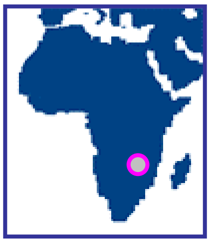
HELIO INTERNATIONAL

ZIMBABWE



Sustainable Energy Watch
2002 Report

Energy and Sustainable Development in Zimbabwe

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Development and promoting the use of an efficient public transport system in addition to the use of clean transport like non-motorized bicycles can reduce fossil fuel consumption (100 % imported), CO_2 emissions and pollution.

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Executive Summary

This being the first observer report for the country, it is pleasing to note that all the indicators were calculated, although in some cases estimates were used.

Carbon emissions have decreased since 1990 due to reduced coal consumption. This will however be short-lived since there are plans to build more coal fired thermal power plants in the country to meet the increasing power demand. SO2 emissions from energy use and conversion are high. In the capital city, SO2 emissions, mainly from industry and transport sector, have been observed to be well above W.H.O. recommended levels. Access to electricity especially in rural areas in Zimbabwe, though by Sub-Saharan Africa levels is considered relatively high, remains very low. The Expanded Rural Electrification Program (EREP), recently embarked on, will see more and more people in rural areas having access to electricity in a short period of time. The country to a large extent relies on non-renewable energy imports in the form of fossil fuels and electricity from coal-fired thermal power stations. Development and promoting the use of an efficient public transport system in addition to the use of clean transport like non motorized bicycles can reduce fossil fuel consumption. Increasing internal electricity generation capacity will reduce electricity importation, which drains the much-needed foreign currency from the country. Zimbabwe's energy intensity remains 4 times the world average. This is due to the fact that contribution to the GDP is mainly from energy intensive sectors likes industry, mining, agriculture, and transport that use outdated and inefficient machinery. Although investment in clean energy has increased in value it remains very insignificant compared to the total investment in energy. Besides woodfuel, the deployment of other renewables in the country is very rudimentary. More efforts are needed to overcome barriers to renewable energy deployment.

The country is in the process of coming up with solid legislation on environment protection. It is envisaged that this piece of legislation will facilitate close control and monitoring of most environmental concerns like pollution that are in most cases related to energy issues. Below is a summary of the country's indicators for 1990 and 1998.

Indicator	**1990**		**1998**		**% Change**	
	Metric	Vector	Metric	Vector	Metric	Vector
1. CO2 emissions	406.4	0.09	313.6	-0.032	-23%	-136%
2. SO2 emissions	12.33		10.43	0.83	-15%	N/A
3. Access to electricity	24%	0.76	36%	0.64	50%	-16%
4. Clean energy investments	0.008	-	0.0054	0.997	-32%	n.a.
5. Energy trade – imports	-	0.314	-	0.33	-	5%
6. Burden of energy investments	-	-	-	0.42	-	-
7. Energy Productivity	43	4.39	40.13	4.08	-6.7%	-7%
8. Renewable energy	35.79 %	0.686	34.92%	0.696	-2.43%	1.5%

Introduction

Kudakwashe Munjeri is currently a lecturer at a college in Zimbabwe. He holds a B.Sc Honours degree in Applied Physics from the National University of Science and Technology and an M.Sc. in Renewable Energy from the University of Zimbabwe. He is currently preparing for Ph.D. studies. Kudakwashe has considerable experience in energy research in the country. He has a keen interest in renewable energy. He has worked with various local firms on the dissemination of renewable energy technologies in rural areas in Zimbabwe. Alois P. Mhlanga (apmhlanga@yahoo.com) who is a renowned researcher in energy and environmental issues made the success of this report possible by the vital and influential contribution. Other contributions came from Chii Mangwandi, J. Takaendesa , Ndhlukula Kudakwashe – ZEN Solar, Suzan Madau – DoE Tel: 04-791670.

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General Discussion of Zimbabwe

▸Zimbabwe's profile

Located in the southern part of Africa and with cosmopolitan population of just less than 12 million people on a total area of 390 thousand square kilometers, Zimbabwe has a population density of 31 people per square kilometer. The country's economy is based on agriculture, mining and a well established manufacturing sector. It produces minerals like gold, iron & steel, chrome, copper, asbestos, nickel and lately platinum that are predominantly exported. The agricultural sector produces sugar, maize, cotton, tobacco, flowers, paprika and beef. The country's major imports are machinery and transport equipment (27.6%) [CSO Stats-Flash January 2001], chemicals (16.7%) and liquid fuels (19.5%) while on the other hand its major exports are tobacco, gold, asbestos, and other minerals [CSO Stats-Flash January 2001].

