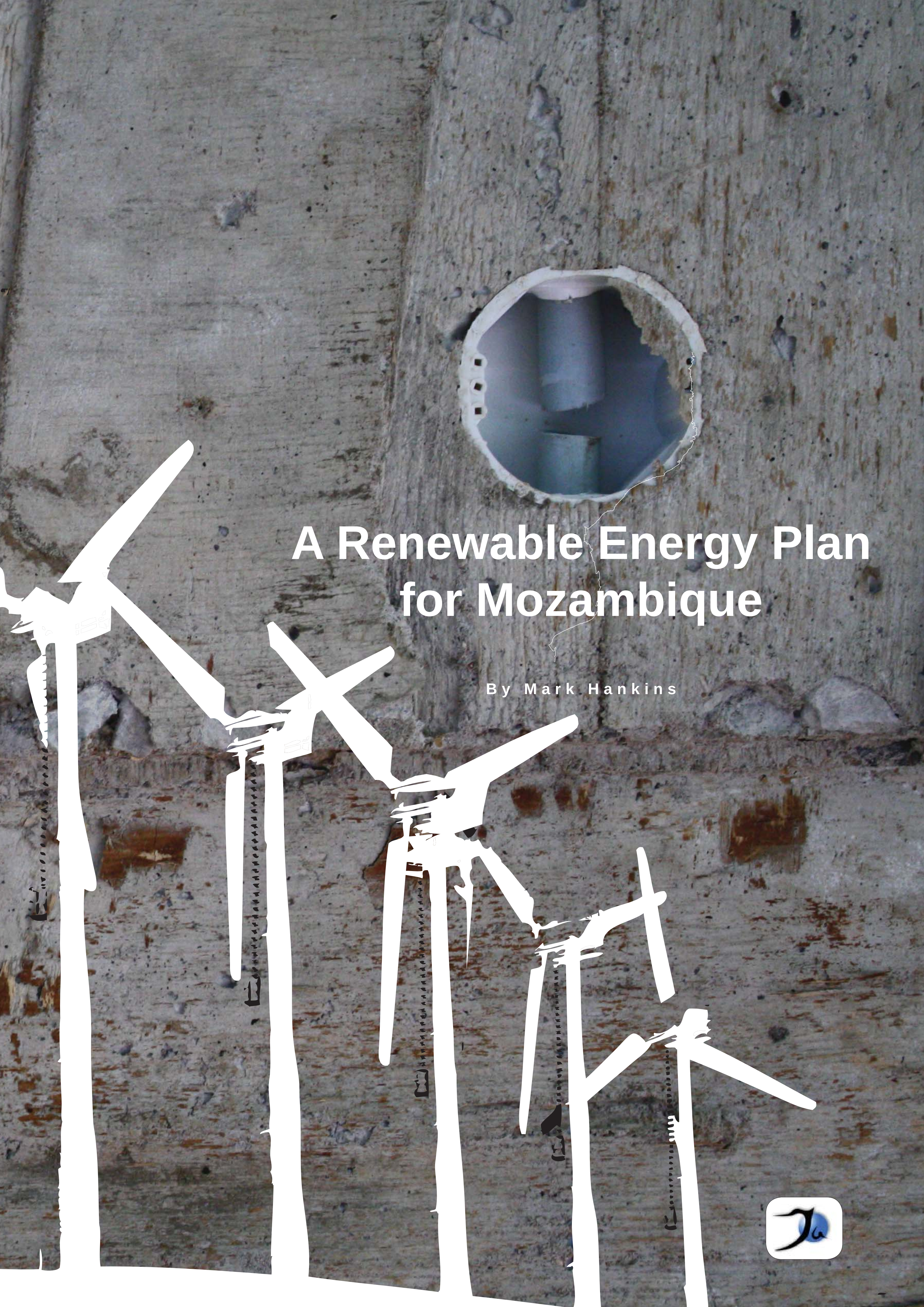

A Renewable Energy Plan for Mozambique

By Mark Hankins

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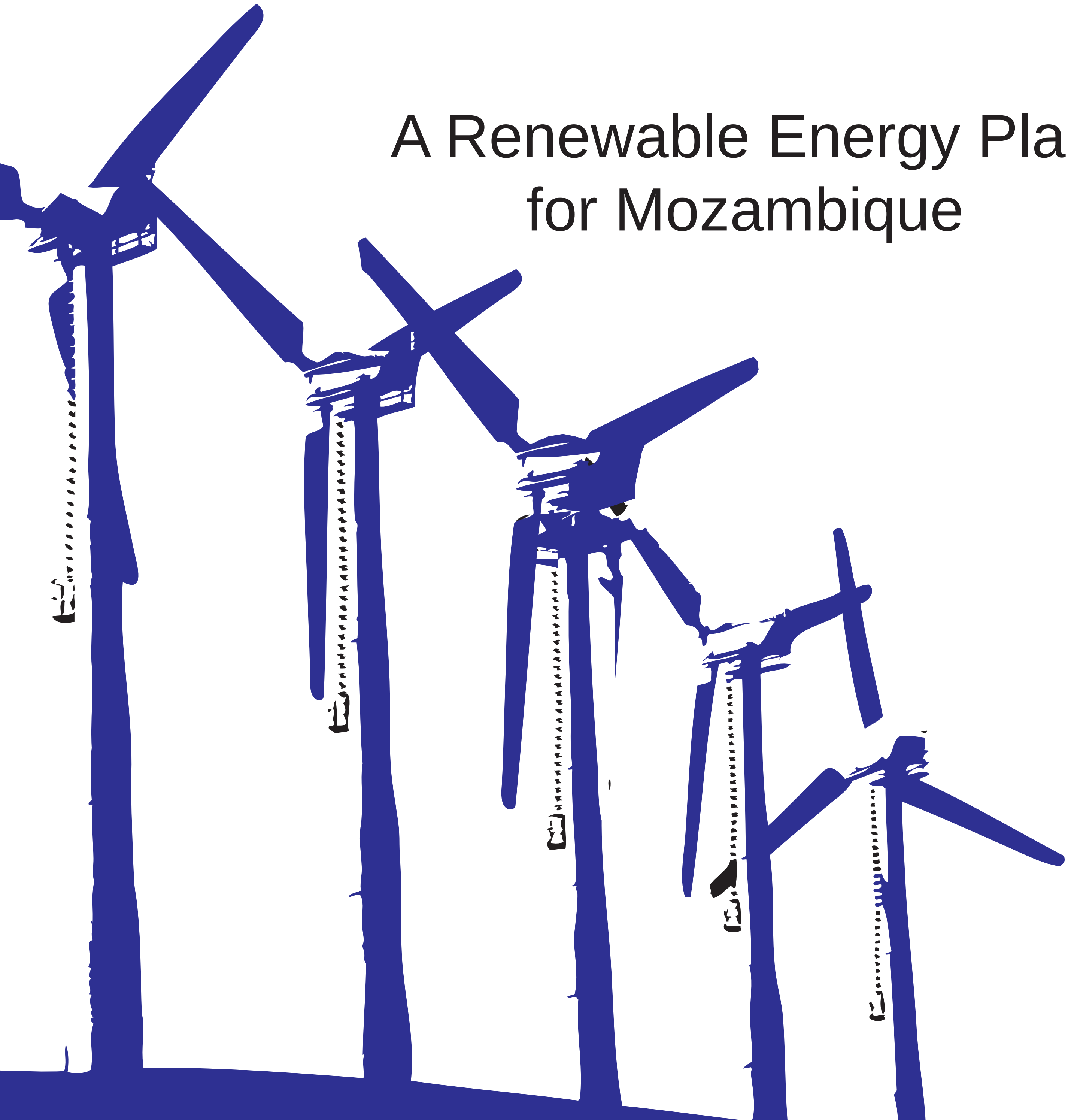

Abbreviations

ADB	African Development Bank
CSP	Concentrating Solar Power
DBSA	Development Bank of South Africa
DSM	Demand Side Management
EDM	Mozambique National Power Company
ERAP	Energy Reform and Access Program
Eskom	South Africa's state power company
FiT	Feed in Tariff
FUNAE	Mozambique national rural energy fund
GoM	Government of Mozambique
HCB	Hidroelectrica Cahora Bassa
kWh/m2/day	Solar energy resource measurement
kVA	Kilovolt-ampere
kW	Kilowatt
MW	Megawatt
MoTraCo	Joint venture company formed to convey power from South Africa to MOZAL aluminium plant
MOZAL	Mozambique Aluminium
NERSA	South Africa's electricity regulatory body
NORAD	Norwegian international aid agency
PV	Photovoltaic solar energy devices
RSA	Republic of South Africa
SADC	Southern African Development States
SAPP	Southern African Power Pool
Sida	Swedish international aid agency
SWH	Solar water heaters

Exchange Rate:
28 MT = 1US$
38 MT = 1 Euro

Fiche technique

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Foreword

I am pleased to be able to present this report, which lays out a green energy plan for Mozambique – a plan designed to bring electricity to everyone in the country without sacrificing our most precious resources, our rivers.

My organization has for years argued for cleaner energy and for protecting our rivers from the ravages of large, destructive dams, but until today, we could not offer specifics. With the help of Mark Hankins, an expert on African renewable energy, we can now put forth a clear vision for a sustainable energy system that will truly "lift all boats."

At present, Mozambique's energy plans involve putting all of our eggs in the hydropower basket, at a time when diversity is called for to protect us from a changing climate and less predictable river flows. Our current strategy also puts us in the unhappy camp with Nigeria and other nations that have been hit with the "resource curse"—the paradox that nations that export their natural wealth (such as oil, minerals, or hydropower) have worse development outcomes than countries with fewer natural resources. And finally, our current strategy puts the needs of large, often unsustainable industries such as aluminum smelting and mining over the needs of our own people. Mr. Hankins clearly lays out this problem with his apt description of Mozambique as being "Three countries" in the development of energy. It is time to unite our country, and to develop our energy supply in ways that share the wealth, protect our natural heritage, and prepare to adapt for a changing climate. We believe the plan put forth here can help us do all of these things.

Justiça Ambiental, has tried to find a reason or justification for Mphanda Nkuwa dam, and studied the various impacts it will have (social, environmental, financial), and have found the project is not worth the problems it will cause. Nor will a mega-dam solve the energy problems we face in this country, where most people are living in rural areas far from the national grid. We believe the plan put forth here will have the fewest impacts on Mozambique, her people and the planet.

This plan cannot happen without public support and understanding of the issues put forth within. Please join us in helping to call for a sustainable energy future that will bring Mozambique's citizens into the light with clean, green distributed energy systems.

Anabela Lemos
Executive Director, Justiça Ambiental
Maputo

Acknowledgements

Despite Africa's huge solar, wind and biomass resources, as a continent, it is far behind the rest of the world in mobilization of these resources for electrical power generation. There are many reasons for this: poverty, lack of finance and subsidies, lack of expertise, low cost alternatives, aversion of project developers, poor policies, etc.

However, as an advocate involved for 25 years in renewables throughout east and southern Africa, for me, the main barrier to renewable energy uptake is a lack of imagination at policy and investment levels. It is astonishing that a continent with so much solar and wind power has taken so long to wake up to the real possibilities they offer.

Mozambique is just one of many African countries where the focus has been on hydro and coal megapower --- and where policy makers and investors still ask doubtfully about solar and wind costs, as if these were the only important considerations in choosing future energy sources. Yes, the cost of electricity is important. But the costs of not investing and gaining expertise in solar, wind and biomass power at the beginning of the 21st century are even higher.

This report was prepared with support and assistance from Justica Ambienta! in Maputo Mozambique. Many thanks to Anabela Lemos and the JA! team for support during the research and production of the report and for valuable comments throughout the process of developing it.

Thanks also to those who contributed ideas, comments and feedback to the report, and then helped in the final editing.

Thanks also to the many people from government, NGO, research and parastatal organizations who were willing to share information about Mozambique's energy sector.

This report is dedicated to the many people I met with in Mozambique who asked the question "Why are we not investing more in solar and wind energy?" Indeed.

Mark Hankins,
Nairobi, Kenya,
September 2009

Executive Summary

Mozambique is three countries.

The "first country" is a power house for the Southern Africa region. Based on low-priced electricity from Cahora Bassa, it is able to pump hundreds of millions of dollars worth of power into South Africa and to attract investors that set up energy-intensive "megaprojects" such as smelting plants and refineries. Electricidade de Mozambique, the national power company, is a leader in the region, with an electrification program that is expanding at the rate of 100,000 new connections per year. This "country" is negotiating with international investors to install the multi-billion dollar Mphanda Nkuwa dam, and inject still more power into the Southern African Power Pool (SAPP) grid.

Mozambique is missing out on critical global developments in new clean sources of energy that could benefit its population, create new industry, jobs and capacities, and bring clean power to its own population.

The "second country" is predominately off-grid, poorly served by electricity infrastructure, and --- at less than 50 kWh/capita/annum --- has among the lowest per capita use of electricity in the world. This second country is unable to extend or build power stations in remote regions, and its planned transmission infrastructure forces most of the power it produces to be exported to South Africa, before re-importing at higher cost. It relies on international donors to fund over 75% of its slow-moving rural electrification programs. Its rural areas have poor access to communication, roads and income generation, in large part because there is little economic activity or ability to process agricultural products.

The "third country" is energy-rich with a vast potential for decentralized clean electricity and fuel production. It has virtually unlimited solar power across the entire country and large biomass resources that could be used for electrical production in strategic areas. It has over 1000 MW of mini-hydro potential, much of it in areas that are currently electricity-starved. It has the second largest coastline in Africa, with unexplored wind resources that could contribute to the national grid.

Zambezi Valley village being bypassed by power lines for Cahora Bassa Dam

Mozambique's future development will largely be determined on whether it utilises the ample energy resources of the "third country" to bring power to the "second country". However, at a time when many countries in the world are actively implementing renewable energy programs, Mozambique still does not have such a program and is primarily focused on the "first country's" mega-power needs.

Mozambique's huge untapped potential of renewable energy technologies are well-suited for both urban and rural energy development. But its electricity sector has a short-sighted and risky reliance on electricity from large dams which is primarily driven by a need to sell low-cost power to South Africa and industry. Because of this focus on power prices and large projects (and, typically, an avoidance of addressing environmental and social costs in pricing these projects), Mozambique is missing out on critical global developments in new clean sources of energy that could benefit its population, create new industry, jobs and capacities, and bring clean power to its own population.

Moreover, a lack of leadership, implementation capacity, policy and incentives is causing Mozambique to miss out on viable renewable opportunities that would benefit the country for the long term. The lack of Government-designed incentives constrains renewable development and lowers investment appetite for rural electrification.

Mozambique's close integration with South Africa and the SAPP impacts immensely on the way energy projects are developed. SAPP's rapidly increasing power demand has strong implications for planned energy project portfolios. In fact, through use of energy efficiency programs, South Africa has the potential to quickly reduce its own electricity consumption by an amount equivalent to 3 to 5 times Mozambique's entire consumption! As long as Mozambique's power planners focus on the huge consumer next door, they will never adequately meet the needs of their own country, which remains largely off-grid and unconnected.

Moreover, by proxy, Mozambique is supporting relatively wasteful electrification initiatives for South Africa's industry and its rural electrification programs. South Africa is slowly learning that unlimited growth in demand for power is not sustainable. As one of the highest CO2 emitters in the world per GDP, South Africa's demand for dirty power not only affects the global environment, it affects its neighbours. Namibia was forced to re-open an obsolete coal generation station during South Africa's 2007 power crisis. Meanwhile, Zambia and Mozambique often seem to be more focused on supplying power to South Africa than their own populations.