At attainment of independence in 1980, the government embarked on massive social investment in form of construction of new schools and rehabilitation of old schools, clinics, hospitals, electricity grid expansion, roads, service centers, etc. The overall effect of such social investment was a general improvement of the living standards in the country. Social statistics improved rapidly. Adult literacy figure rose from less than 50% in 1980 to 87.2% in 1998 [World Bank website]. The population growth rate for the period 1980-1990 was 3.3% while that for the period 1990-1999 was only 2.2%. In the period from 1990 to 1998, life expectancy declined from 56 to 51 years predominantly due to the effects of the AIDS scourge. The country's industrial base increased with FDI changing from 12 million US$ in 1990 to 76 million US$ in 1998 [World Bank Statistical Reports]. During the same period, the urban population as a percentage of total population rose from 28% to 34%. More socio-economic data on Zimbabwe are in box below.

Box 1 : Zimbabwe Socio-economic Data - *IEA*

1. GNP/capita (US$)	688
2. Electricity consumption/pop. (kWh/capita)	910
3. Rural pop. with access to sanitation (%)	48
4. Urban pop. with access to sanitation (%)	99
5. TPES/GDP (toe/000 90US$)	0.96

Source : International Energy Agency

General living standards for people improved drastically until the early 1990s when the government decided to implement IMF and World Bank funded economic reforms to attain a free market economy. The only evidence of these reforms today are rampant and abject poverty in the majority of the population, astronomically high unemployment, figure currently reaching 70%, and collapse of social services due to limited state funding. Most local industries could not compete on the international markets, thus they folded up resulting in massive retrenchments. Both micro and macro economic conditions in the country deteriorated. Yearly inflation rose from 20.5% in 1996 to 55.7% in 2000. The recent political problems primarily caused by the need to redress land distribution imbalances caused by the country's colonial past have worsened the economic conditions. Zimbabwe's FDI has been reduced by over 60% and inflation has rose to 115% [Reserve Bank Quarterly Review, 2002]. Associated environmental degradation resulted as people turned to the exploitation of natural resources for survival. The country's total value of external debt in 1998 was more than 4 billion US$ with total debt service requirements of just under 1 billion US$.

The government has however been always conscious of the need to protect the environment that sustains life, that is as per its documented policies. Economic benefits have however in some cases resulted in total disregard of the need to protect the environment. Several policy positions have been taken to try and encourage environmental protection. The National Conservation Strategy of 1997 sets out the objectives and targets set for the protection and sustained utilisation and development of the country's natural resources. Guidelines for Environment Impacts Assessments for all sectors are in place for use by project developers. Zimbabwe has a fragmented environment protection legislation, which is characterized by different pieces of legislation that also fall under different ministries. Concerted efforts are currently underway to try and formulate an all-inclusive Environmental Management Bill that will be enforced by a single body under a single ministry. It is envisaged that this move will ease a lot of environmental problems in the country like massive localised land degradation, air pollution, deforestation, land pollution, water pollution etc.

▸Zimbabwe's Energy sector

The country's energy sector has several players whose roles and functions are given in the table below:

Organisation	***Role***
Ministry of Mines and Energy – Department of Energy (DoE)	Energy Policy Administration of the Electricity Act Petroleum product regulation Downstream coal activities Renewable energy development
Zimbabwe Electricity Supply Authority (ZESA)	Generation, importation, transmission and distribution of electricity.
National Oil Company of Zimbabwe (NOCZIM)	Fuel procurement and primary distribution Maintaining primary importation infrastructure
Petroleum companies (Shell, BP, ENGEN, Total-Fina-Elf, Caltex, EXXON, etc)	Importation and distribution of petroleum products Establish and maintain contracts and services to retail stations
Some agro-based industries	Private generation of electricity for their own needs
Independent Power Producers	Generation of electricity and selling to ZESA

The energy sector in Zimbabwe accounts for about 12% of public revenue mainly from exercise duties on liquid fuels. This sector, however, has a more significant share in national aggregate investment, foreign borrowing and debt. The country's major energy resources are coal, hydropower, biomass and solar energy. Coal bed methane exploitation is still in the planning stages. 48% biomass, 15% coal, 3% coke, 22% liquid fuels and 12% electricity account for the country's final energy supply of 290334 TJ. A total of about 280 PJ is consumed per year in Zimbabwe. The national energy consumption by fuel is as illustrated in figure 1 below. Biomass accounts for 50% of the energy used in while coal and electricity account for 13 and 12% respectively.

Energy consumption has grown at an average rate of about 3.5% per annum since 1990, which has exceeded GDP growth rate of 2.7% [Reserve Bank Quarterly review, 2002].

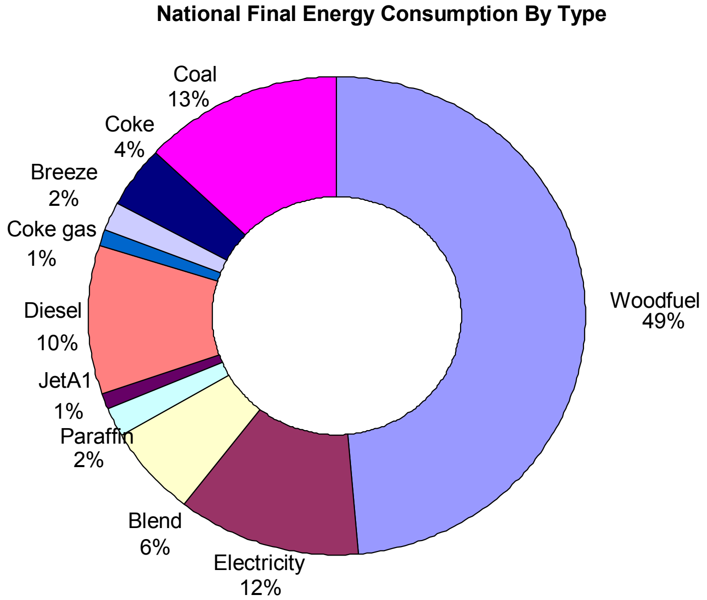


Figure 1. Zimbabwe's Energy Use by Type.

Woodfuel is the most important domestic fuel in the country. It is the major source of energy for cooking, lighting and heating for over 70% of the population. Apart from woodfuel, coal is the most abundant source of primary energy found in the country. Zimbabwe has 30 billion tonnes of probable bituminous coal reserves in 21 deposits of which *in situ* reserves are estimated at between 10 and 20 billion tonnes. Proven reserves can last for 107 years and total reserves for over 200 years at the present extraction rate of about 5,3 million tonnes per annum [Annual Report, Wankie Colliery, 2001].

Most liquid fuels are imported from the Middle East (30%) and Libya (70%) in refined form. The liquid fuels are predominantly diesel, gasoline, Jet A1, kerosene, aviation gas, LPG and ethanol. Gasoline and diesel are imported as finished products while some ethanol is produced locally. Electricity is generated locally at coal-fired Hwange Thermal Power Station [920MW], Kariba Hydro Electric power station [666MW] and three other coal fired thermal power stations at Harare [135MW], Bulawayo [120MW] and Munyati [120MW] [ZESA Annual Report 2001]. Electricity supply is augmented by imports from neighboring countries, which constitute 41% of the total. Renewable energy, excluding biomass, is also used albeit to a limited extent. To date Solar PV systems with a capacity of more than 1 MWe have been installed countrywide. About 200 biogas digesters have also been constructed in various communities in the country. Two sugarcane-crushing mills to the southern part of the country use more than 1.3 million tonnes of bagasse to generate electricity which is used in the sugar mills. Animal power is another very useful form of energy, which remains unaccounted for in the Zimbabwean energy mix because there is not a conventional energy measure. Informed estimates put the equivalent national animal power use in the agricultural sector at about 7 million litres of diesel annually [Southern Centre, 2000, Renewable Energy In Zimbabwe, barriers and potential].

▸Sectorial Energy Use

Energy consumption in the various sectors in Zimbabwe is as shown in Figure 2 below.

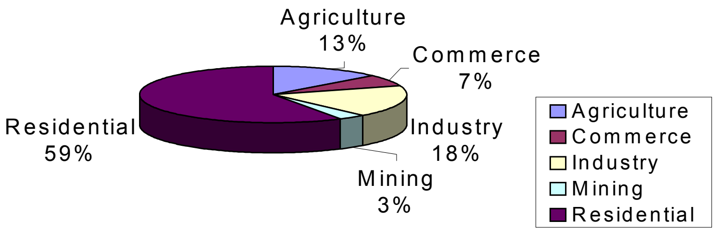


Figure 2 : Zimbabwe's energy use by sectors.

The demand for energy comes primarily from residential (59%), followed by industry (18%), agriculture(13%), commerce (7%), and mining (3%). The high energy consumed in residential areas comes from woodfuel used with value of 127PJ annually.*(Zimbabwe Energy Bulletin 2001, 1998 Energy Balance)*

▸Other Energy Related Developments

Zimbabwe's energy policy has five main objectives:
1. Ensuring accelerated economic development
2. Facilitating rural development
3. Promoting small-medium scale enterprises
4. Ensuring environmentally friendly energy development
5. Ensuring efficient utilisation of energy resources.