This report recommends that Mozambique urgently undertake the following activities to build up its renewable and decentralized energy capacity:

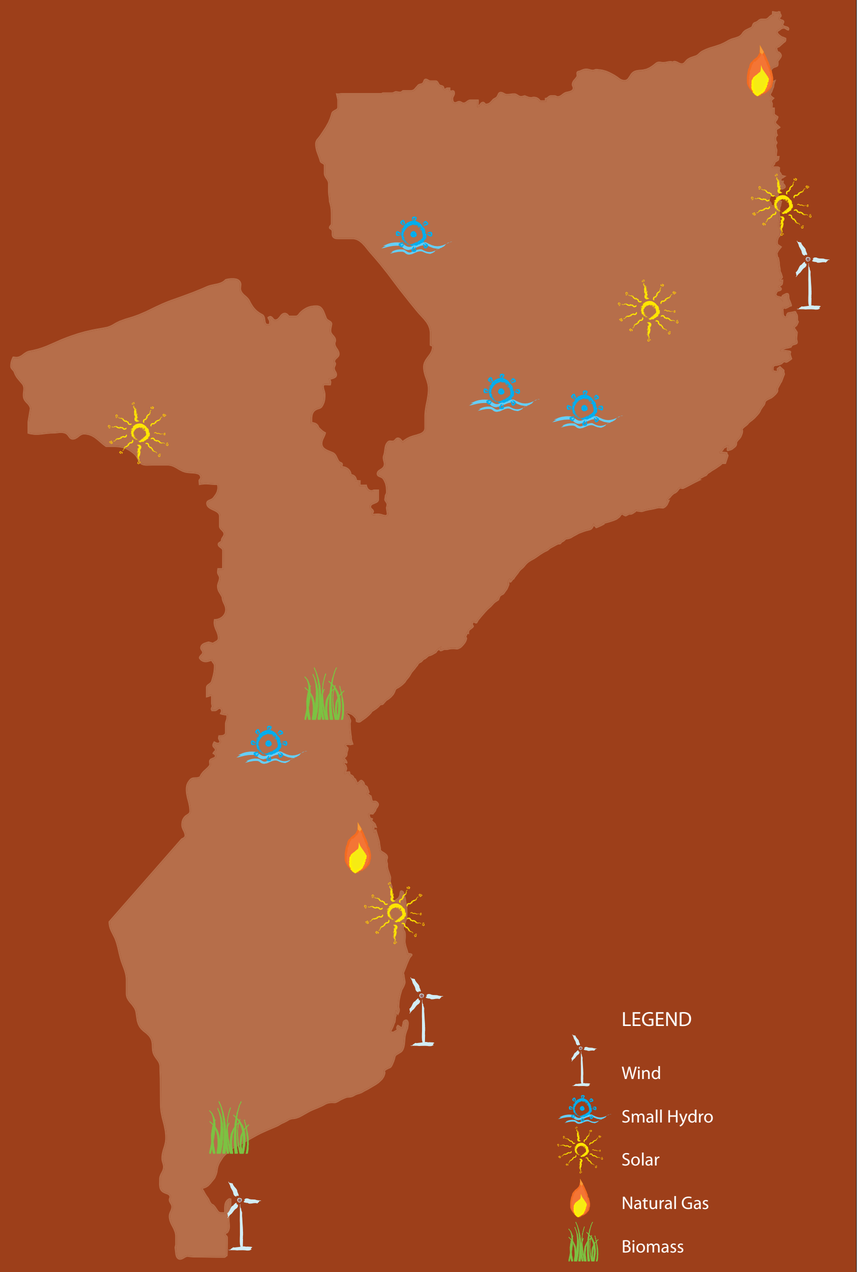
1. **Develop a renewable energy policy that sets aggressive targets for priority renewable energy technologies.**[1] The policy should contain specific and separate guidelines for the development of renewable energies on-grid and off-grid.
2. **Remove all duties and tariffs on renewable energy technologies.**

1 All references to renewable energy in this paper exclude large hydro, per most international standards.

3. **Actively encourage private-sector investment in renewable projects in Mozambique.** Create clear incentives for investors, manufacturers and developers to utilise and promote renewable energies when making investments in the country. Renewable energy support should not be targeted exclusively to off-grid initiatives and poverty alleviation; renewables should be encouraged in economically-active sectors including tourism, telecommunications and commercial as well as among middle-class households.
4. **Create Feed-in Tariffs and standard agreements for grid-connected mini-hydro, solar (CSP and PV), wind and biomass cogeneration projects.** Such tariffs can be based upon similar programs in South Africa or other neighbouring countries. Actively seek revenue through energy export taxes and donors to support Feed-in-Tariffs and off-grid renewable energy projects.
5. **Expand subsidy funds for off-grid renewable energy infrastructure that support PV, wind, microhydro and biomass projects in isolated and mini-grids.** Open this fund up to private sector investors and/or EDM. Task FUNAE to be a facilitator --- rather than implementer --- of renewable projects in remote areas. It would be useful for Mozambique to examine the experiences of Uganda and Tanzania, both of which are developing innovative approaches to off-grid private sector and/or community-managed rural electrification.
6. **Actively seek support through energy export taxes and donors to support Feed-in-Tariffs and off-grid renewable energy projects.**
7. **While stimulating the growth of a local renewable energy sector, increase programs for training qualified personnel in engineering, installation and maintenance of renewable systems.**
8. **Actively encourage energy efficiency in Mozambique through policies and programs.** First steps would be appliance and building standards, and working with the largest industries to reduce energy use. A program to retrofit public buildings would also send a strong message.
9. **Seek to harmonize SAPP efforts to introduce decentralized energy technologies, energy efficiency standards, demand side management and feed-in tariff pricing for renewables.** Seek support for region-wide funds to develop renewable energy projects that benefit SAPP. SAPP needs to adopt policies that prepare for climate change --- in whatever form it takes --- by quickly shifting its focus from mega-coal and dam projects to smaller, environmentally friendly solutions.

Although EDM has demonstrated that at least one agency in the country can deliver large numbers of connections, there is a need to develop a similar aggressive capacity with renewable energy and off-grid technologies. Furthermore, because climate change is expected to have especially large impacts on water resources in the region, there is an urgent need to transform the current SAPP demand for low-cost electricity "at any price" into demand for clean and renewable energy, and for energy planning that helps Mozambique and the region adapt to a warming world.

As long as Mozambique's power planners focus on the huge consumer next door, they will never adequately meet the needs of their own country, which remains largely off-grid and unconnected.



Mozambique has ample solar, wind, biomass, gas and small scale hydro resources. The symbols show areas where resources are concentrated. Note, however, that solar resources are widely distributed throughout country --- sites with especially high resources are noted with the solar symbol. As well, biomass resources are well distributed in the country. The biomass symbols show the area where sugar plantations are located.

1. Mozambique's Electricity Sector

This section provides an overview of the electricity sector in Mozambique. The purpose herein is to outline the current situation and suggest how the country can move to a cleaner, decentralized and renewably powered future. This report is not meant to be a definitive documentation of the power sector in Mozambique.

The Portuguese-built 2,075 MW Cahora Bassa dam on the Zambezi River --- developed primarily to supply power to South Africa and Maputo industry --- dominates the electricity sector. Electricidade de Mozambique manages an additional 160 MW of available hydro and thermal capacity. Largely due to its colonial heritage --- which invested little in rural development --- Mozambique has not diversified its power supply away from large dams or projects intended to feed the Southern Africa Power Pool (SAPP) or Maputo-based industry. Mozambique's transmission and distribution infrastructure is relatively limited due to the large size of the country and the high cost of transmission and distribution infrastructure in far flung regions.

1.1 Supply Side

This section outlines electricity systems and resources currently available in Mozambique. It provides a brief background of existing projects. Further, it provides a general indication of potential electricity resources that have been identified in the country.

1.1.1 Conventional Electricity Projects and Resources

Mozambique is an energy-rich country. It has proven gas and coal reserves. It has 39 rivers emptying into the Indian Ocean --- including the Zambezi, the fifth largest river basin in the world. Moreover, Mozambique has a wealth of unexploited biomass, solar and wind resources.

Like many African countries, Mozambique has followed a centralized approach to electricity supply, selecting power sources according to criteria that are largely determined by cost --- and ease of financing. Its current supply focus on large-scale energy projects is directed primarily at electricity for industry and electricity for export to SAPP --- which has rapidly increasing demands for power.

Major players in supply of electricity in Mozambique include:

- Electricidade de Mozambique (EDM), the national power utility, is wholly owned by the Government of Mozambique. It participates in all parts of the electricity supply chain --- including some generation (though it is not the primary generator in the country) to transmission to distribution to consumer connection, supply and billing.
- Hidroelectrica de Cahora Bassa (HCB) manages and operates the Cahora Bassa Hydroelectric power stations and their associated transmission networks that convey power into the South African Power Pool

(SAPP). In 2007, Mozambique's ownership of HCB increased from 18% to 85% when an agreement with Portugal was reached.

- MoTraCo is a joint venture company formed by the state power companies in Mozambique, South Africa and Swaziland to convey power from South Africa to the Maputo Mozal plant. The company manages transmission lines in the three countries, and was created in 1998 through an equity-debt arrangement worth US$ 120M.

Mozambique's potential for power generation has been estimated at 14,000MW (85% of which is hydropower, based on historic river flows and not accounting for potential disruptions from climate change). More than 80% of the hydropower potential is located in the Zambezi Valley, including the existing Cahora Bassa Dam. Mozambique already has 12 medium-sized and large dams, most of which are managed by EDM. The above estimates do not include estimates of solar, wind or other renewables.

As mentioned above, HCB manages the Cahora Bassa Dam, which has an installed capacity of 2,075 MW. It is the primary electricity source for the country --- as well as a key source for Southern Africa. Cahora Bassa was built by a Portuguese, German, British and South African consortium between 1969 and 1974. The original construction of the dam included a 1,400 km dual 530-kV transmission line to South Africa. In 2005, majority share ownership was transferred from the previous owners to the Mozambican government.

Box 1: Least-cost electricity is not always low cost electricity

In many developing countries and especially Africa, planners often select electricity sources using "least cost" criteria. In this regard, the preference of Mozambique's power sector to "low cost power" is frequently mentioned herein. While least cost criteria have the short-term advantages in procuring energy sources for the lowest amounts of money, narrow financial considerations when selecting power sources are not necessarily healthy for the long-term.

Strict adherence to "least-cost" power planning has a number of drawbacks. First, least-cost power sources often have environmental problems that are not considered in the least-cost accounting. For example, coal-fired power plants give off massive amounts of carbon dioxide and cause increased reliance on coal mining --- which is not necessarily healthy for national environments or economies. Mega-dams, as explained elsewhere, have similar negative impacts. Secondly, mega-projects that deliver power centrally have the disadvantage of not decentralizing power distribution to parts of the country that need investment. This is certainly the case in Mozambique. The costs of transmission and distribution lines from the central locations to remote areas are high --- and the result is that many areas remain un-electrified. Thirdly, least-cost planning ignores new sources of energy that will become more important in the future, such as solar and wind. Finally, least-cost planning does not encourage diversification of power sources. Obviously, a power grid supplied by numerous and varied sources is less risky than one that relies primarily on a single source --- such as mega-dam hydro.

Mozambique is in the awkward position of having to export electricity from Cahora Bassa via the RSA Eskom transmission system, and re-import it for use in the southern part of the country, namely Maputo. The transport of electricity via this system encourages a relatively high waste of electricity, as large amounts of power are lost in these transactions.

EDM power plants have a nominal capacity of 252 MW, with 104 MW available. Of this, 109 MW is nominal capacity of hydro (with 81 MW currently available) and 148 MW is nominal capacity of gas and diesel-power generators (with only 59 MW) available. A large portion of the off-grid generators in regional capitals were not operational as of 2007, and the relative proportion of total electric energy supplied by hydro is about 97%.

Priority Pipeline Projects.

Mozambique's current pipeline of power projects includes a number of "traditional" large-scale hydro, coal and gas generation projects. Table 1 summarizes pipeline power projects that the Mozambique Government is pursuing.

Obviously, a power grid supplied by numerous and varied sources is less risky than one that relies primarily on a single source --- such as mega-dam hydro.

Table 1: Pipeline Power Projects in Mozambique

Project Name	Type of Project	Size	Comments
CB North Bank	Hydropower expansion	850 to 1200 additional MW	Detailed feasibility study is underway
Mphanda Nkuwa	Hydropower	2500 MW	
Massingir	Hydropower	40 MW	EDM managed
Lúrio	Hydropower	120 MW	
Majawa	Hydropower	25 MW	
Malema	Hydropower	60 MW	
Moatize	Coal fired power plant	1500 MW	IES is the developer
Temane	Combined Cycle natural gas fired power plant	300-400 MW	On the SASOL gas pipeline. 2010

Two additional dams are proposed downstream on the Zambezi from Mphanda Nkuwa: Boroma (400 MW) and Lupata (650 MW).

Mphanda Nkuwa is a preferred project for the Government because of the "firm energy" it can supply to the grid and because of its potential for exporting power. The Government has:

- Identified a developer (Camargo Correia, Brazil)
- Conducted a pre-feasibility study[3]
- Conducted a preliminary Environmental Impact Assessment
- In March 2009, a final Environmental Impact Assessment study was in initial stages. The first stage involves the design of the Terms of Reference and the public circulation of this document[4].

The project design has been re-engineered, increasing the estimated rated capacity from 1300 MW to 1500 MW. The 2008/09 global financial crisis has also affected the financing of the dam.

Enlarging the spillway at Cahora Bassa: This retrofit, which would greatly increase the capacity of HCB, was considered the "preferred option" in an earlier EIA for Mphanda Nkuwa. The project would likely reduce the need for Mphanda Nkuwa and also help with the restoration of downstream flows.

2 EDM 2007 Statistical Abstract
3 This study was not made available to JA!
4 Interview with Impacto, one of the partners in the on-going EIA

1.1.2 Status of Renewable Energy Projects and Resources in Mozambique

This section provides an introduction to renewable energy resources available as well as projects currently planned or underway. Further analysis of renewable energy project potentials are discussed and analysed in sections 2 and 3.

As is the case with renewable energies in many African countries, renewable energy projects in Mozambique have historically been confined to traditional uses (i.e. wood and charcoal for cooking) and off-grid power supply sources (PV, wind pumping). There is increasing Government and private sector interest, but investment lags behind this interest and written policy.

Table 2: Key Renewable Energy Resources in Mozambique

Resource	Resource Availability	Comments
Biomass / Cogen	100's of MW, various fuel sources Bagasse: potential availability 433 thousand tones (dry weight, 2006)	5 sugar plantations located in Maputo and Sofala
Wind	Encouraging wind resources along coast, Niassa Tests show >6m/s average in some areas	4 sites studied (but at 10m masts, 20m tests will probably reveal greater resource). Resource mapping needed.
Solar	High -- 4.5 to 7 kWh/m2/day Assuming average insolation of 5.2 kWh/m2/day 1.49 million gigawatt hours of annual radiation is incident on Mozambique land surfaces.	Estimated 1MW of off-grid PV systems installed; FUNAE study on PV potential underway.
Small-scale Hydro (up to 10MW)	>1000 MW	> 60 potential projects
Geothermal	Possible resources, but no studies completed yet. Conservative estimates of at least 25 MW in Tete, Manica and Niassa.	No realistic plans or resource assessments
Tidal	Ample resources, but no studies completed yet	No realistic plans or resource assessments

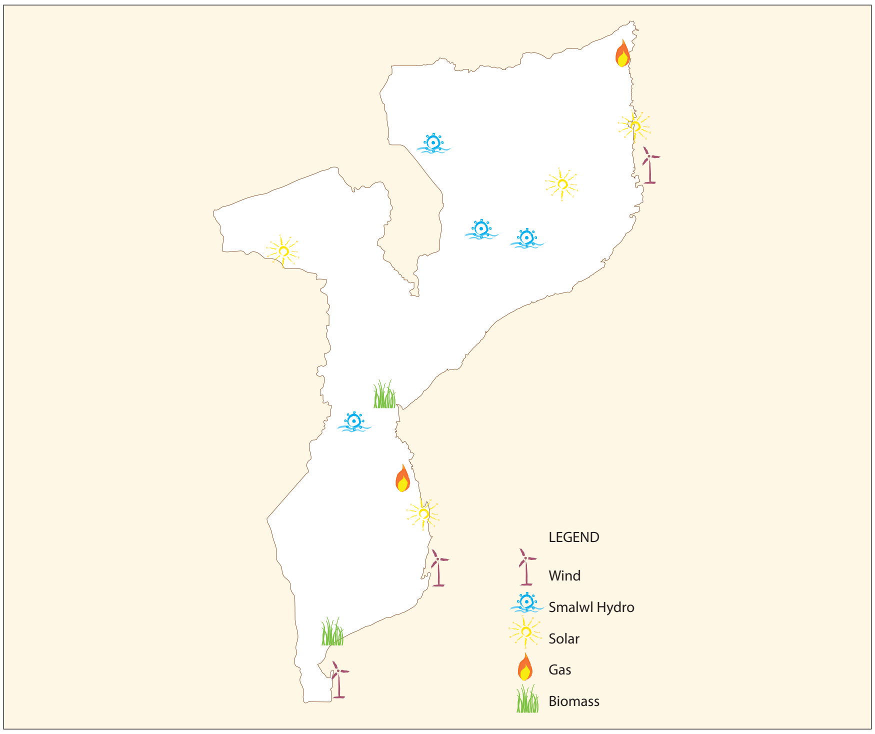


Figure 1: Sustainable energy sources in Mozambique

Small-Scale hydro

The Department of Energy estimates that over 60 potential micro- and mini-hydropower projects with a potential of up to 1,000 MW exist in the country[5]. The central part of the country (Manica Province) has the best resources. Table 3 provides a summary of priority Government projects[6].

Table 3: Priority Small Hydro Projects

Hydro-power Project	Installed Capac-ity (kW)	River	Prefea-sibility Done?	Distance to Nearest Vil-lage (km)	Location (Dis-trict, Province)
Mbahu	2000	Lucheringo	Yes	30	Lichinga, Niassa
Majaua	1000	Majaua	Yes		Milange, Zam-bezia
Kazula	30	Lazula	Yes	~12	Chiuta, Tete
Maue	280	Maue	Yes	~1	Angonia, Tete
Mavonde	30	Nhamukwarara		3	Manica, Manica
Rotanda	30	Rotanda	Yes	~1.5	Sussundenga, Manica
Sembez-eia	30	Bonde		2	Sussundenga, Manica
Honde	75	Mussambizi	Yes	4	Barue, Manica
Choa	20	Nhamutsawa		~2.5	Barue, Manica

5 Interview in DoE offices with Planning Officer, 26 February 2009.
6 From Ministry of Energy

At present, the following small-scale hydro activities are being carried out:

- a 200 kW plant was recently installed in Honde, Manica Province
- several pre-feasibility studies for small hydro units are being carried out by FUNAE in Tete, Manica, Zambezia Provinces, including:
  - Máue na Vila de Ulóngue, (Tete, 1MW)
  - Chidzolomondo (17kVA)
  - Mavonde, in Manica (200kVA)
  - Rotanda, (80 kVA)

Through the 2009 draft Energy Strategy, the government is establishing a simplified process by which investors can obtain exclusive rights to develop concessions less than 15MW --- FUNAE is involved in this. Further, in 2007 the government invited foreign investors to build hydropower projects in 100 locations (though it is not clear which of these are large hydro, mini-hydro and micro-hydro)[7].

Despite the ample resource and large number of potential sites (as well as the positive Government policy towards small and micro hydro), the overall development focus has been on mega-scale projects such as Mphanda Nkuwa. Only a handful of small and micro-hydro projects have been completed over the past five years. This is largely due to the lack of capacity to implement small-scale microhydro projects, lack of clear process and lack of focus on the sector[8].

Biomass and Biofuels[9]

Biomass is a primary potential source of both electricity and fuel and is increasingly seen as a modern energy resource for Mozambique.

> "Mozambique has only recently begun to understand that it is a 'biofuel superpower'. Its agro-ecological resources allow for the production of a wide range of efficient energy crops, including eucalyptus, grasses, starch crops like cassava, or sugarcane and jatropha. Analysts affiliated with the International Energy Agency estimate that the country can produce around 7 Exajoules of biofuels sustainably, that is roughly 3.1 million barrels of oil equivalent per day."[10]

There is a great potential to develop biofuels as only 4.3 million hectares of the country's 63.5 million hectares of potential arable land, or 6.6 per cent is currently utilised. Moreover, some 41 million hectares of poor quality land are available for the production of energy crops that require few inputs and are not suitable for food production.

Nevertheless, biofuel production does have social and environmental risks that need to be accounted for. Early experiences in Africa are already showing that there are risks of displacing vulnerable communities and losing other productive uses of lands without compensation. Large-scale production also tends to attract foreign investors rather than developing community-driven partnerships. Such arrangements may bring relatively few local benefits. To ensure a positive experience with large-scale bio-

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7 http://www.engineeringnews.co.za/article.php?a_id=138534

8 A Danida report advocated transferring responsibility of small hydro project execution from FUNAE to EdM because of the latter organisations greater capacity to implement projects. See section 1.2.

9 See reference section for sources of information on biomass and biofuels.

10 http://news.mongabay.com/bioenergy/2007/10/mozambique-signs-ethanol-mega-deal-

fuels, protection of community land rights need to be improved, and clear policies that avoid impacts on food production need to be developed.

Biomass sources of energy can be divided into two primary categories: 1) traditional fuels and devices (including wood, charcoal and agricultural wastes) and 2) modern biomass fuels and devices. This document is primarily concerned with electrical energy, and is less concerned with traditional biomass fuels --- although it should be recognized that over 80% of the energy utilised in the country is from traditional biomass sources[11]. Note that, through the use of pellets and briquetting, traditional fuels can be converted into "modern" fuels and used in electricity production.

Modern biomass fuels and devices include sources that can be either burned to produce steam (and electricity) or converted to fuels for use in the transport sector. Again, because this report is primarily focused on the electricity sector, oils and liquid fuels that would primarily be used by the transport sector are not analysed. Nevertheless, intelligent use of biomass at the small-scale primary level can contribute to rural development in critical ways, as outlined in the bullet points below and can help equitably distribute energy resources in ways that electricity cannot. (FUNAE is undertaking some of these tasks today, albeit on a relatively small scale):

- Making charcoal production more efficient and professional can improve income streams for rural people and reduce pressure on forest reserves while retaining the importance of the charcoal industry in the rural economy
- Improved wood and charcoal stoves can reduce demand for biomass fuels and make kitchens in rural and urban settlements cleaner, more efficient and safer
- Sustainable production of wood fuels through plantations and agro-forestry can improve rural energy sources and incomes
- Development of technologies like biogas digesters[12] can be integrated in farming and dairy systems and help produce energy for rural needs
- Kerosene and liquid petroleum gas (LPG) also have an important role to play as fuel for cooking and lighting.

Increasing African household use of LPG, kerosene and sustainable charcoal has significant greenhouse gas emission and health benefits compared to conventional biomass harvesting and combustion.[13]

Available biomass crops and wastes that could potentially be converted into electricity or power fuels include:

- Bagasse from sugar cane waste
- Copra (waste from coconut shells)
- Cashew wastes and oils

Only a handful of small and micro-hydro projects have been completed over the past five years. This is largely due to the lack of capacity to implement small-scale microhydro projects, lack of clear process and lack of focus on the sector.

11 Cuamba et al, A Solar Energy Resources Assessment in Mozambique.
12 Biogas digesters convert manure into a gas that can be used for cooking, lighting and heating. An estimated 16 million rural families worldwide benefit from household-scale digesters. The digesters are relatively affordable, can be built by the users, and do not require imported technology or expertise. A particular advantage of biogas is that digesters produce a soil amendment that can help boost farm yields.
13 See Bailis, R., M. Ezzati and D.M. Kammen (2005) "Mortality and Greenhouse Gas Impacts of Biomass and Petroleum Energy Futures in Africa." Science 238, 1 April.

- Maize and agricultural wastes
- Cassava (the second largest crop in Mozambique after maize)

On the policy front, the Government "has decided to embark on a modern bio-fuels programme based upon the potential benefits of these systems". In a 2008 speech in Germany, the Minister of Energy stated that biofuels meet the needs of the country because "They are labour intensive, and can create agricultural and agro-industrial employment, self-employment, and income". As well, he stated that Mozambique will focus on bioethanol (from sugar cane and sweet sorghum) and biodiesel (copra oil, cotton seed oil, sunflower seed oil and jatropha[14] seed oil). The GoM has already adopted legislation for introducing biofuels and expects to engage the private sector using public-private partnerships[15].

Less controversially than opening new lands for biofuel production, the Government has a strong interest in making use of agricultural wastes through cogeneration power plants, and expects to incorporate 60 MW of power from cogen projects, including Masinjire (50MW) and Manica (10 MW)[16]. Given the ample biomass waste resources (particularly from sugar, wood and copra), there is potential for other biomass to electricity projects.

Sugar, Ethanol and Bagasse. In the 1970s, Mozambique was among the world's leading exporters of sugar. After the independence struggle, sugar production declined, but it has been undergoing a recovery in recent years. In 2009, the five local sugar mills estimate that they will produce 419,000 metric tonnes of sugar, a 68 percent increase from the 250,191 metric tonnes produced in 2008. Based on the amounts of bagasse available and experience in Mauritius, where bagasse is a significant contributor to the grid, hundreds of megawatts of power could be fed into the grid from existing sugar plantations using modern boilers. Edward Mondlane University has proposed pilot rural electrification schemes with sugar plantations to FUNAE in collaboration with a Danish partner. Mauritius is interested in collaborating with the work.

Table 4: Mozambique Sugar Plantations

Name of Sugar Plantation	Location	Notes
Maragra	Near Maputo	Illovo owned
Xinavane	Near Maputo	RSA-owned
Buzi	Sofala	
Mafambisse	Sofala	RSA-owned
Marromeu	Sofala	

Jatropha. Canada's Energem acquired a jatropha biodiesel project based on an initial 1000 hectares and will begin planting a further 5000 hectares. It plans to invest in an additional 60,000 hectares over the coming years.

14 Jatropha experience in Mozambique is poor. See Jatropha: Ribeiro; D & Matavel; N, A Socio-Economic Pitfall for Mozambique, Justiça Ambiental and UNAC, Maputo 2009.
15 Presentation by Salvadore Namburete, Mozambique Minister of Energy at EU Africa Energy Partnership meeting in Hamburg Germany, June 2007.
16 Interview with Ministry of Energy team, 26th February 2009. The fuel sources were unclear.

Chinese, Italian, Portuguese and Brazilian companies are active in the sector as well.

Cassava. Mozambican scientists are seeking to develop varieties of cassava, the country's second largest food crop, that are appropriate for the production of biofuels. They aim to develop a cassava industry as a tool for poverty reduction and rural development.

Coconut/Coir. Pilot projects for coconut shells/coir are being conducted in Inhambane (individuals) and Zambezia (plantation sized).

Solar Energy

Mozambique has a huge and virtually unexploited solar potential.

Mozambique has a huge and virtually unexploited solar potential. Annual incident solar radiation, distributed evenly across the country, is about 1.49 million GWh --- thousands of times more than the country's current annual energy demand.

Figure 2 shows that solar radiation availability varies between 4 and 7 kWh/m2/day throughout the country with the annual daily average at 5.7 kWh/m2/day. Average daily availability varies with seasonal cloudiness and solar position.

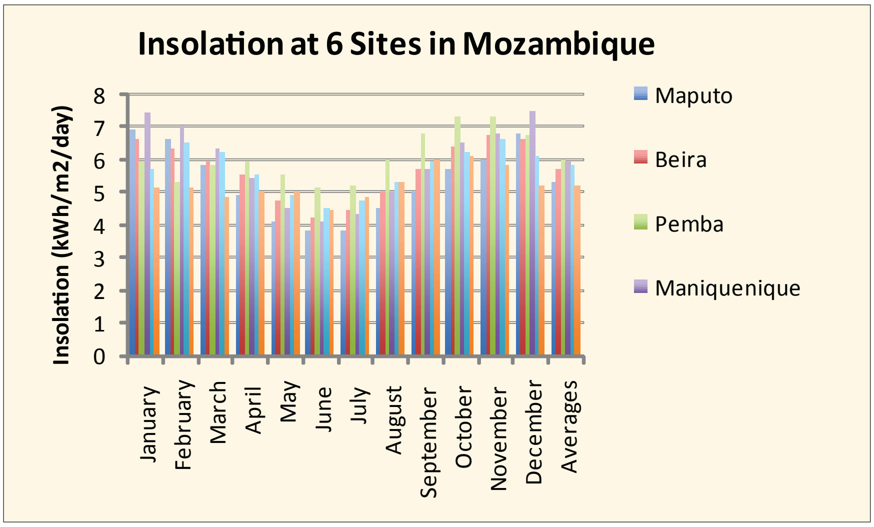

Figure 2: Solar radiation availability varies between 4 and 7 kWh/m2/day

Potential applications of solar energy in Mozambique that could impact the electricity sector include:

- Solar water heaters (which can replace electric water heaters and serve in demand management)
- Solar electric (PV) sources (both on and off-grid)
- Concentrated Solar Power (CSP). Large scale solar power stations (now being installed on a large scale in the US and Europe) have yet to be considered in sub-Saharan Africa.

17 Mozambique power sector players interviewed for this report had little knowledge of the rapid changes taking place with grid-connected PV technology or CSP in Spain, Germany, California and China.

Grid-connect solar PV is largely seen by the Government and stakeholders as "too expensive" to be considered as a grid support in Mozambique in the near future[17]. However, even without much Government support, it will, in all likelihood, play an increasingly important role, especially as falling costs of PV bring the technology closer to grid parity. Government direction and support would certainly improve the chances of PV playing a role on the grid.

Off-grid use of solar PV is the most common use of solar energy, mainly targeted at small-scale sites where the grid is unlikely to reach. Government and donors have funded most of Mozambique's solar PV investments as part of energy service projects for rural centres for health clinics, schools, Government offices or street lighting. PV is also being used in some off-grid tourist hotels.

FUNAE is a major player in the solar PV sector, having installed hundreds of PV systems in remote sites around the country. Those familiar with the local solar industry estimate that as much as 1 MW of PV capacity has been installed, much of it contracted by FUNAE as part of its work.

There is relatively little private sector activity in the solar PV sector (though FUNAE has commissioned KPMG to conduct a market survey). Active commercial markets have not yet developed (especially in rural areas), and even off-grid projects tend to be outsourced to international companies. PV prices are still very high in Mozambique. There is no tax exemption or reduced duty for solar equipment.

Solar Water Heaters (SWH). Unlike photovoltaic (solar electric) devices, solar water heaters convert solar energy into heat that is used to raise the temperature of water. The equivalent lifetime cost of solar water heater systems is less than 5 US¢/kWh, making solar water heaters exceptional investments for households and commercial establishments that would otherwise use electricity to heat water.

Because of the low cost of electricity, and a lack of incentives for alternatives, little has been done to develop the solar water heater market. A few solar water heaters can be seen on rooftops in Maputo --- but there is no concerted effort to promote their use.

Current government policy is to utilise solar water heaters in the tourism and building sector and PV power in remote off-grid applications.

Wind

Mozambique has long used wind pumps for supply of water[18] in remote regions. Experience with wind pumps, and long experience with seasonal winds along the coast hint at a much greater wind potential.

Recent research (as well as some early investments) indicates that there is a considerable potential for wind in the country. Figure 3 presents the results of a study[19] of four sites from which long-term data is available. The studies are encouraging because anemometers were only at 10m --- full studies at higher heights (30-40m) generally yield much higher wind speed results.

18 FUNAE is continuing this trend
19 Cuamba et al, Identification Of Areas With Likely Good Wind Regimes For Energy Applications In Mozambique

Primary wind resources are located along the country's long coastline and in the Niassa highlands. Average wind speeds are as high as 6 m/s, with the windiest periods during June to August. There is a need for a full wind resource mapping exercise in the country (the Government is seeking funds to prepare a wind atlas).

Because of the low cost of electricity, and a lack of incentives for alternatives, little has been done to develop the solar water heater market.

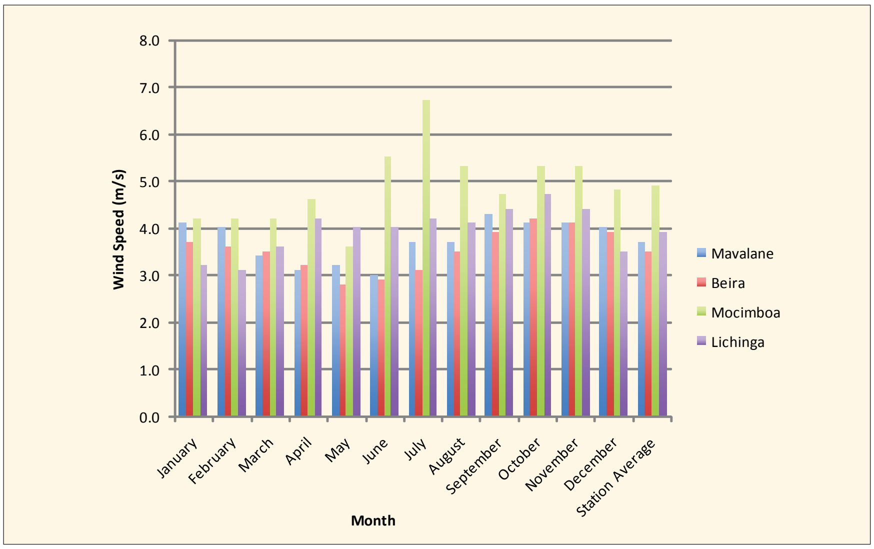

Figure 3: Average Monthly Wind Speeds at 4 Sites (30 years of data, 10m anemometers)

As part of a program to develop wind power projects in the southern part of the country, 20m anemometers have been erected to assess the potential for large-scale wind farms. Encouraging results have emerged. Data collected in two sites (Ponta de Ouro, Maputo province and Tofinho, Inhambane province) indicate average wind speeds of 6-7 m/s. A 300 kW pilot generator is being erected in Inhambane. Meanwhile, private sector interest in wind is focused along the Costa del Sol.

Using local wind data, work by UNEP Risø Centre on Energy, Climate and Sustainable Development modelled a 10MW wind farm at US$20.25M and showed several scenarios where a wind farm might be feasible at 9 US¢/kWh sales rates[20].

Geothermal

Government and international experts are only just beginning to study geothermal resources in Mozambique. Government preliminary studies indicate that there may be at least 25MW of exploitable power. The following is an excerpt from a report on geothermal resources in Mozambique:

> "At least thirty-eight thermal springs have been identified in Mozambique. The most interesting geothermal area is within the East Africa Rift just north of Metangula where vigorously boiling water is reported on the edge of Lake Nyasa. Several lower temperatures (below 60°C) found in the springs issue from Mesozoic crystalline terrain along and to the west of major faults in the Espungabera-Manicaareas, near the border with Zimbabwe.

20 J. P. Painully, UNEP-Risø Centre. Support for Wind Power Development in Mozambique. Economic and Financial Analysis

> "The most promising areas for geothermal energy development are the northern and central provinces of Mozambique where heat-flow values range between 70 and 170 mW/m2. The local availability of geothermally interesting fluids confirms the possibility of small-scale power generation, and warrants more detailed studies and eventual exploratory drilling. For further information see "Geothermal Features of Mozambique Country Update," published in the Proceedings of the World Geothermal Congress 1995." [21]

1.1.3 Transmission and Distribution of Electric Power

Power transmission in Mozambique is an especially critical issue for the country for two reasons. First, the large size of the country and its dispersed settlement patterns make dispatching power to the entire population extremely expensive (this issue is covered in Section 1.2 on demand). Secondly, HCB must first export power to Eskom, which in turn sells the power back to southern Mozambique at an increased rate. There are serious technical, financial and national security implications of this. In addition, long-distance dispatching of power wastes a considerable amount of power due to line losses.

Investment in large dams in the Zambezi basin will not help to alleviate the above issues. In fact, as explained in Section 3, decentralized power sources are likely to be better investments for both the energy security of the country and for energy access to the general population as a whole. A decentralized system also reduces waste of electricity lost through transmission[22].

Income from export of HCB electricity is vital for the government's revenues. When Mozambique took over majority control of HCB in 2005, it was forced to pay compensation to the international owners and the income from power sales is off-setting this.

HCB power exports to South Africa, and the low rates paid for it, was the subject of a major dispute between the countries in 2006. Mozambique cut off power to South Africa to force a re-negotiation of prices for HCB electricity. Now, prices to RSA for electricity are gradually being increased to "fair" levels.

To rectify the problem of having to export power, a new internal transmission plan is in the late stages of design that will transmit HCB power (and any other Zambezi electricity dam) directly through the central part of Mozambique (Tete, Manica, and Inhambane provinces) to Maputo. There will be substations from which power can be taken off for distributed supply to these regions (see Figure 4).

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21 Taken from: "Mozambique - Geothermal energy potential", J.M. Nicolau, G. Martinelli and L. Carapellese, IGA News, 1995, n.21, p.7 A Hypertext Document by Liù Bellucci, Marnell Dickson, and Mario Fanelli, http://iga.igg.cnr.it/mozambique.htm

22 Transmission systems can be hugely wasteful. Africa's power grid, for example, loses twice as much electricity during transmission as do more modern systems in other parts of the world, and those losses can equal 2% of GDP annually.