It is quite evident that the policy is sensitive to the developmental needs of rural areas and with only 18% of the rural population having access to electricity, the government has enacted a new piece of legislation that is targeted at accelerating rural electrification. Under the Expanded Rural Electrification Programme (EREP), it now becomes mandatory for the government, through the local utility Zimbabwe Electricity Supply Authority (ZESA), to allocate resources towards the widespread rural electrification drive without considering the economic merit of the grid extension. The vision of this programme is the total electrification of the country in order to expand the country's economic base. This policy position will see the provision of power to most rural areas thereby enabling them to initiate activities that create wealth. The long-term objectives of this programme are to:
- Improve accessibility of electricity by all rural communities
- Improve the quality of life through the delivery of modern social services like health, education etc.
- Stimulate investment in rural areas so as to create employment and increase incomes.
- Improve the general economic and social status of people in rural areas.
- Help reverse urban migration and energy-related environmental degradation.

The programme with a total budget allocation of US$ 500 million will be implemented in several stages. The first stage will see the electrification of areas within 5km distance from the network and then increase in 5km distances per stage up to stage 4. The last stage of the project will see the extension of the grid to areas more than 20 kms from the current network. Several financial packages have been put in place to aid rural projects access low interest capital to pay for grid extension. The results of this program have been impressive so far, within three months of the inception, more than 50 rural schools and homesteads have been electrified.

Environmental sustainability

▸Indicator 1: Per Capita Energy Sector Carbon Dioxide Emissions

The country emits considerable carbon dioxide from its energy sector given that 48% of its final energy consumption is from biomass while 39.4% is from fossil fuels which are coal, coke and petroleum products. Liquid fuel consumption in the country has risen from 39,600 TJ in 1990 to 63,700 TJ in 1998 [Min. of Mines & Energy, Energy Balances 1990 &1998]. This increase has been largely due to increased volume of road traffic in the country whose density per 1000 people rose from 30 in 1990 to 62 in 1998 [CSO, CSO National Statistics Bulletin, 2001]. Although the use of liquid fuels has increased significantly, the use of coal, which is a major source of carbon dioxide, has modestly decreased from coal with energy value of 138 PJ in 1990 to 134 PJ in 1998. Per capita energy sector carbon dioxide emissions has declined modestly since 1985 [www.IEA.org] due to the rapid population growth caused by the widespread availability of social services like health and education soon after attainment of independence in 1980. The population of the country has continued to increase at an annual average rate of 2,6% [World Bank, 2001, World Bank Atlas].

Calculation of the vector:

Zimbabwe's fuel combustion carbon dioxide emissions per capita dropped from 1.49 tonnes in 1990 to 1.2 tonnes in 1998 [IEA, CO2 emissions from fuel combustion 1971-1998, 2000 Edition]. These figures translate to a change from 406.4 kgC/cap in 1990 to 327.3 kgC/cap in 1998 and 1999 of 313.6 kgC/cap.

- 1990 vector = (406-339)/791 = 0.09.
- 1998 vector = (372.3-339)/791 = 0.042
- 1999 vector = (313.6-339)/791 = -0.032

Discussion:

From 1990 to 1999, the vector has moved close 0 and even became negative in 1999. This indicates at one hand some aspect of sustainability and on the other hand it indicates lack of development. Industrial development that comes with increased carbon emissions from energy consumption has been very minimal in the country. These low figures are attributed to a significant component of hydroelectricity in the national energy mix that meets 17% of electricity demand. The situation is however bound to change remarkably in the near future as ZESA's system development plant shows that between 2005 and 2010 the utility will build coal-fired power plants with a capacity of 1884 MW.

▸Indicator 2: Most Significant Energy-Related Local Pollutant – SO2

Coal is the major fossil fuel used in the country. 46% of the country's estimated total annual sulphur emissions of over 120 000 tonnes comes from the power production sector while another 48% also comes from the industrial sector. 42% of the electricity supplied in the country, amounting to 10 TWh [Zimbabwe Energy Bulletin 2001 – 1998

Energy Balance], is generated from coal-fired thermal power stations located in the west of the country. Coal is also used as a fuel and raw material in local industries that include iron & steel, cement manufacture, brick making, sugar mills & refineries and foundries. Technological advances that reduce particulate emissions are used in most power plants in the country and they are also located in areas that are not inhabited, thus particulate emissions tend to affect only the vegetation around these plants. Therefore, besides other minute emissions spread around the country, sulphur emissions from coal burning is the most significant pollutant. On average 5,3 million tonnes of coal are supplied in the country per year. In Zimbabwe, coal is mined form three main sites that produce coal with sulphur contents as below:

Hwange coal : 2.5% S (mostly for power production)
Sengwa coal : 0.5% S (currently not in use)
Lubumbi coal : 1.6% S (currently not in use)