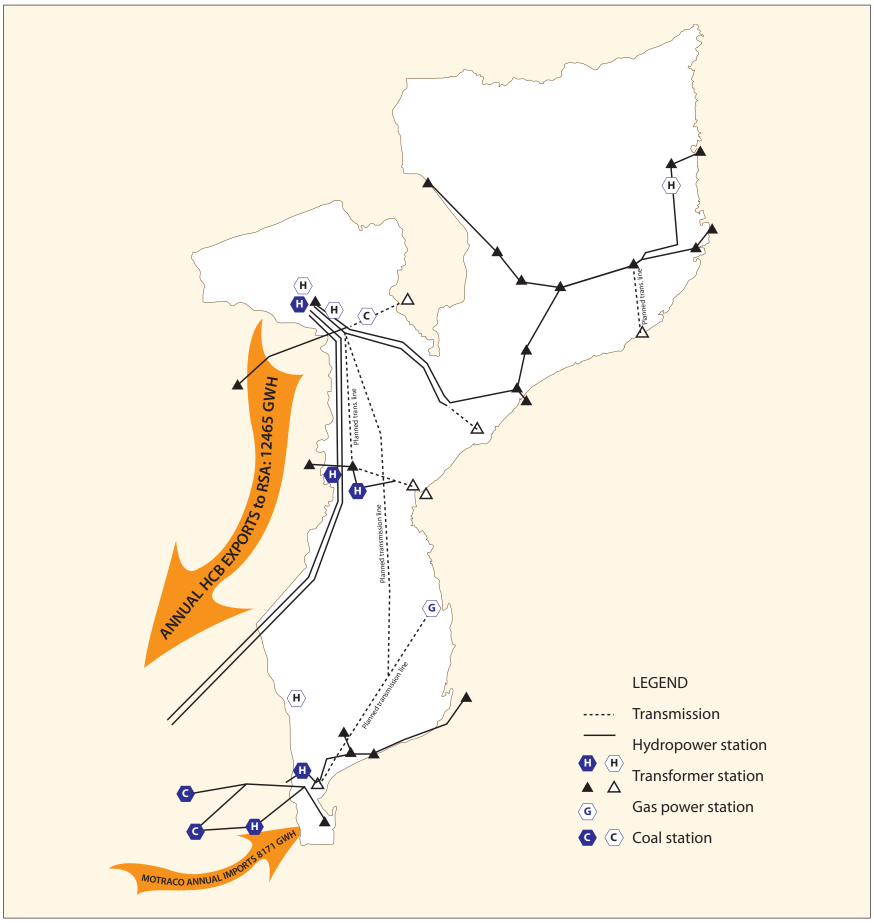

Figure 4: Mozambique's Electricity Transmission Infrastructure

> **Africa's power grid, loses twice as much electricity during transmission as do more modern systems in other parts of the world, and those losses can equal 2% of GDP annually**

Currently, the following major new transmission lines are planned[23]:

- Tete – Maputo. 765 kV line[24].
- HCB-Malawi (Funded by the World Bank with ABB handling the contract)
- HCB-Nampula thorough Malawi

Malawi, currently facing a serious electricity supply deficit, is banking on extremely low-cost power from Mozambique via this new transmission project.

EDM has held negotiations with Artumus, a company generating electricity from gas fields in Mtwara, Tanzania, about Mozambique's desire to extend a 122 km transmission line from gas-fired generators in Mtwara southward into Nampula. According to EDM, this would be useful to stabilize the Nampula system. Power could be exported and imported to and from Tanzania depending on demand patterns. Fifty to sixty megawatts of transactions are expected in this project which NORAD has expressed interest in supporting.

23 It was pointed out to the consultant by UNIP that investment cash for dams is much easier to secure than investment for power distribution and transmission.
24 Study copy was shown to consultant, not provided

1.2 Demand

In order to understand why there is so much interest in building Mphanda Nkuwa --- when local demand for electricity is relatively small in comparison to existing power generation --- one must understand the potential local industrial and export electricity markets.

Demand for electricity produced by Mozambique (with much of it wheeled through South Africa) can be broadly categorized into three categories:

- Local residents and business markets (low voltage consumers)
- Mozambique industry markets (which are served by both EDM and MoTraCo) (medium and high voltage consumers)
- SAPP and South Africa markets

A fourth demand category, off-grid electricity demand is handled by a separate organisation, FUNAE and does not feature in overall electricity grid planning. This is discussed in Section 1.2.3.

1.2.1 Mozambique Electricity Demand

Overall maximum demand for power within Mozambique's interconnected system is summarized in Figure 2[25]. As can be seen, 244 of 364 MW of the country's 2007 maximum demand was dispatched to the "Southern System" which includes the Maputo Province, Gaza and Inhambane. 73 MW is taken by the Central-Northern and Tete system that includes Zambezia, Tete, Manica and Sofala. 59 MW maximum demand is taken by Cabo Delgado, Niassa and Nampula. Peak demand in 2008 was about **400 MW.**

Figure 3 breaks down electricity sales from EDM between 2000 and 2007, indicating the relative portion of energy that was sold for commercial, domestic and industrial, as well as exports. Note that even EDM exports power, as current local demand is at times lower than EDM production. Note also that these figures do not include power supplied to Mozal by MoTraCo (see below).

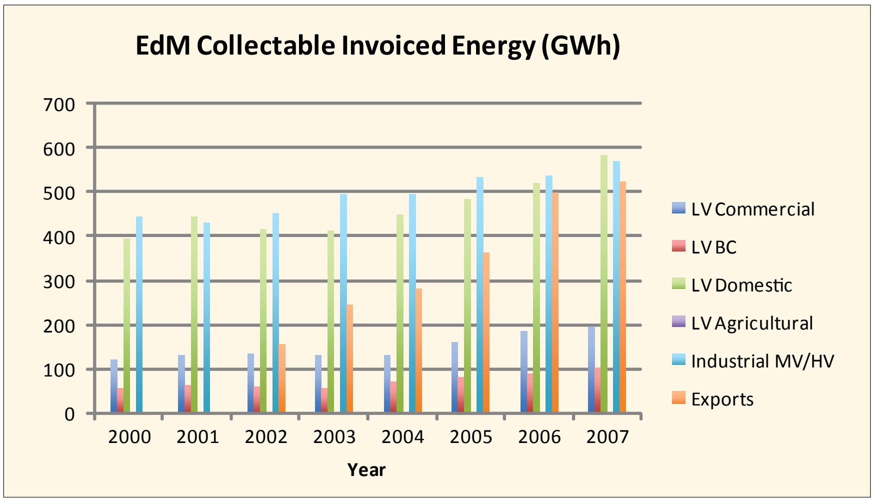

Figure 5: EDM Collectable Invoiced Electricity (2000-07), GWh

25 EDM Annual Statistical Report 2007

As the figure makes clear, the value to EDM of each domestic power connection is relatively low in comparison to industrial customers and, increasingly, exports. To illustrate the stark difference between power consumption of domestic consumers and industry, it is useful to compare Mozambique's overall per capita electricity consumption with and without industry[26]:

In short, if one includes the industrial demands for power in the per capita figures, Mozambique is a leading country in Sub-Saharan African per capita electricity consumption. If one considers the residential consumption, Mozambique is at the bottom end of electricity access in Africa. This trend continues, as the next section demonstrates, with the country's focus on the development of "mega-projects", both in production and consumption of electricity.

If one includes industrial demands for power, Mozambique is a leading country in Sub-Saharan African per capita energy consumption. If one considers the residential consumption, Mozambique is at the bottom end of electricity access in Africa.

Industrial Power Demand

Table 5 summarizes the major industrial projects planned and operational in Mozambique that will depend on low cost power. As mentioned earlier, Mozal Phases 1-3 are supplied by the MoTraCo company as a special purpose vehicle, not EDM. The other projects listed in the table below will require power sources and transmission lines for their operation.

Table 5: Proposed Projects in Mozambique and their Energy Requirements

Project	Status	Maximum Demand (MW)
Mozal Phase 1	Completed 2000	425
Mozal Phase 2	Completed 2000	425
Mozal Phase 3	Planned 2009	650
Maputo Iron and Steel Plant	Planned	850
Kaiser Aluminium Smelter, Beira	Planned (??)	625
Nacala Titanium Smelter	Planned	150
Chibuto Corridor Heavy Sands Project	Planned	150
Matuweni Refinery	Planned	???

Source: ITC, 2004 and interviews

As can be seen from the table, there are approximately 2500 MW of additional demand in line. Investments in these industries are largely dependent on the availability of low cost electricity[27].

The doubling of the Mozal smelter plant (Mozal Phase 2) in 2000 required the MoTraCo interconnection to be strengthened in order to raise available power for Mozal from 425 MW to 850 MW.

26 Source: Mozambique Ministry of Energy 2006 Energy Statistics
27 UTIP called this a "chicken and egg" situation.

Table 6: Electricity Imports and Exports, 2006 (GWh)[28]

Imports	GWh
EDM purchases from HCB	1648
EDM other imports	19
MoTraCo	8171
Exports	
EDM	360
HCB	12465

On-Grid Electrification Approaches

Current electrification access rates are about 12% of the country, with the vast majority of these connections in urban and peri-urban areas. EDM is responsible for grid-based electrification initiatives.

EDM is primarily involved in grid-based transmission and distribution, levy collection and, to a lesser extent, power generation. At present, its involvement in power generation is confined to five hydropower sites, and the numerous off-grid and back-up generators it operates in regional capitals (see Section 1.1.1). EDM tariffs are unified and rural electrification activities are cross-subsidized.

EDM has one of the most ambitious rural electrification roll-outs in Africa. It has, over the past three years, aggressively expanded its electrification network, adding over 260,000 connections. An estimated 100,000 connections were made in 2008 at an estimated cost of $800 per connection[29]. Grid-based rural electrification in Mozambique is mainly funded by grants and soft loans. About $80 million was spent on rural and peri-urban electrification activities in 2008 --- $60M of this came from Sida, NORAD, Danish aid, the World Bank and the AfDB.

All regional capitals are connected, and 83 out of 123 district capitals are now on the grid. This number is expected to rise to 106 in 2011/12. There is one isolated minigrid grid (in Villanculus).

EDM is, with DBSA funding, rolling out connections in low income areas of Maputo. The program expects to connect 12,000 households (10 MW at 200W per household) and is conducting "backbone strengthening". EDM has standardized low-income connections and is using low-income appropriate ready-boards and MCBs for many of the connections.

28 Source: Mozambique Ministry of Energy 2006 Energy Statistics
29 Interview, Luis Amado, EdM February 26th 2009

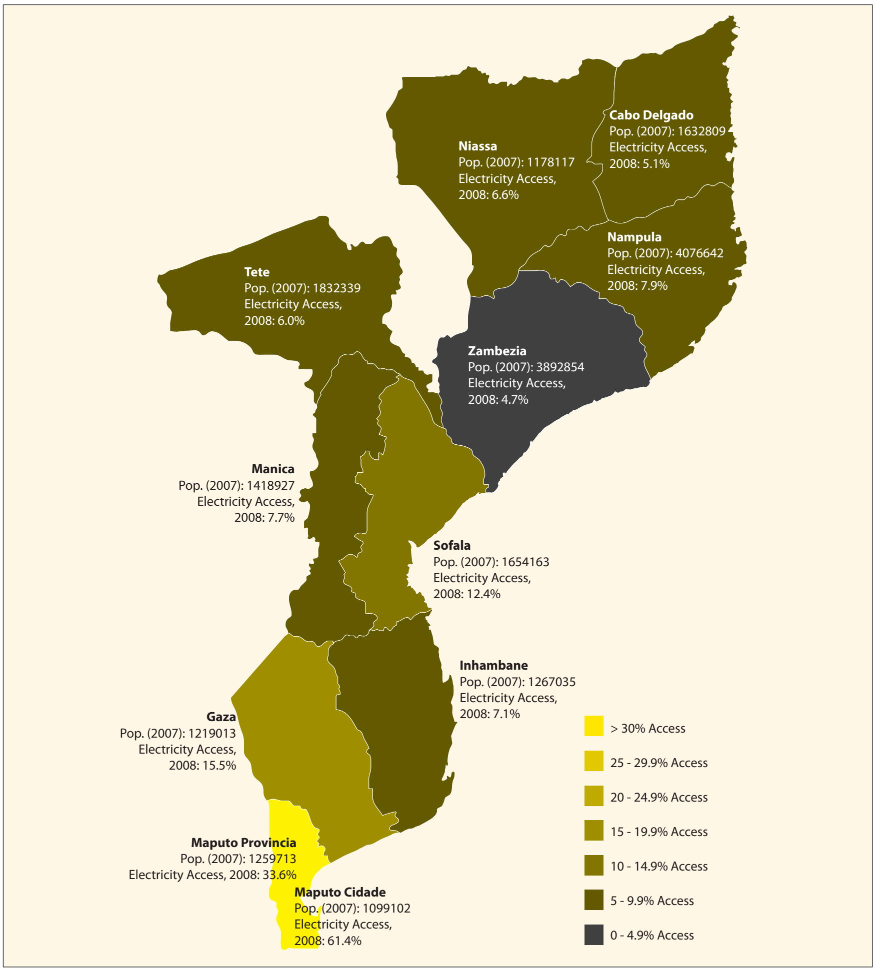

Figure 6: Electricity Access by Province

Figure 6 shows the estimated electricity access in the 10 provinces in 2008. The figure clearly shows the preponderance of electricity distribution investment in the southern parts of the country.

1.2.2 Demand for Electricity within the South African Power Pool

SAPP was established in 1995 to share electricity in the region, but the reality is that 80% of the grid's power is used by South Africa. SAPP members include utilities and Government Ministries from Angola, Botswana, Congo, Lesotho, Malawi, Mozambique, Namibia, Swaziland, South Africa, Tanzania, Zambia and Zimbabwe. In 2002, SAPP established the Short-Term Energy Market for the SADC region that attempts to create better inter-country electricity trade conditions.

SAPP has an installed capacity of 53,000MW, of which 41,000 MW is dependable[30]. As shown in Figure 5, SAPP's power requirements are

30 SAPP 2007 Annual Report

dominated by Eskom, which accounts for over 80% of electricity demand. Through HCB, Mozambique is the second largest exporter of power to SAPP, providing well over 2000 MW of capacity, or close to 4% of the demand.

There is a growing shortfall of power in the region --- and SAPP demand is increasing at 1500 MW per year. In the period 2004 to 2007, only 2836 MW of capacity was added – and only minimal efforts were made to reduce demand through efficiency measures or demand-management[31].

SAPP receives financial support from power utilities in participating countries, participating Governments, as well as donor aid from Norway, Sweden and the World Bank.

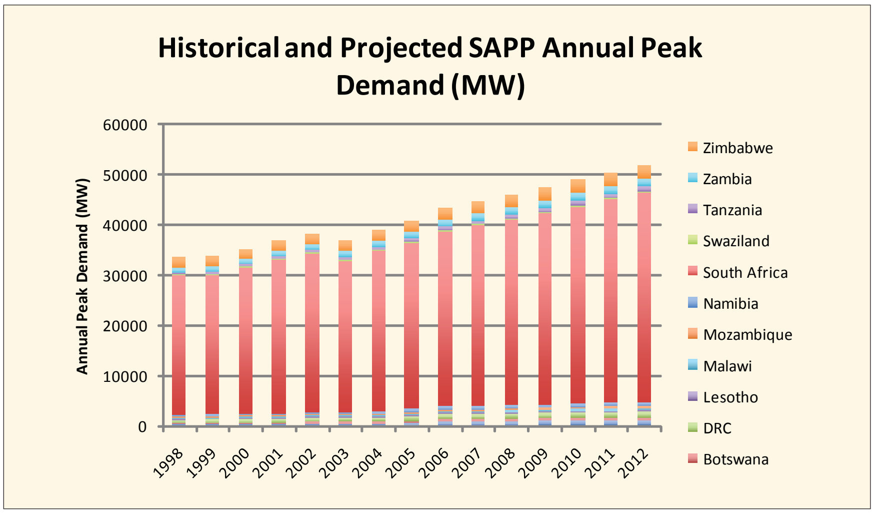

Figure 7: South African Power Pool Energy Supply and Demand

The main export clients for Mozambique power are South Africa, Zimbabwe and potentially, Malawi. Currently, Zimbabwe's power demand is depressed as a result of the political and economic problems the country is experiencing. Power demand is expected to grow rapidly when the current problems are resolved. Additional demand from Malawi is expected to come on line in the next two years following the completion of the World Bank-supported connection between the countries.

SAPP demand for power is taken very seriously by Mozambique, and it sees itself as a major contributor to the market.

Several features of the SAPP power system is critical when discussing alternatives to large dams and coal-fired generation:

1. The market group predominately focuses on installation of new capacity to address the gap between power supply and demand. All of the projects in the SAPP pipeline are large hydro, coal or gas turbines.
2. Low cost power is a stated priority for the region. It is critical for the profitability of the extensive mining and smelting activities that take place. It also serves the political agenda of maximizing access. The RSA En-

31 1757 was expected to be added in 2008, SAPP 2008 Annual Report

ergy Security Master Plan 2007-2025 makes it clear that RSA's electricity status quo will be difficult to change in the near future:

> "South Africa is… the lowest cost producer of electricity in the world, a position we would like to retain for strategic reasons. A number of challenges have arisen in the past few months, related to the security of electricity supply, and it is in that context that it has become imperative to conclude the Master Plan that will address those challenges."[32]

3. Little attention is given to new and renewable sources such as cogeneration, wind and solar in the SAPP reports. As well, demand-side management is only now beginning to be discussed by SAPP.

1.2.3 Off-Grid Electricity Demand and Electrification Approaches

More than 80% of Mozambique's population is off-grid. A large majority relies on traditional wood and charcoal biomass resources for all of their energy needs. This group has little access to conventional electricity or modern fuels --- in fact, they pay much more per kilowatt hour of energy for the little they get than those who have access in urban areas.

To solve the special problem of off-grid energy demand, the Government set up FUNAE in 1998, mandating it to tackle the unique problems faced by rural populations. FUNAE[33] is responsible for off-grid energy and electrification efforts. Its organizational objectives are:

- Development, production and use of different forms of low cost power.
- To promote the rational and sustainable management and conservation of power resources.

FUNAE provides financial aid and financial guarantees for economically and financially viable projects that are in tune with its stated objectives.

More than 80% of Mozambique's population is off-grid. This group has little access to conventional electricity or modern fuels --- in fact, they pay much more per kilowatt hour of energy for the little they get than those who have access in urban areas.

Its off-grid activities include:

- Provision of financial assistance/guarantees, loans to enterprises that have as their objective the production, dissemination of production techniques, distribution and conservation of power in its diverse forms.
- Provision of financial assistance for installation of power production equipment or distribution of power.
- Acquiring, financing or supplying financial guarantees for the purchase of equipment and machinery destined for the production and distribution of power, with particular attention for the use of new and renewable power sources.
- Promotion of distribution networks of petroleum products in rural areas. Provision of financial assistance for the transport for petroleum products for the supply of rural areas

32 13 August 2008: "Will Dirty Energy Continue To Fuel Africa's Economic Powerhouse?" www.issafrica.org

33 During a meeting with FUNAE on Feb. 25th (which was granted after a written request) the organization's manager declined to provide information in an interview format. She requested that JA! prepare all questions in writing. These were prepared and submitted, but FUNAE did not respond to these requests. The information in this section if gathered from FUNAE's website, from donor reports and from interviews with other stakeholders, including the Ministry of Energy.

- Support of consulting services and technical assistance for rural energy projects.
- Publishing and financing the preparation of studies and investigative papers on technologies for the production, distribution and conservation of power products or renewable power.
- Promotion of the development and planting of forests for biomass production.

With support from the Mozambique Government, the EU, Norad, Danida, World Bank/GEF and others, FUNAE has managed the installation of PV systems, development of microhydro projects, installation of wind pumps and promotion of fuel-efficient stoves in the country. However, given FUNAE's small size and modest budget[34], and given the huge scope of the off-grid population in the country, the impact of the work is relatively small. A 2006 review of energy programs in Mozambique put it this way:

> "FUNAE has a huge task - in scope and in scale - in rural energy. Despite being a young, eight year old organization, FUNAE is involved in:
>
> - all forms of energy supply: traditional and modern fuels, decentralized grid, stand-alone energy systems;
> - all forms of uses: household energy, productive use promotion, energy savings
> - all forms of finance: loans, subsidized loans, subsidies, guarantees
> - all forms of investments: project preparation, project implementation, project rehabilitation
>
> Whether any institution is capable of handling such a scope of project activities effectively is doubtful."[35]

PV Programs

Two pilot projects have been implemented in the south and central region of the country, providing electricity to schools, clinics and water pumping systems in areas where the power from the national grid is not yet available. These experiences are being replicated throughout the country in 300 rural schools and clinics.

FUNAE is managing the installation of PV in 100 schools, 100 health posts in Zambezia and Nampula by Indian companies (worth an estimated $3M). FUNAE has also contracted Mohane Energy of India to install 50 schools and 50 health posts in Gaza and Masinjere (this may also include solar home systems for teachers' houses).

As a pilot, FUNAE has procured as many as 200 solar home systems in Inhambane province. The Government procures systems and families pay this back over a long period. Systems are tendered to pre-qualified companies.

The centralized procurement model followed by FUNAE for PV systems (and other investments) does not easily allow for the development of local private sector capacity. As of 2009, FUNAE had commissioned a study through KPMG of the local private sector PV market and how it might be developed.

34 EDM's electrification budget is at least 5 times the size of FUNAE's, despite that fact that the latter is tasked to meet the energy needs of 80% of the population.
35 Wolfgang Mostert Associates, Energy Sector Support Programme, Technical Review, DANIDA, January 2006.

Isolated Grids

As mentioned elsewhere, there is a large potential for the development of isolated grids for portions of the population that are distant from the national grid. However, thus far there has been little success in developing isolated grids through FUNAE or subsidized private sector approaches.

EDM is prevented by the Electricity Law from implementing isolated grids. Attempts by FUNAE and district administrative bodies have failed to build sustainable approaches to private sector-led isolated grids. The Government has had trouble attracting private concessions, and where they have been used, subsidies to project implementers have been unsustainably high. Following the lack of success in the World Bank Energy Reform and Access Project (ERAP) approach, a Danida report recommended the following:

> A working group should "look into the option of allowing EDM to go into decentralized electrification and propose the legislative changes required to achieve that. EDM is the technically best qualified candidate in Mozambique for the job. Donors can give loans to EDM on a pluri-annual basis covering on-grid as well as isolated grid projects. Giving EDM the responsibility for on-grid as well as isolated grid projects offers advantages of integration: EDM's Electricity Master Plan, financed by AfDB, identifies investment priorities and appropriate low-cost technologies. Funding isolated grid electrification through EDM results in significant economies of scale and of scope compared with the present alternative of funding projects one by one through FUNAE. With the management transformation, which EDM at present is undergoing, there is also hope that EDM will turn into an efficient operator. The isolated grid activity could be undertaken by EDM as clearly ring-fenced activity through an "isolated grid subsidiary". The ring-fencing will clearly show the costs and the cross-subsidies of the activity."[36]

EDM has few if any activities related to the application of modern renewable energies, though it does operate some small hydropower plants.

1.3 Existing Human and Technical Capacity

This section discusses the key government institutions in the energy sector, their roles, and how they are building --- or might help build --- a clean energy future.

Electricidade de Mozambique (EDM)

EDM was created in 1977 as the state-owned national electricity utility. It became a public enterprise, expected to operate on commercial terms, in 1995. It is a virtual monopoly even though the 1997 Electricity Act opened the way for private sector involvement in generation, transmission and distribution. EDM has few if any activities related to the application of modern renewable energies, though it does operate some small hydropower plants.

Of all of the agencies in the electricity sector in Mozambique, EDM has the most capacity. It has 3323 employees (2007) --- of which 1972 are skilled. It maintains offices in all of the regions and has capacity to conduct a wide variety of work. Its customer-to-employee ratio of 154 is relatively high for SAPP utilities.

36 Wolfgang Mostert Associates, Energy Sector Support Programme, Technical Review, DANIDA, January 2006.

National Energy Fund FUNAE[37]

FUNAE was established by the government in 1998 as an administrative and financially independent institution to mobilise financial resources for investments in the supply of energy services, particularly modern energy (including renewable energy), to the rural areas. Apart from financing energy services, FUNAE's mandate includes the provision of technical assistance, the initiation of information campaigns and the implementation of projects to increase energy supplies to low-income urban and rural areas.

The revenues to FUNAE come primarily from taxes and levies imposed on licences and concessions for petroleum and electricity activities, licensing of electricity and petroleum installations, and penalties for infringement of energy legislation. Since FUNAE has no control over the relevant taxes and levies, it is dependent on uncertain budget allocations, and only to the extent the finances are forthcoming is it able to operate as intended in its mandate. FUNAE also receives donor funding through the World Bank GEF, NORAD, and other donors.

FUNAE is based in Maputo where it has 53 staff divided into five departments (renewable energy, conventional energy, planning, finance, and quality and environment). It has two offices outside Maputo, one in Tete and another in Nampula.

Ministry of Energy

The Ministry of Energy was created in 2005 when MIREME (the Ministry of Mines and Energy) was split into energy and mineral divisions. It has overall responsibility for energy sector developments, including policy formulation and follow-up of policy implementation, initiation and formulation of regulations and rules on safety and environmental aspects related to the energy sector and inspection of their fulfilment; energy planning, management and conservation. It is responsible for supervising and regulating activities in the electricity and liquid fuels sub-sectors, including the evaluation of tenders for concessions. It is also responsible for regulating and supervising activities in renewable energies. The Energy Department of each Provincial Government acts as the local arm of the Ministry, but has very limited capacity.

Line divisions of the Ministry of Energy include the following:

- Direcção Nacional de Energias Novas e Renováveis/National Directorate of New and Renewable Energy
- Direcção de Estudos e Planificação/Directorate of Studies and Planning
- Direcção Nacional de EnergiaEléctrica/National Directorate of Electricity
- Direcção Nacional de Combustíveis Líquidos/National Directorate of Liquid Fuels
- Departamento de Relações Internacionais/Department of International Relations
- Departamento de Recursos Humanos/Department of Human Resources

37 Source: FUNAE website <http://www.funae.co.mz>

- Departamento de Administração e Finanças/Department of Administration and Finance
- Departamento de Informática/Department of Information Technology

  It has a total staff of 87 people of whom 48 have university degrees.

National Electricity Council CENELEC

CENELEC, which was established under the 1997 Electricity Act, only became operational as of May 2008. It is intended to be a regulatory instrument in generation, transmission and sale of electricity. During the period from 2008 to 2010, and until its role is legally expanded, it does not have the authority to act as a full independent regulator. It currently serves as an independent council with advisory and dispute-mediating roles but no executive powers. Its main role at present is to monitor the performance contract between EDM and the Government. It currently has just three professional staff, though it is expanding its staff at present. It is also hiring a firm to set up a tariff-setting methodology for the power sector. It has not played any role in the Mphanda Nkuwa project.

The lack of capacity at CNELEC presents a potential problem in the development of energy pricing policy. First, as a small organization, it has limited power to regulate EDM (and improve its operational efficiency), which is literally a “state-within-a-state”. In an ideal electricity sector, the role of a regulating organisation like CNELEC would be to implement (and ensure compliance with) government policy and play a neutral role in setting prices for both consumer retail and renewable energy electricity. In the absence of a neutral regulator, EDM has little or no interest in developing incentives for renewable electricity despite real government interest in this as an issue.

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Training and Capacity Building

In virtually all countries where renewable energy sectors have developed successfully, policies and government support have come first, and private investment has followed. Investment activities support training and capacity building led by actual demand for products and services. In Mozambique, there have been isolated capacity building efforts, but the policy and investment support that would otherwise mainstream capacity-building work has not yet occurred on a large enough scale.

The development of capacity for renewable energy planning and implementation is still at an early stage. Although the University of Eduard Mondlane (as outlined below) has played an impressive role in studying renewable energy resources --- and training a small cadre of professionals and technicians, the overall task of building human capacity for a renewable energy infrastructure has yet to begin.

For example, thus far there are no renewable industry association or lobby groups, no formalized technical training programs, and no government or NGO-led public education programs about the importance of renewables. This is to be expected given the lack of a private sector that actively trades in renewables in the country. As mentioned elsewhere, development of a renewable energy industry must commence with companies that are actively trading in equipment and services --- these companies will in turn lobby for training programs (or develop them themselves) and absorb manpower as it is created.

The **University of Eduard Mondlane (UEM)** has a renewable energy programme under the Faculty of Science, the focal point being several academics. The UEM graduates several students every year as engineers with RE as a speciality. The UEM has since 1992 focused primarily on off-grid uses of renewables:

- Monitored PV water pump systems and carried out various measurements on PV components as part of the curricula.
- Monitored PV systems for health clinics and schools.
- Compiling a Solar Radiation Atlas for Mozambique in collaboration with INAM (the Mozambique meteorological agency) based on data records covering up to 30 years (a national wind atlas is planned).
- Conducted solar PV installation trainings for FUNAE
- A Masters' Level program has been introduced in renewable energies

1.4 Institutional & Legislative Framework

At the time this report was being prepared, the Government of Mozambique was preparing a new energy strategy document. A draft copy of the policy was obtained; it is summarized and analyzed with respect to renewable energy sources below. Other information in this section is from public presentations, reports made available by donor organizations and interviews from a few helpful government individuals.

The Electricity Masterplan[38] between 2004 and 2020 (which is now being updated) forecasts an investment of US$1 billion in electricity access expansion activities with expenditures at a rate of US$70 million per year. Thirty percent of this will be paid by EDM and 70% will be paid by donors. The target is to achieve 15-20% access by 2020.

The Government strategy has long been to finance electrification and transmission investments through taxation of international electricity sales and megaproject investments. This tax will cross-subsidize rural electrification. As well, the Government strategy is to improve EDM performance significantly.

The new energy strategy document presents an admirable broad-brush plan for an energy sector that is less environmentally destructive, more focused on overall national access for poverty alleviation, and on diversifying its energy resource base using sustainable resources and end-use efficiency. Development of renewable energy technologies, and utilisation of the private sector partners to implement projects are mentioned as key principles.

However, specific plans for energy resources, in practice, mostly look towards large projects such as Mphanda Nkuwa and export of power to SADC. The strategy is weak on specifics for the renewable energy sector and targets for achieving plans are not clearly laid out. There is little indication that renewables will be scaled up in the near future, or that they will

38 Information on Mozambique's policy is from: Mulder, Peter & Aurélio Bucuane. Financing the Electrification of Mozambique. See Bibliography.

receive anywhere near the type of support that large dams are currently receiving. No feed in tariffs are mentioned.

- **Small Scale Hydro.** A program to develop concessions for hydropower schemes below 15 MW is laid out. A working group is to be created to develop concessions according to international practice.
- **Wind Energy.** The strategy calls for a wind mapping exercise to be completed and establishment of pilot wind farms.
- **Biomass Energy.** The strategy focuses on efficient use of fuel wood and diversification of biofuels for transport. It does not address how biomass fuels (i.e. bagasse) can help the electricity sector.
- **Solar Energy.** Solar energy focuses on use of solar water heaters in buildings as part of demand-side management and in the off-grid tourism sector. Use of PV is confined to rural and remote area electrification (though specific mention is made of hybrid systems for remote tourism facilities). Grid connect PV and CSP are not mentioned at all.

Long-distance power lines not only waste large amounts of electricity, but have not served African rural communities well. Here, Cahora Bassa power lines take electricity from the dam to South Africa, but skip local villages, who would be better served by small regional grids and locally produced renewable power.

2. Clean-Energy Alternatives for Mozambique and the Region

This section discusses potential alternatives to large-scale hydro and the factors that affect each option. It builds on the status of each energy technology introduced in Section 1.

Power planners normally tailor electrification approaches to:

(1) grid-based electrification

(2) mini-grid-based approaches

(3) off-grid based approaches (i.e., stand alone systems).

The costs and benefits of each of these approaches and the technologies utilized vary considerably. For example, the cost per connection with grid-based approaches in Mozambique is around US$800. The cost per connection with stand-alone systems is over US$1500 per connection. It is important to distinguish between approaches when discussing technologies (for example, solar PV on-grid is at this time less viable than solar PV as a stand-alone solution).

Section 2.1 discusses centralized options that can feed into the grid and provide power within Mozambique and the South African Power Pool. This is the most relevant section on the types of power systems that have the most potential to add power for use in Mozambique in lieu of more mega-dams on the Zambezi River.

Section 2.2 analyzes mini-grid options for off-grid locations with a need for more modest amounts of power (i.e. isolated towns) and isolated off-grid options where distribution is not required and energy requirements meet the needs of the consumer directly. Note that although these approaches have much to offer the Rural Electrification Strategy of Mozambique (and remote locations within SADC), they will not offset SAPP power demand.

Section 2.3 discusses demand-side approaches that SAPP and South Africa might take to reduce demand for power now and control growth in demand in the future. These approaches have more potential than the off-grid approaches discussed in section 2.2 to reduce SAPP demand.

2.1 Centralized Options

The options presented below provide a guide for modern sources of power that can be used for "centralized" power production and fed into both the Mozambique and SAPP grids. All of these options have a "scalability" advantage over large dams: they can be brought on in increments that match growth patterns in energy use, and without incurring huge debt over long periods. Below the table, likely alternatives to large hydro and coal are discussed in broad detail.

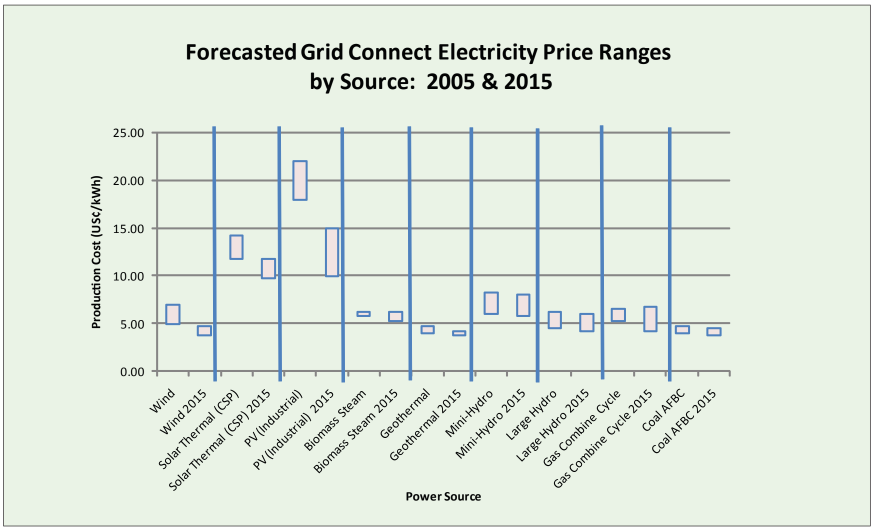

Figure 8: Forecasted Grid Connected Electricity Price Ranges, 2005 & 2015[39]

Use of biomass electricity has the potential to generate the most jobs because Mozambique's small and medium sized enterprises can be involved in all stages of the supply and production chain.

2.1.1 Biomass steam cogeneration

As mentioned in Section 1, Mozambique increasingly sees itself as a country with a large base of resources for both biofuels and biomass-fired generation. However, investments are yet to be made in power generation. Use of biomass electricity has the potential to generate the most jobs because Mozambique's small and medium sized enterprises can be involved in all stages of the supply and production chain[40].

Resources. Bagasse wastes from the sugar industries, copra wastes from the coconut industries and the other sources listed in section 1, could enable Mozambique to quickly build up a power industry based on clean, indigenous biomass fuels.

Costs. The table above shows that biomass steam turbines are close to being competitive with other power sources. Given the mature status of cogeneration, the clean nature of biomass, the connection with the established sugar industry, and the benefits that the additional income provides to farmers, it is clear that, as a first step, there is a need to build upon the bagasse resource in the sugar industry for power generation.

Trends. Biomass fuelled power generation --- especially in the sugar sector --- is a mature technology. Although costs are not expected to drop considerably, there is considerable growth potential in Mozambique and Africa. In 2008, Eskom received 5,000 MW in proposals for co-gen plants, and it is expected that the industry will grow by as much as 50% per year over the next 5-10 years[41].

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39 The tables on costs and forecasted costs of alternatives have been taken from: Technical and Economic Assessment of Off-grid, Mini-grid and Grid Electrification Technologies, ESMAP Technical Paper 121/07, December 2007.

40 See also Electricity Supply and Demand Management Options for Namibia: A Technical and Economic Evaluation. Final Report, March 2008. EMCON Namibia.