Liquid fuels with a total volume exceeding 2 million cubic metres are used in the country predominantly in the transport sector. Gasoline combustion emits 42 tonnes of sulphur per year while diesel consumption emits 5800 tonnes of sulphur. High levels of liquid fuels combustion are however concentrated in major cities especially Harare the capital. The City of Harare's Health department published in 1999 stated that the air in the city had an average sulphur dioxide concentration of 86.73 micrograms per cubic meter which is well above the WHO standard of 50 micrograms per cubic meter. Areas that are however to the west of the city had high values of even up to 286 micrograms per cubic meter in some cases. The city has other major pollution problems associated with energy given the increasing poverty resulting in 50.95% [Ecowebsite www.ecoweb.co.zw/education-statistics.asp] of the population relying on paraffin for cooking [City of Harare, 2000, City Health Dept. Annual Report].

Calculation of the vector (Energy Sector Only):

Country's emissions in 1990 = 60090 tonnes of S = 120180 tonnes of SO2
[Southern Centre, 1999, GHG Country Studies]
In 1998 = 61450 tonnes S = 121900 tonnes of SO2
Country's population 1990 = 9.75 million In 1998 = 11.69 million
Country's emissions per capita in 1990 = 12.33 kilograms of SO2 per capita.
Country's emissions per capita this year = 10.43 kilograms of SO2 per capita.
1998 Vector = (10.43-1.233)/11.097 = 0.83

Discussion:

Between the years 1990 and 1998, SO2 emissions per capita from Zimbabwe have modestly decreased. Although the volume of traffic in the country has increased significantly in this period, the amount of coal, which is a major source of this gas, slightly decreased while the population increased significantly hence the decrease in country per capita emissions. While these figures are good national indicators, the geographical location and wind regimes that affect these areas to a large extent determine the severity of the impacts of the pollution. Studies have shown that in the SADC region Botswana, Zimbabwe and South Africa emit the largest volumes of sulphur. It was however shown that due to transboundary pollution other countries like Swaziland, Lesotho and Mozambique could be affected by the pollution from the three emitting countries [SADC ELMS, 1995, SO2 emissions and transfrontier Air Pollution in Southern Africa].

Social sustainability

▸Indicator 3: Households with Access to Electricity

At attainment of independence in 1980, the government had to adopt a new policy that provided electricity to the black majority who was previously denied access by a colonial government. The effect of this policy was a massive extension of the grid to cover a lot of high-density residential areas, rural service station, small towns and some rural areas. To date the provision of electricity to these remote areas has had the following noticeable results:

- improvement of quality of life through improved services provision
- employment generation through a number of projects
- improved economic and social status through income generation from agricultural activities in resettled areas
- reversal of environmental degradation due to fuel switching and reforestation initiatives.

Renewable energy systems especially solar home systems, have also been deployed in a lot of rural services centre like hospitals and schools. Table below shows the trend in number of installed Global Environment Facility PV projects in Zimbabwe. As can be noted from the table, just between 1993 and 1997, more than 8500 institutions and homes out of a total of over 2,5 million [DoE,1997, Alternative Energy Strategy] had been electrified under just one project. Other parallel projects also contributed to this rural electrification drive, thereby increasing the contribution of renewables to the electrification of the country.

Table 3: Trends in number of installed GEF PV systems (45-watt equivalent)

End User	1993	1994	1995	1996	1997
Households	7	404	917	842	1400
Clinics	0	300	400	1000	781
Schools	1	20	115	200	600
Small Business	0	67	200	523	470
Others	0	8	72	200	15
Total	8	799	1704	2765	3266

Source: Zimbabwe-UNDP GEF Solar Project , 1997 Annual Report.

On realising the apparent lack of resources to implement the rural electrification, the government then tasked the national utility to share the cost of grid extension with the potential beneficiaries. This then created a situation where only those who could pay for the grid extension could have access to electricity. However the recently introduced rural electrification programme seeks to extend the grid to most rural service centres to enable people to create wealth for their sustenance.

Calculation of the vector:

1. % of population with access to electricity in 1990 = 24% [ZESA Annual Report, 1992]
2. Percentage of population with access to electricity in 1998 = 36% [2000 ZESA Annual Report].
3. 1990 vector = 1-0.24 = 0.76
4. 1998 vector = 1-0.36 = 0.64

Discussion:

Compared to most developing countries, especially African countries, the country has a significantly high population with access to electricity. It is more than clear that as the population of the country continues to grow, more and more people especially in rural areas will be without electricity. Therefore, there is a need to both extend the grid at a faster rate and increase the use of efficient appliances. The decentralised approach that is based on renewable energy resources will be beneficial to both society and the environment. Despite of renewable energy resources being abundantly available, especially solar, less than 1% of households in the country use electricity derived from renewable energy. The currently introduced EREP will see a significant number of households in rural areas accessing electricity thereby rapidly increasing the percentage of the population with access to electricity that in turns reduces the vector close to zero. The EREP has been very successful so far with over 100 electrification projects being completed every month. So far about 733 projects have been completed [Zimpapers – The Sunday Mail 21-04-2002, Electrification Review].