41 Cogen growth in SA: http://www.engineeringnews.co.za/article/sa-cogeneration-market-set-for-significant-growth-ndash-frost-amp-sullivan-2008-01-23

2.1.2 Pico-, Micro- and Mini-Hydro

Resources. Because much of the resource is located in parts of the country that are poorly served by the grid (i.e., Manica), these forms of small-scale hydro have great potential to build up energy resources where power is needed to help develop remote areas. As mentioned previously, there are more than 60 potential mini-hydro sites with over 1000 MW of potential.

Costs. Small-scale hydro is slightly more expensive than large scale hydro. However, it requires lower up-front investment than large scale hydro. It also carries much less risk in terms of outputs, as power output is not determined by a single river. Finally, if managed locally, mini-hydro provides a decentralized “development” focus for the country, enabling medium-sized developers or even communities to enter construction and ownership programs.

Trends. Costs are slowly reducing for mini-hydro, and experience in carrying out projects in other countries in Africa is growing[42].

A major constraint for the development of decentralized small-scale hydro in Mozambique (as well as other off-grid technologies) is the lack of capacity at regional levels to develop projects, and the lack of private investors to take up projects. Early efforts to stimulate “privately led” isolated grids have not been successful --- and some have suggested that EdM, because of its capacity and knowledge of the country, be invited to develop sites.

2.1.3 Wind farms

Even though wind does not provide dispatchable power (i.e. power that can be “turned on” to meet sudden demands[43]), wind farms are complementary to hydro power resources. First, when wind is blowing water can be stored in dams; and secondly, wind blows mostly during Mozambique’s dry seasons --- when river flows are reduced.

Resources. Mozambique’s Indian Ocean coastline presents a large area with high potential, which should be surveyed for wind resources. Thus far, although no areas show outstanding resources (6 m/s have been registered), there is much potential for study. Seasonality of wind resources must be closely analyzed.

Costs. Given the modest potential and the extra expenses of building capacity in Mozambique, it is likely that wind costs will be above 6¢/kWh. The UNEP study estimated that a 20 MW project in the south --- with a 9¢/kWh tariff —— would have a 4.3% internal rate of return.

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42 Rwanda, Tanzania and Kenya are developing aggressive experiences in concession-based installation of mini-hydro systems that build local capacity, industry and feed power into local networks.

43 Wind and solar are often criticized by power planners because, due to the transitory nature of solar and wind resources, they cannot be effectively called upon when they are needed. Generator power from gas and diesel, hydro power behind dams and geothermal power are all sources that are “dispatchable” because they can be more or less “turned on” when needed by power system controllers (although hydropower is intermittent when water is low, either due to drought or reduced flows from climate change).

Trends. Wind farms are being developed in Kenya (>400MW), Tanzania (>100MW), Ethiopia and South Africa (>200MW). Wind is showing relatively rapid and large reductions in cost, and will be considerably less expensive by 2015.

2.1.4 Concentrating solar

Because concentrating solar power projects (CSP) are able to store the sun's heat energy for some hours and dispatch power when needed (and storage is continually being improved), they are better suited for large-scale grid connect projects than PV. Large-scale concentrating solar projects have yet to be developed in southern Africa, despite high potential (in 2009 Morocco is completing a 20 MW CSP station integrated with a natural gas power station, and Eskom has plans to introduce feed-in tariffs for CSP). Given the relatively high resources in the region, concentrating solar has the special potential to provide a stabilizing counterbalance to hydropower during droughts. Moreover, CSP technologies are rapidly developing energy storage capacities that enable them to become firm power providers.

Resources. Mozambique has excellent solar resources and could be a major CSP player.

Costs. Although CSP is still relatively expensive, experience with the technology is being gained rapidly and prices are beginning to drop for projects in the US and Spain. Northern Africa is also expected to make considerable investments in CSP in the near future.

Trends. 5000 MW of CSP is set to come on-line in the US and Spain by 2013[44]. The recently introduced feed-in tariffs in South Africa (US¢20.59/kWh) have made CSP especially attractive in that country.

There are more than 60 potential mini-hydro sites with over 1000 MW of potential.

Given the relatively high resources in the region, concentrating solar has the special potential to provide a stabilizing counterbalance to hydropower during droughts.

2.1.5 Other Potential Grid Supply Options

The following options can contribute to centralised grid programs, but would not be expected to make major contributions in Mozambique in the near future. They may have more potential in South Africa or other more wealthy SAPP countries such as Botswana or Namibia.

- **Solar PV.** Although grid-connected solar PV is dismissed on cost grounds, rapid increases in world production, consumer interest in generating decentralized power and environmental factors have led to sharp decreases in costs and predictions of grid parity in many parts of the world in the next 5 years[45]. PV may make small contributions to Mozambique's power grid. Opportunities for Building Integrated PV will become increasingly interesting to developers and tourism investors.

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44 …"solar thermal can provide electricity for around $0.18/kWh (pre-subsidies) in the US Southwest". To put this into perspective, we estimate conventional silicon based solar (PV) currently costs $0.10-0.15/kWh more. Even more compelling is that solar thermal has yet to benefit from the cost savings that usually come with manufacturing scale. Assuming a 5% annual cost reduction and a renewal of the US investment tax credit, we believe solar thermal should reach peak generation parity within as little as 4 years" Merrill Lynch Solar Industry Overview, September 2008.

45 Estimated US PV kWh costs dropped 2.5% between October 08 and April 09 and stood at US¢ 20.4 in July 09. (www.solarbuzz.com)

However, even in countries where there have been significant investments in PV (Germany, Japan), it does not make a significant contribution to overall supply (i.e. greater than 5%). Thus, in Mozambique, where the Government does not have resources to subsidize PV, and where consumers do not have capital to invest in PV, it is unlikely that PV will emerge as a major grid-based power source.

- **Methane capture** from landfill gas. In Mozambique, potential for methane capture from landfills is relatively limited. There is considerable more potential for methane capture in the SAPP region, and South Africa is aggressively pursuing the technology (see Section 2.3.3). The reason for this is that there are only a handful of exploitable municipal waste sites (i.e. Maputo). Other towns do not yet have large enough populations to support the type of municipal wastes that produce landfill gas.
- **Geothermal** may be significant in Mozambique and southern Africa. In Africa, only Kenya has explored and exploited geothermal power options (>120 MW) --- but primary research indicates that there is considerable additional potential resource in the Rift Valley and other parts of Africa. Mozambique should, in its exploration of geothermal, consider both electrical generation aspects and smaller-scale heat generation uses of the technology.

It can take decades for countries to study, exploit and develop large-scale geothermal resources. Initial studies of Mozambique do not indicate that it has large reserves.

2.1.6 Energy Efficiency

Thus far, in its electricity strategies, Mozambique has done little to seriously promote energy efficiency. In modern energy sector planning, energy efficiency should not be ignored as a strategy in overall sector planning, especially when plans are in place to add energy supply so quickly. In fact, for growing economies like Mozambique's, putting energy efficiency programs in place early makes economic sense. Implementing serious energy efficiency strategies means that, in the future, there will be more electricity to share with those currently without access to electricity --- and it will free up money to invest in other pressing needs.

The McKinsey Institute estimates that by choosing more energy-efficient appliances, improving insulation in buildings, and selecting lower-energy-consuming lighting and production technologies, developing countries like Mozambique can cut their annual energy demand growth by more than half[46]. According to IEA analysis, it would take almost twice as much investment—$2 trillion over 12 years—to expand the supply capacity for the additional 22 percent of energy consumption that would occur without an improvement in energy productivity.

Because of lower labor costs, the price tag for investing in energy efficiency is on average 35% lower in developing economies than it is in advanced economies. Moreover, the relatively early stage of economic development works to the advantage of countries like Mozambique during implementation of energy efficiency measures.

46 "Fueling Sustainable Development: The Energy Productivity Solution," Oct. 2008

Mozambique could take the following steps to boost its electricity efficiency without sacrificing any of the benefits:

- **Develop strong building and appliance standards** and promote the aggressive deployment of energy-efficient technologies and strategies. To be effective, these standards should have a strong policy backing. Because so much of the current is from relatively few consumers, efforts to get these consumers to adopt better standards and efficient appliances (particularly CFL lamps, air conditioners, refrigerators) would pay off quickly --- as well as lead to future energy use patterns that are more sustainable.
- **Develop policies that de-link utility sales and revenue:** This is a necessary step to encourage utilities to pursue a path of energy efficiency over simply expanding supply.
- **Establish standards for utilities:** While de-linking utility sales and revenue will not cut electricity demand, it does mean that utilities can provide incentives for conservation programs without losing revenue. Enforceable targets for energy efficiency for utilities (also known as a "portfolio standard") will ensure steady progress. Other strategies to help utilities limit the need for new power plants include energy conservation, distributed renewables (such as solar PV on large industrial buildings and homes), and tactics to manage peak demand for electricity.
- **Adjust energy prices** to encourage ongoing efficiency. While this can be politically difficult, blanket subsidies discourage efficiency and mainly benefit the better-off. Low-income people can be protected from higher energy prices by subsidizing basic consumption (life-line tariffs) and stepping-up unit costs for the heavier users.
- **Focus on the energy-intensive industries,** such as cement, aluminium, petroleum refining, pulp and paper and chemicals. Not only do industrial efficiency efforts quickly reduce overall demand on power grids, they also save large companies money and can attract savings through carbon trading as well. In countries where electricity is more expensive and less available (i.e. East Africa) large industries are making huge improvements in energy efficiency, and hiring full-time staff to implement these changes because of the additional revenue it allows to be generated.

The McKinsey Institute estimates that by choosing more energy-efficient appliances, improving insulation in buildings, and selecting lower-energy-consuming lighting and production technologies, developing countries like Mozambique can cut their annual energy demand growth by more than half.

2.2 Mini-Grid Options and Off-Grid Stand-Alone Alternatives to Rural Electrification[47]

This section outlines approaches to the electrification of areas that are not connected to the grid. Off-grid electrification is done using mini-grids (i.e. in towns which are distant from the grid) OR using small stand-alone systems that are installed directly in the institutions, homes and businesses to meet

47 Information is from the ESMAP-funded report "ESMAP Technical and Economic Assessment of Off-grid, Mini-grid and Grid Electrification Technologies, ESMAP Technical Paper 121/07, December 2007".

end-uses. The costs and methods of these two approaches is summarized in Tables 10 and 11.

Most governments in Africa primarily conduct rural electrification campaigns using grid-based technologies. Mozambique is no different --- between 2006 and 2008, EdM made over 250,000 connections to their grid system. By contrast, only several thousand electricity connections were made using mini-grid and stand-alone PV solutions. This is understandable as grid-based technologies enable lower cost connections (when the users are close to the grid). As well, grid based technologies usually supply better-quality power (although long-distance systems are more prone to outages from weather disruptions, sabotage, and have higher losses than decentralized systems).

The problem with grid-based approaches --- in Mozambique and elsewhere --- is that they do not reach the far-flung rural communities where most of the population lives and they cause populations to move to electricity and amenities rather than bringing the latter to them. As can be seen from Figure 4, 55% of the new connections were made in the four southern regions of the country, and the northern parts of the country typically have electrification rates below 8%.

As shown in Tables 10 and 11, off-grid electrification efforts have much higher unit prices for electricity than on-grid approaches. Therefore, it is remote, off-grid poor communities --- which also tend to have lower access to health care, education and employment --- who must pay the highest prices for electricity.

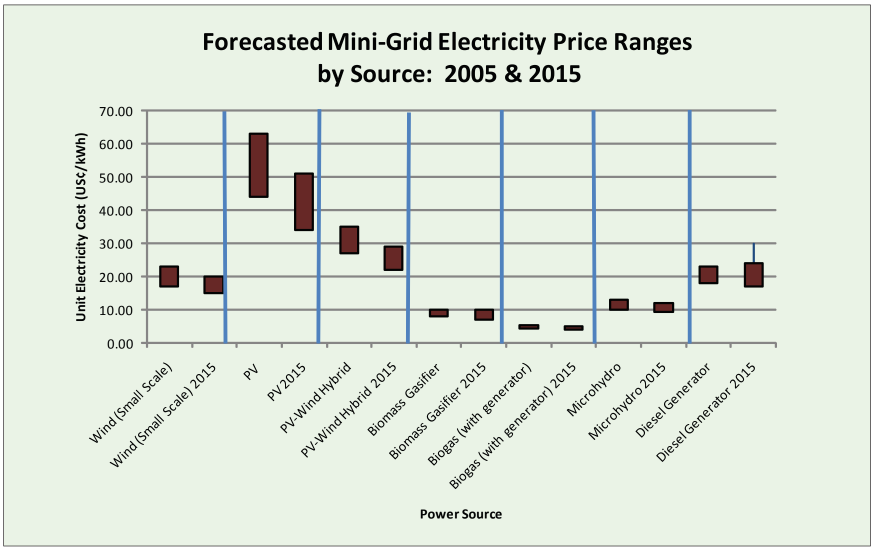


Figure 9: Forecasted Mini-grid Electricity Price Ranges, 2005 & 2015

At present, EdM-managed diesel generators power virtually all mini-grids in Mozambique. Experience with microhydro has only just begun. From the table above, the most cost-effective sources of power for mini-grids (today and in the future) are biogas units, biomass gasifiers and micro-hydro stations. Solar PV and wind for mini-grids are less cost effective, though both are more cost effective if the mini-grids are located where the costs of transporting fuels are high.

The table above shows that resources that are most plentiful in remote parts of Mozambique --- biomass and small-scale hydro --- are the lowest cost sources of power.

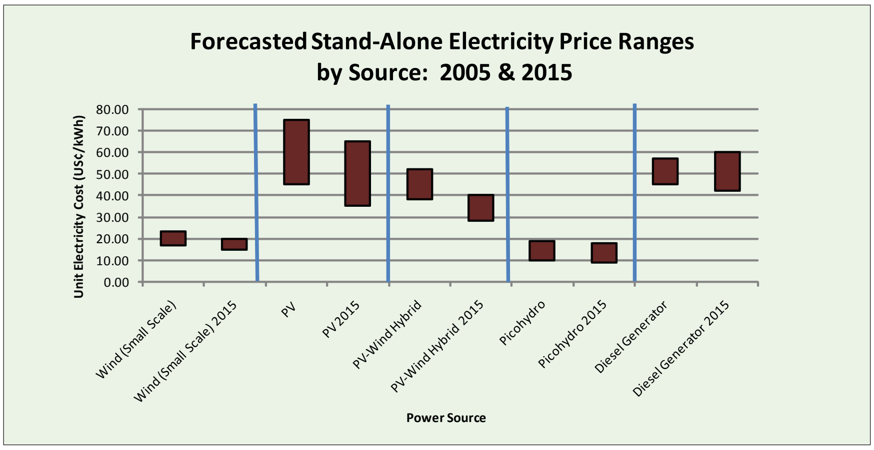


Figure 10: Forecasted Stand Alone Electricity Price Ranges, 2005 & 2015

The table above shows that, for low-power (i.e. <3kW) isolated schools, clinics, Government posts and households, pico-hydro, solar PV and wind can all provide lower cost power than generator sets. This fits largely with FUNAE's existing PV off-grid approach to rural electrification (in all but scale, as FUNAE investments are not on scale with the need, nor with EdM's investments).

2.3 Cross-border Trends: Initiatives to Reduce Power Demand

2.3.1 Gas-electricity from Tanzania

Artumas Group Inc. is an independent international oil and gas exploration and production company exploiting the natural gas fields off Mtwara in southern Tanzania. They have identified large gas reserves off Mtwara and are currently exploiting this gas for power generation to supply Mtwara, Lindi and Masasi.

Artumas carried out a desk study for a 132 kV line from Mtwara to Macimboa de Praia in the northeast region. EdM said it was keen to complete the project --- however, because of the low costs of electricity in Mozambique the project would need a grant and/or soft debt to make it work[48].

Cabo Delgado is at the end of a line that is hundreds of kilometres from the power source (i.e. Cahora Bassa). Because of the distance from the power source, there are large power losses and the power supply in Cabo Delgado is weak. Because of these weak end-of-the-line networks and

48 The competing electricity is based on Cahora Bassa's, which is extremely low priced. No official figures were available to Artumas, but estimations were made at 0.02$/kWh.

transmission losses, EdM views the input of power from the nearby Mtwara source favourably.

2.3.2 South African and SAPP Demand Side Actions

Mozambique's close integration with South Africa and the SAPP impacts immensely on the way energy projects in Mozambique are developed. SAPP's rapidly increasing power demand has strong implications for planned project portfolios.

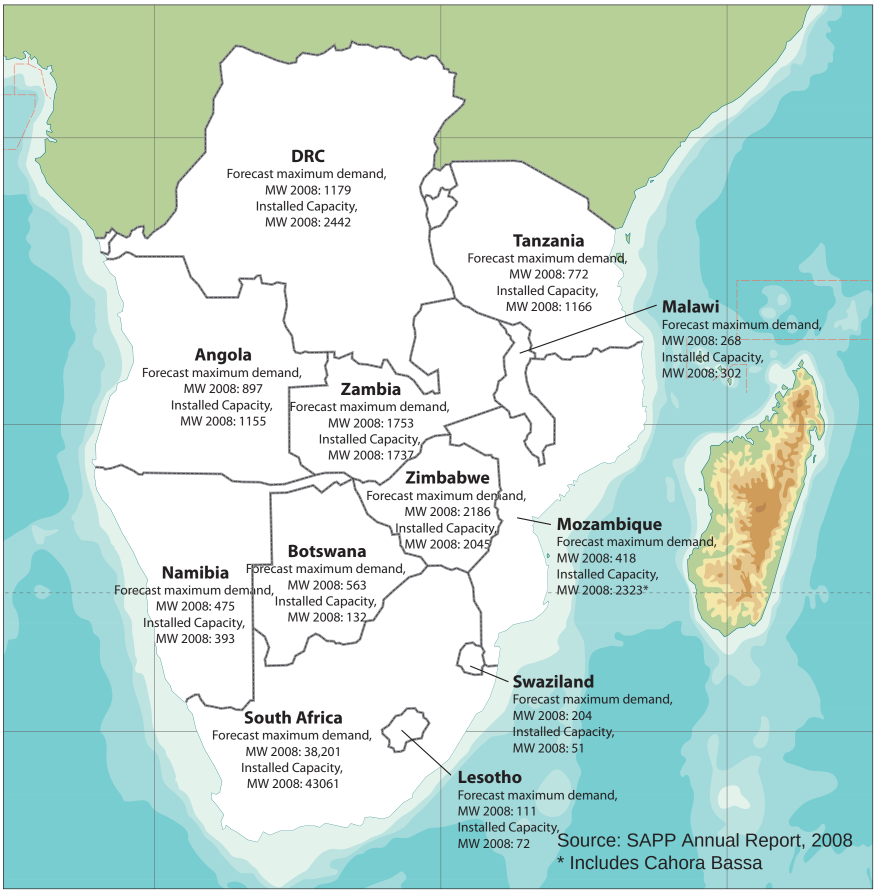


Figure 11: South Africa Power Electricity Pool Installed Capacity and Peak Demand (2008)

In the past, South Africa (and SAPP) focused exclusively on increasing supply of power rather than managing demand for electricity, decentralizing supply or switching to renewables. Mining and smelting industry demand for low-cost power has been a primary driver for South Africa's energy strategy. As well, South Africa's rapid electrification of its population --- and the low-cost electricity mentality --- has also led to a good deal of electricity waste. Before 2003, few incentives had been given to household and commercial users to save electricity – and this waste has contributed to a sizable portion of South Africa's demand. In fact, relatively modest energy efficiency measures in South Africa could quickly reduce South Africa's consumption by the equivalent of 3 to 5 times Mozambique's entire consumption!

As is the case with developed countries, South Africa is slowly learning that unlimited growth in demand for power is not the answer. First, South Africa is one of the highest CO2 emitters in the world (per GDP) and has a power grid primarily fuelled by coal and imports. Secondly, South Africa's insatiable demand for electricity is affecting its neighbors. Namibia was forced to re-open an obsolete coal generation station during South Africa's 2007 power crisis. Meanwhile, Zambia and Mozambique, which have relatively low per capita access to power, are more focused on supplying power to South Africa than their own populations.

For this reason demand side management primarily in South Africa must be considered as an alternative to endless investment in megadams and coal fired power plants.

Although Mozambique's electricity use is small, it is growing rapidly. Each year, 100,000 new customers are hooking up lights, refrigerators, air conditioners, etc. to the underpowered grid. Currently, Mozambique appears to have no plan in place to encourage more efficient use of this limited resource.

Relatively modest energy efficiency measures in South Africa could quickly reduce South Africa's consumption by the equivalent of 3 to 5 times Mozambique's entire consumption!

Box 2: Energy Efficiency: The first step in increasing energy supply

"In the search for more secure and cleaner energy solutions, improving the efficiency of energy use tops almost everyone's list. Few will argue about the merits of achieving the same objective while using less energy, as long as it is cost effective. And opportunities for cost-effective energy efficiency improvements abound, especially in developing countries."

"Development and operation of energy efficiency investment delivery mechanisms is an institutional development issue, and energy efficiency financing programs and projects must recognize this clearly. Lack of domestic sources of capital is rarely the true barrier; inadequate organizational and institutional systems for developing projects and accessing funds are actually the main problem. Therefore, mechanisms to capture the opportunities for energy efficiency investment need to be created or strengthened. This entails sustained efforts over years—new institutional constructs cannot be expected to develop and grow overnight… Delivery systems developed in one institutional environment in one country often do not work effectively in a different institutional context. For success, local institutional environments must be well-understood, and general solutions usually need to be at least partly customized for those environments." both from Taylor et al, "Financing Energy Efficiency", (World Bank, 2008)

Within SAPP, Namibia and South Africa are beginning to take steps to improve efficiency and manage demand. South Africa has by far the most potential for reducing its use of electricity, but has been slow to tap this resource. When Eskom unveiled its DSM program in April 2002, it announced that it could achieve a savings of 7300MW by 2015 through a combination of efficiency, load shifting, and load interruption programs. This reduction is equivalent to the output of five Mphanda Nkuwa-size power plants.

Demand side management is one of several tools power companies have to reduce power demand --- other tools include pricing[49], regulation, power buy back, fuel switching (i.e. from electric cooking to gas) and load shedding.

49 Eskom is seeking to double power prices in the next two years, and this will undoubtedly have an affect on power consumption.

South Africa has ample potential for energy efficiency in the commercial, industrial, and residential sectors. Eskom believes it can shave about 3000 megawatts of demand by 2011. In 2002, RSA launched a national energy conservation program that had the target of reducing final energy demand (electricity as well as transport and cooking fuels) by 12% in 2014[50]. An electricity Demand Side Management Policy was developed by NERSA in 2003.

Eskom had already initiated the above DSM program, but has aggressively expanded it following the current power crisis. As shown in Table 12, the program has industrial, commercial and residential components:

Table 7: Eskom's DSM Program

Sector	Strategy	2014 Targets MW Reduction
Industrial	Individual projects Efficient lighting Motor systems Heating, ventilation and air conditioning	1000 -1250 MW
Commercial	Individual projects Efficient lighting Motor systems Heating, ventilation and air conditioning	100 -150MW
Residential	Mass approach Efficient lighting Solar water heating Smart meters	1500 – 2050 MW

The use of efficient lighting has been a major part of the program so far. According to Eskom:

> "Since the programme began in 2004 more than 18 million CFLs have been exchanged for incandescent globes. The national programme was recently implemented in the Western Cape, Northern Province, Gauteng and Free State where four million CFLs were exchanged for incandescent globes. The programme has reached more than 315,000 households and continues to reduce the energy demand from the household sector."

Eskom is also installing **smart meters** that operate geysers through ripple switching. Although they do not reduce overall energy use, they do shift peak demand to periods when more power is available.

In the residential sector, a shift to **solar water heaters** is being promoted through buy-back schemes (though figures on up take are not yet available). In 2005, existing SWH displaced the equivalent of 652 MW (or 1377 GWh). There is potential to remove a total of 4500 MW from peak winter load and 1000 MW of summer load[51].

50 Draft Energy Efficiency Strategy of the Republic of South Africa, April 2004
51 Holm, D., Banks, D., Schäffler, J., Worthington, R., and Afrane-Okese, Y., Renewable Energy Briefing Paper.

In 2007/8 Eskom surpassed its target of 400 MW in DSM savings, reducing demand by 650 MW. Still, many observers view this target to be relatively un-ambitious[52]. "Even at its best, Eskom's commitment to DSM programs is less than 1% of its annual new-build budget," says Mark Borchers, head of the South African NGO Sustainable Energy Africa[53].

2.3.3 Decentralized Power Options and Feed-in tariffs

The artificially low-cost electricity from coal and large-scale hydro in Southern Africa works against the development of renewable energy sectors.

If governments exclusively use cost parameters when selecting power sources (as done historically), they tend to only select technologies that are low-cost (at least if "externalities" such as environmental and social damage are not factored in) and well-developed in the country. This tendency works against new technologies, and in the past has continually caused power companies to reject renewable energy sources in favour of traditional sources.

Recognizing the value of renewable energy contributions to offset global warming (and avoid other social and environmental costs as well), a number of developed countries have instituted special "feed-in" tariffs (FiT) for producers of wind, biomass and solar power. Feed-in tariffs essentially create strong incentives for developers of wind and solar projects by ensuring minimum payments for electricity generated from "desirable" sources. Developers and consumers that are awarded feed-in tariffs are insured that they will be able to profitably benefit from their investments. Feed-in tariffs are set to benefit particular technologies, based on the desirability and the need to attract investment in that technology. For example, if a country feels it has a particular advantage in developing biogas electricity, it will set attractive rates for that technology.

Over the past eight years, based on forward-looking feed-in tariffs, Germany, Spain and certain states in the US[54] have installed tens of gigawatts for wind, solar and biogas capacity. At the same time, these countries have become the world leaders in these technologies. Korea, China and India, among others, are leaders in the developing world that have also instituted feed-in tariffs.

The South African government is formalizing feed-in tariffs for wind, landfill gas, small hydro and concentrating solar (by comparison, Kenya offers a FiT for wind, small hydro and cogeneration). The law sets FiT rates for each technology between 2008 and 2013. Initially, the FiT rates offered for were quite low[55]. This caused an outcry from renewable developers

52 Namibia, a country with a comparatively miniscule power sector (and acute power shortages), was able to achieve much more impressive DSM savings through a far more aggressive program.
53 World Rivers Review, March 2009
54 California has a "public goods charge" on energy to help pay for energy efficiency and renewables.
55 See National Energy Regulator of South Africa. South Africa Renewable Energy Feed-in Tariff (REFIT). Draft Guidelines 15th May 2008.

and proponents alike --- and there was a total lack of applications for new projects from developers.

In March 2009, these rates were reviewed upwards as follows[56]:

Table 8: South African Feed-in Tariffs (March 2009)

Technology	Rate (Rand/kWh)	Rate US Dollar ¢/kWh
Wind	1.25	12.2
Small scale hydro (<20MW)	0.94	9.2
Landfill gas	90	8.8
Concentrating solar power	210	20.59

The new rates have proven to be extremely attractive and have changed the attitudes of developers. It is expected that a relatively large scale roll-out of renewables will occur based on the new FiTs.

56 NERSA, MEDIA STATEMENT, NERSA DECISION ON RENEWABLE ENERGY FEED-IN TARIFF (REFIT), March 2009.

3. Issues and Analysis

This section reviews the issues raised in this document and provides a basic analysis of the trends in Mozambique and Southern Africa's power sector planning. It explains why Mozambique and its neighbours tend to focus on large hydro and coal at a time when much of the rest of the world is turning to renewables. It considers the rationale for investing in export-led power projects when rural electrification still has an extremely low penetration. It also explores the slow progress in developing the decentralised renewable energy resources within the country.

3.1 An Untapped Potential for Renewables

Mozambique has a huge clean-energy potential, with small biomass, solar, wind and small-scale hydro resources that are particularly well-suited to meet its decentralised electricity requirements.

Ample decentralized and renewable power supply options can strengthen the grid in various regions and create jobs and industry in these regions. These include small hydro (>1000 MW in 60 sites mostly in the central and eastern regions), wind (confirmed resources along the coastline), cogeneration from biomass resources distributed throughout the country and a huge widely distributed solar resource. Natural gas is also available in the central region, and recent discoveries have been made in along the northern coastline[57].

Thus far, Mozambique limits use of renewable energy resources to a small number of off-grid power generation sites. It is in the early stages of developing grid-connected strategies.

Renewable energy technologies are well-suited for both on- and off-grid projects that support rural energy access.

Unlike Cahora Bassa and Mphanda Nkuwa, which focus narrowly on the Zambezi corridor, Mozambique's renewable energy resources are widely distributed throughout the country and can be rapidly deployed both off-grid and on-grid. Mini-hydro schemes can supply firm power to remote parts of the country in both mini-grids and to support weak end-of-line transmission within the grid network. Wind can feed into grid lines in the south and east of the country. Solar PV is suited for both off-grid and on-grid applications. Biomass resources could be tapped immediately from the sugar industry to feed into the central part of the grid.

57 Natural gas is not a renewable energy resource, but it is the most "clean" fossil fuel available. Gas turbines enable power sectors to respond rapidly to sudden surges in demand.

3.2 An Export-Driven Power Sector with a Risky Reliance on Low Cost Electricity and Large Dams

Large scale power projects are planned primarily to sell power into SAPP and to provide cheap power to industrial consumers.

Mphanda Nkuwa is primarily focused on selling power to the South African Power Pool and industry. SAPP desperately needs power and supports Mphanda Nkuwa as a leading project for this reason.

Where Mphanda Nkuwa electricity is used in Mozambique, it will be sold for industrial purposes such as smelting and running refineries. However, the historical tendency to use cheap power for refining metals and mining does not make sense in economies that are electricity-starved. Smelting aluminium is extremely energy intensive. About 80 percent of world aluminium smelting capacity is in nations at risk of electricity shortages[58].

Mphanda Nkuwa itself will not directly benefit local inhabitants of Mozambique or widen access for electricity.

On paper Mozambique has a relatively large consumption rate of electricity per capita. Removing MOZAL power consumption from the electricity equation puts Mozambique among the lowest per capita use of electricity in Africa and the world.

Because rural electrification and domestic electrification have much lower returns than selling power to SAPP, Mozambique risks being trapped in a cycle of utilizing scarce development resources in production of cheap electricity for export (from mega-dams and coal) without being able to attract investment in remote areas of the country that currently have little access to electricity.

In principle, Mozambique is using revenue from power sales to MOZAL and SAPP to fund rural energy initiatives of EDM and FUNAE. Whether energy access in remote parts of the country is receiving enough focus is debatable (Tete province, where Cahora Bassa is located, has an electricity access rate of only 6%!). Undoubtedly, there is room for clearer targets (for EDM and FUNAE) and for more transparency in the overall monitoring of expenditures and results achieved with public funds.

The low price of electricity is a major barrier to the implementation of decentralized and renewable power projects for the grid.

With the extremely low price of electricity in Mozambique, there is little incentive to invest in the development of grid-based solar, cogeneration, wind or other sources of power. This means that, even with its huge renewable resources, Mozambique will not be able to attract investors from the on-going worldwide boom in renewable energy technologies unless it offers feed-in tariffs.

Mozambique will find itself trailing behind other countries (such as Namibia and Rwanda) that are already actively investing and developing ca-

58 http://www.bloomberg.com/apps/news?pid=20601103&sid=aCUU6NbjPfmM&refer=us. “Metals Surge as Rationing Cuts Power at Biggest Mines”, By Saijel Kishan and Gavin Evans

pacity in solar and mini-hydro technologies. When renewable costs do become competitive, Mozambique will have little capacity, policy frameworks or experience in executing projects.

Increased reliance on dams on the Zambezi basin will greatly increase the risk of reduced power availability during drought periods, which will increase with climate change.

By planning such a large investment in Mphanda Nkuwa, Mozambique is literally placing all of its "energy eggs" in one basket --- that of hydropower in the Zambezi basin. When the water flows in the basin are reduced by drought (and climate change is certainly increasing these risks), Mozambique will have insufficient power to feed into SAPP --- or to support its own populations. There are certainly ample clean alternatives in Mozambique to enable it to balance its electricity supply without using a risky single source approach[59].

The argument that developing countries could escape poverty if they just use more of their hydro potential is an over-simplification at best. While there is a clear trend for countries to get richer as they increase their use of modern energy, the trend goes the other way for hydroelectricity dependency. Hydropower provides more than 50% of total electricity production in 58 countries, and more than 90% in 24 countries. The majority of these extremely hydro-dependent countries are among those with the lowest human development indicators as measured by the UN Development Programme. Of the world's 40 richest countries measured by per capita GNP, only one is more than 90% hydro-dependent; of the world's 40 poorest countries, 15 are more than 90% hydro-dependent.[60]

By planning such a large investment in Mphanda Nkuwa, Mozambique is literally placing all of its "energy eggs" in one basket --- that of hydropower in the Zambezi basin. When the water flows in the basin are reduced by drought (and climate change is certainly increasing these risks), Mozambique will have insufficient power to feed into SAPP --- or to support its own populations.

Box 3: Another View On Mphanda Nkuwa

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 in Mozambique agree that the project will not address the energy or other basic needs of the 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 region's projected energy scenarios in the near future and as part of a process of regional economic cooperation.

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.

FROM: Intermediate Technology Consultants, The Mphanda Nkuwa Dam project: Is it the best option for Mozambique's energy needs? Final Report for WWF. June 2004

59 In July 2009, Kenya has to shut down turbines in its major hydroelectric facilities, chiefly located on one river, because of drought-induced low flows.

60 "Spreading the Water Wealth: Making Water Infrastructure Work for the Poor," Patrick McCully, International Rivers, 2006

3.3 Lack of Leadership, Capacity, Policy and Incentives for Viable Renewable Projects

Renewable energies are constrained less by cost and technical feasibility than by a lack of leadership and political will to utilise existing resources[61].

As is the case in many African countries, the development of large-scale renewable energy projects in Mozambique is still in its infancy. Because of climate change and the need for diversified power sources, Germany, Spain, Japan, China, India and the US power industries[62] are rapidly recognizing the need to make systematic shifts away from large hydro and coal-fired power. They have developed strong policy drivers, such as feed-in tariffs, renewable targets, and special purpose incentives to rapidly build up their renewable energy industries.

For example, utilizing revenue from power bills of consumers, Germany developed a renewable energy feed-in tariff and support program that aims at achieving a specific target in terms of percentage of the grid supplied by renewable wind energy. Likewise, and nearer to home, utilising GEF and World Bank support, Tanzania and Uganda have provided consumer subsidies on off-grid PV systems that seek to help those countries meet renewable energy targets.

Mozambique's power sector is only beginning to consider such moves, and on a relatively small scale. Senior players in the government and energy sector have not demonstrated knowledge or interest of the rapid policy changes being made in other countries, or of the need for leadership and strong incentives in the development of renewable energy markets.

Lack of finance and incentives for rural electrification, decentralized and renewable projects constrains their development and lowers investment appetite.

Even with Government leadership lacking, financing is a major issue in the selection of energy projects. Rural electrification is funded by the Government and by grants and soft loans from donors. It is therefore not possible to suggest that funds for a potential Mphanda Nkuwa --- raised by investors seeking a return on capital – would be readily available for rural electrification projects or for renewable projects. In short, a large dam is an investment activity while rural electrification – however desirable it is from

61 The same is true in South Africa: "The main constraints are neither resource availability nor techno-economics but a limiting mindset focussed on the supply-side, partial energy costing, low (indirectly subsidised) energy prices and short-term thinking favouring low initial costs. Dominance of the state-controlled power monopoly and the influence of vested interests (particularly of the minerals sector) on key stakeholders are exacerbated by a lack of awareness and informed leadership as well as a real shortage of person power. It is concluded that the most important constraint is not money, men, machines, materials or management, but the motivation, the inspired political will." Holm, D., et al, Renewable Energy Briefing Paper: Potential of Renewable Energy to contribute to National Electricity Emergency Response and Sustainable Development March 2008

62 And, soon --- with its new feed in tariffs --- even South Africa.

a development perspective --- requires capital and does not, in the short term, generate revenue.