▸Indicator 4: Investment in Clean Energy

While the government has always been very positive about the deployment of renewables, the allocation of resources to this cause has been another thing. Despite of this situation, the country has been receiving international assistance to promote use clean energy. To date, several projects have been implemented in the country. Below is a table showing some of the international assistance the country has received to promote clean energy. These projects were spread over a number of years so it remains important to spread the investment over the duration of the project for the purpose of calculating the indicators.

Table 4: International assistance to deploy renewable energy the country has received

Donor	Area of Support	Project cost
UNESCO	Schools and Colleges training program in RE Solar Heating for Tobacco Curing	ZIM$[1] 900 000
GTZ	Solar Water Pumping (Masvingo province) (1992-1994)	DM 9 million
UNDP-GEF	Solar PV program (1994-1998)	US$ 7 million
CIDA	Rusitu mini-hydro (ENDA) (1994-1996)	C $ 5 million
Australian Aid	Promotion of Solar water heaters, plant oils (1996-1999)	ZIM$ 5 million
JICA	Installation of Clusters of PV systems (1997-1999)	US$ 10 million
UNDP-GEF -PDF	Removal of Barriers to Energy Efficiency in Zimbabwe's Industry (1998-2000)	US$ 250000
Italian Gov.	Lighting of rural schools and clinics (yet to start)	ZIM$ 400 million
DANIDA	Rural Afforestation Phase II	DKr 18 million
FAO/FARMESA	Solar crop dryers, biogas for agricultural production (1997-8)	US$20K
E7	Mini hydro in Manyuchi (1996-) (dropped)	US$ 1.8 million

[*ZERO, 2000, Renewable energy in Zimbabwe*]

[1] 1US$ = 55 ZIM$

Calculation of the vector:

While every effort was made to collect all the relevant information on this indicator, it was not possible to have the information due to several reasons. In some cases the project would have closed and those who would have worked on the project would have moved and in some cases, the project life span could not be determined. Despite of these and other problems, some useful information was collected and in some cases estimates were used to determine the indicator.

Taking the year 1994 and 1998,

Total investment in clean energy in 1994 = 3.77 million US$
and in 1998 = 4.86 million US$

Country's total energy-related investment in 1994 = 471 million US$
and in 1998 = 902 million US$.
[NOCZIM Reports and ZESA Annual Reports 94 & 98]

Clean energy investment in 1994 divided by total energy investment in 1994 =0.008.
Clean energy investment in 1998 divided by total energy investment in 1998 = 0.0054.

Vector = (0.95-0.008)/(0.95-0.0054) = 0.997

Discussion:

From the indicator, it can be realised that compared to total energy investment in the country, investment in clean energy remain just insignificant. The value of investment in clean energy has however increased between 1994 and 1998. Despite of the fact that informed estimates were used in the calculation above, the indicator reflects a correct picture of the situation. With more information expected to come in from different sources, the next report will have more accurate information.

Economic sustainability

▸Indicator 5: Energy Resilience: Energy Trade

All liquid fuels used in Zimbabwe are imported. Although the country produces ethanol from molasse in the southeastern lowveld, it is all exported to generate the much-needed foreign currency. 41% of the electricity used is imported from other countries. Figure 3 below shows the distribution of the sources of electricity imports by Zimbabwe [DoE, Energy Bulletin 2001 – 1998 Energy Balance].