Still, in order to be able to invest significantly in rural electrification and renewables, Mozambique must mobilize private and public sector funds.

Commonly seen as a potential financial booster for renewable energy projects in developing countries, the Clean Development Mechanism (CDM) will not be a major source of support for Mozambique's energy sector. The country has only one CDM project to date (a substitution project in the cement sector[63]). Mozambique's electricity sector relies on over 95% hydro resources and as such has extremely low carbon emissions. With such a low carbon emissions baseline in the electricity sector, there is little chance that CDM or other carbon-trading finance sources could be used to finance biomass, solar or wind projects.

Thus, the lack of financial drivers for biomass, solar and wind means that they are mostly considered for small-scale off-grid purposes and widely seen as "too expensive" for on-grid applications.

The Government-led approach to renewable projects has prevented the growth of the private sector in PV, wind, cogen and small-scale hydro.

Given the relatively large private sector investment flows into other sectors (i.e. tourism, agriculture) --- and the encouragement of these flows --- it is surprising that there is little encouragement of the private sector to enter power generation in areas where EDM cannot reach. World-wide, virtually all successful on- and off-grid PV sector developments have been private sector based, not based on government procurements.

Thus far, Mozambique's isolated renewable energy generation for mini-grids and remote stand alone power is dominated by government procurement (i.e. contracts through FUNAE). Although the World Bank's ERAP project attempted to stimulate private sector initiatives, this was abandoned by the Government and to date the sector remains government controlled.

Private and community-led development --- with incentives --- of solar, wind, small-scale hydro and biomass resources is much more efficient than government-led initiatives. For example in Germany and California, incentives offered for renewable energy production caused rapid development of capacity as consumers took up the incentives and as companies rushed to take advantage of new markets. GEF-supported incentives have resulted in installation of hundreds of thousands of solar home systems in Bangladesh, China, Sri Lanka and Uganda. Private sector led installation of microhydro systems in Rwanda is also increasingly successful. In these situations, the government does not procure --- instead, it provides resources and actively facilitates the installation of systems to private consumers. Companies are able to use these incentives to sustainably build their markets.

63 Cimentos do Mozambique – Matola Gas Company Fuel Switch Project Mozambique Maputo Fossil fuel switch @ 45.59 kT CO2e/year.

The huge size of Mozambique and the extreme poverty of rural areas --- the result of decades of war and lack of investment --- pose a huge obstacle to the development of private sector renewable capacity. Renewable energy companies would be attracted by an expansion of the current policy (which mainly favors a procurement approach of renewable energy systems to alleviate poverty) to an approach that encourages productive parts of the economy (i.e. tourism, agriculture, telecommunication, small-scale business) to invest in renewables.

3.4 Rapid Grid-Connected Rollout, But Much Slower Outreach to Off-grid and Remote Areas

Mozambique has made impressive strides in electrification over the past three years, but the connection rate is geographically skewed and barely keeping pace with population growth.

Adding 260,000 electrical connections in three years is as impressive as any sub-Saharan country outside South Africa. However, this rate of adding connections --- about 5.5% over three years or 1.8%/year --- is only slightly above the population growth rate of 1.79%. Moreover, the connections are heavily skewed toward the south of the country. So, while the Maputo Province has over 40% access, the central and northern parts of the country remain well below 10% access.

At $800 per connection --- a relatively costly figure --- 100% coverage of the existing population would cost $3.3 billion. It will be extremely difficult for Mozambique to raise this amount of funding, as donors are only currently supporting rural electrification at about $60-80M/year.

South Africa went from 35% to almost 70% electricity access in 10 years under former President Nelson Mandela because of huge investments in low-cost electrification (<$300/connection). There is an urgent need for Mozambique to lower its grid connection costs --- and identify the resources required to keep its electrification pace above population growth[64].

Off-grid and decentralized strategies for rural electrification are moving much more slowly than EdM grid electrification.

Although the recent EdM electrification experience is encouraging, efforts outside of EdM have yet to bear significant fruits. Attempts to develop independent private-sector mini-grids have not been successful. If a real

64 South Africa's electrification connection costs are rising rapidly because the remaining un-electrified portion of population is widely distributed and increasingly expensive to reach. For the remote parts of Mozambique, it will be impossible to connect the population as cheaply as South Africa has done. Connection costs in rural parts of Northern and Central Mozambique are likely to be above $1500 per connection.

difference is to be made in remote parts of the country, new and innovative methods must be developed that rely increasingly on the private sector.

FUNAE's success is limited and expensive. First, FUNAE is a tiny organization tasked with a huge electrification mandate. Second, it relies on Maputo and Government-driven funding and leadership. Third, mini-hydro and PV installations are virtually all managed and procured by FUNAE, and little private sector or community capacity has been developed to complete this work on a regional basis.

3.5 Southern Africa Power Pool: A Region Dominated by The High Cost of "Low Cost" Electricity

SAPP power demands are insatiable. Feeding low-cost power into the Southern African Power Pool is currently a key component for export earnings of Mozambique, but does not help build Mozambique's internal power supply and security.

Demand for power within SAPP --- and particularly South Africa --- dwarfs power demand from Mozambique. As long as Mozambique's power planners focus on the huge consumer next door, they will never adequately meet the needs of their own country, which remains largely off-grid and unconnected. Moreover, by proxy, they will be supporting relatively wasteful electrification initiatives of South African industry as well as the South African rural electrification programs, which are both heavily subsidized.

SAPP focuses far too much on large power projects and not enough on demand-side management or investment in renewables or decentralized power sources.

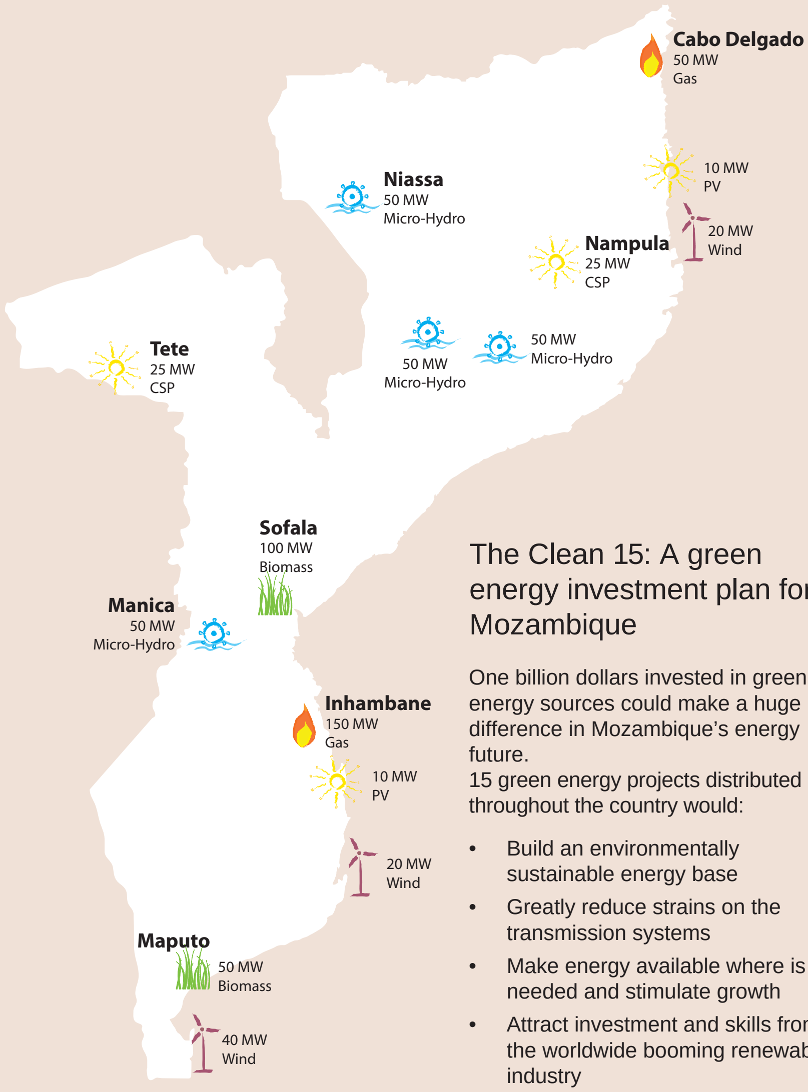
It has taken SAPP a long time to move away from a strategy almost completely focused on large power projects. SAPP documents and reports mention little about demand side management or alternative supply methods. This is largely because the "elephant" next door, South Africa, has been wedded to large centralized supply.

However, Eskom and the South African government have been forced to re-examine their strategies in recent years due to two key factors: the need to reduce the country's massive carbon emissions (in the context of international climate change negotiation) and major supply shortages since 2007. As one of the world leaders in carbon emissions per GDP, and as the major economic player in sub-Saharan Africa, there is considerable pressure on South Africa to play a role as a leader in green energy development for the continent.

4. Action Priorities

The suggested actions presented below would allow Mozambique to aggressively implement a clean energy plan. Such actions will encourage sustainable energy alternatives that develop locally available energy solutions that can be used to meet the needs of the vast majority of the presently unserved population. As well, the actions will promote local opportunities for investment while limiting harm to water resources and reducing vulnerability to climate change impacts.

1. **Develop a renewable energy policy that sets aggressive targets for priority renewable energy technologies.** The policy should contain specific and separate guidelines for the development of renewable energies on-grid and off-grid. There should be some type of equity between rural and urban projects to ensure that a fair allocation is made to areas that have, to date, received little focus from planners.
2. **Remove all duties and tariffs on renewable energy technologies.** This will ensure costs are further reduced for consumers and help ensure that renewable energy technologies can compete on a level playing ground with traditional technologies. This should be done before any incentive or subsidy program is introduced.
3. **Actively encourage private-sector investment in renewable projects in Mozambique.** Create clear incentives for investors, manufacturers and developers to utilise and promote renewable energies when making investments in the country. Renewable energy support should not be targeted exclusively to off-grid initiatives and poverty alleviation; renewables should be encouraged in economically-active sectors including tourism, telecommunications and commercial, as well as among middle- and high-income households.
4. **Create Feed in Tariffs and standard agreements for grid-connected mini-hydro, solar (CSP and PV), wind and biomass cogeneration projects.** Such tariffs can be based upon similar programs in South Africa or other neighboring countries. Actively seek revenue through energy export taxes and donors to support Feed-in-Tariffs and off-grid renewable energy projects.
5. **Expand subsidy funds for off-grid renewable energy projects that support PV, wind, microhydro and biomass projects in isolated and mini-grids.** Open this fund up to community groups, the private sector investors and/or EdM. Task FUNAE to be a facilitator --- rather than implementer --- of renewable projects.



The Clean 15: A green energy investment plan for Mozambique

One billion dollars invested in green energy sources could make a huge difference in Mozambique's energy future.
15 green energy projects distributed throughout the country would:

- Build an environmentally sustainable energy base
- Greatly reduce strains on the transmission systems
- Make energy available where is it needed and stimulate growth
- Attract investment and skills from the worldwide booming renewable industry

Tech-nology	Location	Capacity Target (MW)	Typical Invest-ment Cost ($M/MW)	Nominal Investment (US$M)	Capacity Factor	Electricity Cost (US$/MWh)
Micro-hydro	Manica, Niassa, Zambezia	200	1.4	280	45%	60
Wind	Cabo Delgado, Maputo, Nampula	80	1.7	136	30%	60
Cogen	Sofala, Gaza	150	1.2	180	80%	45
PV	Maputo, Inhambane	20	7	140	20%	180
CSP	Nampula, Gaza, Tete	50	5	250	30%	100
Gas	Cabo Delgado, Inhambane	200	0.8	160	90%	55
Totals		**700MW**		**US$M1146**		

Figure 12:
The Clean 15: A green energy investment plan for Mozambique

6. **While stimulating the growth of a local renewable energy sector, increase programs for training qualified personnel in engineering, installation and maintenance of renewable systems.** Such training would require a balanced mix of university level engineering training, community level instruction to decentralize maintenance and service, as well as support for private sector training initiatives. These efforts would necessarily require government certification to fit within existing policy.
7. **Actively encourage energy efficiency in Mozambique through policies and programs.** First steps would be appliance and building standards, and working with the largest industries to reduce energy use. A program to retrofit public buildings would also send a strong message.
8. **Seek to harmonize SAPP efforts to introduce decentralized energy technologies, energy efficiency standards, DSM and FiT pricing for renewables.** Seek support for region-wide funds to develop renewable energy projects that benefit the SAPP. SAPP needs to adopt policies that prepare for climate change --- in whatever form it takes --- by quickly shifting its focus from mega-coal and dam projects to smaller, environmentally-friendly solutions.

Box 4: Large Scale Electricity Projects, International Finance and Transparency in Southern Africa

Southern Africa (as well as sub-Saharan Africa) has yet to make large scale investments in grid-tied renewables, a practice increasingly mainstreamed in developed countries and Asia. The reasons include the following:

- Governments strive to maintain low electricity prices, and this prevents them from investing in alternatives that they perceive as "more expensive"[65].
- Since colonial days, Governments have been institutionally set up for executing centralized large scale projects and have been reluctant to develop decentralized approaches to power supply.
- The subsidies that have driven the phenomenal growth of wind and solar PV elsewhere are not being made available to project developers in Africa (in fact, coal and large scale hydro are subsidized in Africa).
- There is a lack of skilled knowledge, advocacy and experience about renewables in African energy sectors as well as the management of these resources in grid-connected networks.
- Finally, because of the lack of transparency and the centralized planning so common in key government departments in Africa, renewable energy investors have been reluctant to move into African electricity sectors even where investments would make sense.

The southern Africa energy sector mantra has long been that electricity must be cheap and that its production must be large-scale. Thus, in the South African Power Pool, over 95% of electricity comes from large coal plants or mega-dams in South Africa, Zambia, Zimbabwe, DRC and Mozambique. Indeed, electricity in southern Africa is among the lowest cost in the world. It has long been the strategy of SAPP governments to maintain these low electricity prices to attract investment in energy-intensive industry (i.e. mining, smelting) and to allow low-income families to gain access. This "least cost" mentality has crippled efforts to encourage investment in renewables that traditionally cost significantly more than coal or large hydro. This

Continued on next page

65 The perception that large hydro and coal are lower cost than other sources of electricity does not always hold true. Hydropower projects often take much longer to construct than planned and end up considerably over budget. Increasingly, developers must include the environmental costs of coal in their projections, which considerably increases costs.

mentality has also diminished interest and investment in energy efficiency measures, which are generally cheaper than new supply and quickly repay their costs.

South Africa's ESKOM is one of the largest and most "successful" power companies in the world, and the region looks up to it in terms of execution and philosophy of new capacity development. A decade ago, when European countries began exploring decentralized power options and questioning continued reliance on large-scale coal, hydro and nuclear, ESKOM stuck to its guns. ESKOM has only recently begun to explore how wind or solar might be added to the South African grid, and how best to integrate efficiency measures. Thus, despite southern Africa's ample wealth of potential decentralized power sources, SAPP countries have been extremely slow to develop decentralized approaches.

None of the SAPP countries can afford to subsidize renewables the way Germany, California, China, Spain and Japan have. World Bank, UN and Global Environment Fund investments targeted for renewables in sub-Saharan Africa --- perhaps $150M since 1995 --- have largely supported small-scale off-grid projects on an ad hoc basis. (The success of GEF projects in developing off-grid renewable markets has been particularly limited.) Neither has Kyoto's Clean Development Mechanism brought sufficient cash support to make a real impact on renewables in Africa. Of about 3000 pipeline CDM projects, less than 60 are in sub-Saharan Africa and only a handful of these are renewable supply projects![66] Moreover, when traditional investors bring cash to invest in power projects in southern Africa, they are mostly interested in large-scale traditional opportunities. (On the other hand, efficiency measures don't need costly subsidies. Their up-front costs tend to be fairly low, and they often repay these costs fairly quickly.)

In SAPP countries, renewable energy sectors have been the poor distant cousin of traditional power and petroleum sectors. Government renewable energy departments receive neither the skilled manpower nor the funding required to grow the sector. In fact, because renewable energy departments are so often tasked to work on off-grid power and poverty alleviation, grid-connected renewable projects do not get the attention they deserve, even when they are viable and make sense. All in all, there are often few qualified engineers within government to make the case for wind, energy efficiency, solar, or small-scale hydro, and senior planners do not get good advice about the important role of renewables in the energy mix.

Finally, those in positions of power in African energy sectors tend to be the same people that have been working with international partners on mega-power projects for decades. With the lack of subsidies, targets and incentives for renewables, power planners tend to do what they have done in the past --- invest in large hydro or coal projects that they are familiar with. Long-established networks of government officials, international project developers and corporate financiers seek the path of least resistance to politically-palatable solutions, quick returns and comfortable deals. Indeed, as coal and large hydro become more difficult to fund in the north, project developers increasingly look to Africa to do deals, and the methods employed to "make deals" are often not transparent. Although there is evidence that things are slowly changing as renewables improve their world-wide profile, Ministers and Permanent Secretaries still like to cut ribbons for "high priced" mega-scale projects. With such entrenched attitudes of African Governments, and such a lack of openness in project planning, the investment appetite of wind and solar project developers in Africa is severely stunted. This lack of leadership and the unfriendly investment climate for the private sector are the primary causes of slow renewable roll-out on the continent.

Public education and public pressure (via consumers and civil society) will help challenge the entrenched thinking of the relatively small groups of people who make plans for Africa's power sector. It took decades of concerted consumer education and lobbying in the North to begin the process of changing power sector focus from mega-coal and dams. There is no reason to believe this will not happen in sub-Saharan Africa.

66 Information about CDM projects in Africa can be downloaded at: www.unep.org/pdf/PressReleases/AfricanTrends.pdf

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