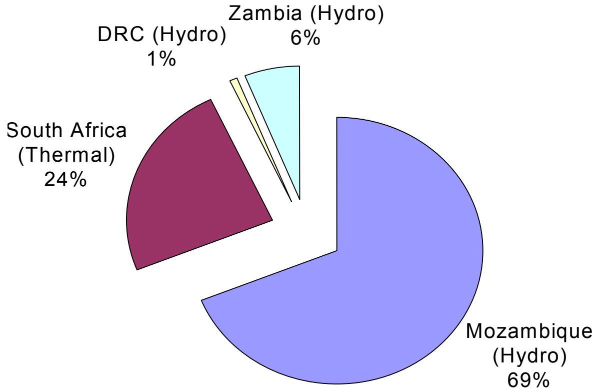


Figure 3: Zimbabwe's electricity imports by source

Of the country's total electricity imports of 4933 GWh, 24% was imported from South Africa, 69% from Mozambique, 6% from Zambia and 1% from the Democratic Republic of Congo (DRC) [DoE, 2001, Energy Bulletin, 1988 Energy Balance]. While the country cannot stop the importation of petroleum products since it does not have known resources in the country, there are plans of expanding locally available electricity resources. Projections by the national utility show that at current rates of demand growth and system development plans, the country will continue to have power deficit until 2011. It is envisaged that after 2012, the country will have developed adequate internal capacity to meet demand and even consider exporting power. Table 4, below, shows the utility's system development plans from 2005 to 2016. It is also important to note here that most of these plans are fossil-fuels based and the development of these plants depends on several factors so that 5 years down the line, the energy situation in the country may need a different plan.

Table 5: ZESA's system development plans from 2005 to 2016

Commissioning Year	Project (h- hydro, t- thermal)	Capacity	Demand (GWh)	Internal generation (GWh)	Surplus(+) or deficit (-) (GWh)
2005	Hwange 7&8 (t)	2*300 MW	14394	11482	-2912
2008-10	Gokwe North (t)	4*321 MW	15331	12892	-2509
2012-15	Batoka George (h)	4*200 MW	17184	17332	148
2017	Kariba South (h)	2*150 MW	18729	19052	323

Source: ZESA Annual report 1999

Calculation of the vector:

1. Total non-renewable energy imports in 1990 = 41853 TJ [DoE, 1998, Zimbabwe Energy Balance]
in 1998 = 65392 TJ [DoE, 2001, Energy Bulletin-Zimbabwe Energy Balance1988]

2. Total non-renewable primary energy supply in 1990 = 133 416 TJ
in 1998 = 198 227 TJ

3. The metric and vector is therefore equals: in 1990 = 0.314
in 1998 = 0.33

4. Total renewable energy imports in 1990 = 3146 TJ
in 1998 = 13495 TJ

5. Total energy consumption in 1990 = 139 945 TJ (commercial energy only)
in 1998 = 290 447 TJ

Discussion:

A significant share of the country's current energy imports are non-renewable based. These are petroleum products and electricity from coal-fired thermal power plants in South Africa. The country's reliance on non-renewable energy will only be based on petroleum products only after 2015. This is because after this year, the country will be no longer importing electricity, as it would have developed adequate internal capacity to meet the projected demand then. While only 11% of the power from system development plans are renewable energy based, it is hoped that advances in technology especially clean coal technologies will help minimize potential greenhouse gases emissions from the power plants.

▸Indicator 6: Burden of Energy Investments

The ever-increasing energy demand in the country has forced the government to invest substantially in the construction of coal-fired thermal power stations and the refurbishment of the hydro-based Kariba power plant. While these investments have not been on a year to year basis due to other social commitments, considerable amount of resources have been, to date, used up in these projects. The government through the local utility plans to build more of these plants to meet local demand utilizing locally available resources thereby mitigating the needs of foreign currency required to import cheaper electricity from the SAPP. The Gokwe North Power station, to be build in 4 phases, has an estimated cost of 1.4 billion US$, the extension of the Hwange station will cost 630 millon US$ while the two hydro based plants the Batoka and Kariba south extension will cost 1.4billion US$ and 280 million US$ [ZESA, 2000, Annual report 2001]. Although investment years for these plants have not yet been finalised, the magnitude of the figures reflects the kind of investment that will be made in non-renewable energy. The National Oil Company of Zimbabwe (NOCZIM) is now focussed on procurement, transportation and distribution, though to a very limited extent, of petroleum products in the country. Most of the distribution and transportation of oil to the country is now left to local and international oil companies like CALTEX, EXON, SHELL, BP, ENGEN, etc. Investment in ethanol production is no longer a national priority as the country is no longer blending since all the ethanol produced in the country is now exported to fetch the much needed foreign currency.

Calculation of the vector:

1. Government investment in non-renewable energy = 1998 = 800 million US$ [Estimated cost of Hwange upgrade – ZESA Research Unit].
2. Since the project will was spread over 3 years then we use 267 million US$

3. Total gross domestic product (GDP) in 1990 = 8784 million US$ [World Bank, 2001, Statistical Outlook]
   in 1998 = 6338 million US$

4. Vector = 267/6338 = 0.042*10 = 0.42

Discussion:

While the development of local power stations in Zimbabwe remain necessary, other factors come into play when they are implemented. Importation of cheap power from the SAPP will for a long time remain a medium-term measure for the country's power problems. With peace in the DRC in the making, the country may consider increasing cheap imports from that country, thereby further delaying capital investments in energy projects. The need for self-sufficiency in the power sector remains very critical to the country's development. This is very important given experiences of political problems in the region that have in the past caused rupture of supplies to the country.

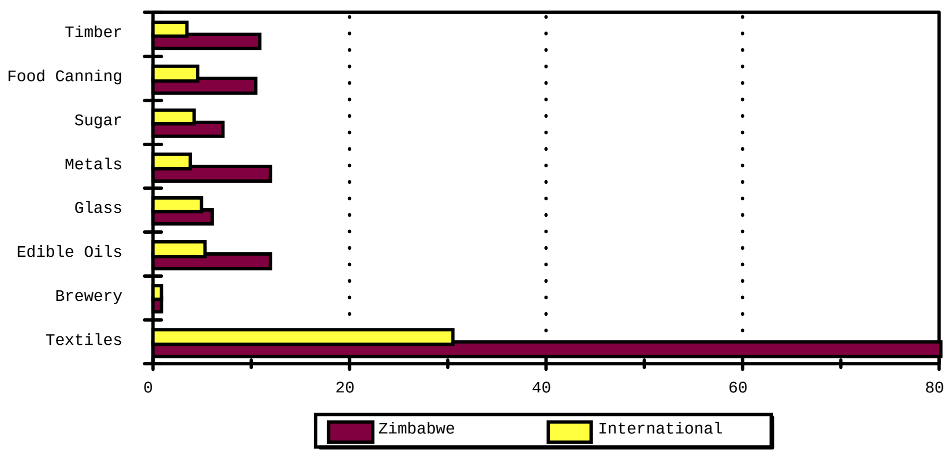
The recent moves to restructure and commercialize ZESA have paid dividend to the country. ZESA has even become more profitable in Zimbabwean dollar terms than before and has enough resources to initiate various capital projects. Although that is the case, the overall shortage of foreign currency in the country has negatively affected the utility's credit position. The shortage of foreign currency has resulted in the parastatal failure to pay for power imported from countries like South Africa in the past. The government has however made a provision to use 40% of all foreign currency earnings to pay for energy imports i.e. electricity and petroleum products.

Technological sustainability

▶Indicator 7: Energy Intensity

Between 1990 and 1998, the economy of the country generally expanded and there was an associated increase in energy consumption by 41 PJ. The increase in the number of vehicles meant for private use has contributed to this increase. However since the vehicles are mostly imports from Japan, their efficiencies are fairly high. The development of infrastructure to accommodate public transport has seen more people using buses and minibuses for transportation. Recently, a train system was introduced to ferry workers from high-density areas and their workplaces in the capital Harare. The benefits of this initiative are yet to be analysed. The local industry has not been completely left out in the global technological trends. In fact, the local brewing industry is run more efficiently than in some industrialised countries. However on the grand scale, the country's industries are in dire need of a technological revolution to keep in line with global trends. Below is a graph that compares energy intensities per unit of production for the different sectors of the local industry to those of industries from developed countries. As can be realised, most industries in the country use more energy per unit of production compared to industries in developed countries.

Figure 4: Comparison of the country's industrial energy intensities to international trends in GJ/unit of production.



Source: Southern Centre for Energy and Environment: 2001, UNDP-GEF Energy Efficiency studies.

Calculation of the vector:

Information in 1,2 & 3 is from [IEA-OECD, CO2 emissions from Fuel Combustion 1971-1998, 2000]

1. Zimbabwe's total primary energy supply = in 1990 = 380 PJ
   = in 1998 = 421 PJ
2. Zimbabwe's total GDP (using exchange rates)
   in 1990 = 8.78 billion1990 US$
   in 1998 = 10.49 billion 1990 US$

3. Zimbabwe's total GDP (using PPP)
   in 1990 = 23.43 billion 1990 US$
   in 1998 = 27.97 billion 1990 US$

4. Energy intensity using exchange rates in 1990 = 43 MJ/$GDP
   in 1998 = 40.13 MJ/$GDP
5. Energy intensity using PPP in 1990 = 16.22 MJ/$GDP
   in 1998 = 15.05 MJ/$GDP

6. The 1990 Vector by exchange rate GDP = (43-1.06)/9.56 = 4.39
7. The 1998 Vector by exchange rate GDP = (40.13-1.06)/9.56 = 4.08
8. The 1990 vector using PPP = (16.22-1.06)/9.58 = 1.59
9. The 1998 vector using PPP = (15.05-1.06)/9.58 = 1.46

Discussion:

If we are to consider GDP obtained from considering exchange rates, Zimbabwe is 4 times more energy intensive than the world average. The contribution to GDP by the different sectors in the country is as shown in figure 5, below [CSO, 2002, CSO – Stats-Flash, March 2001].

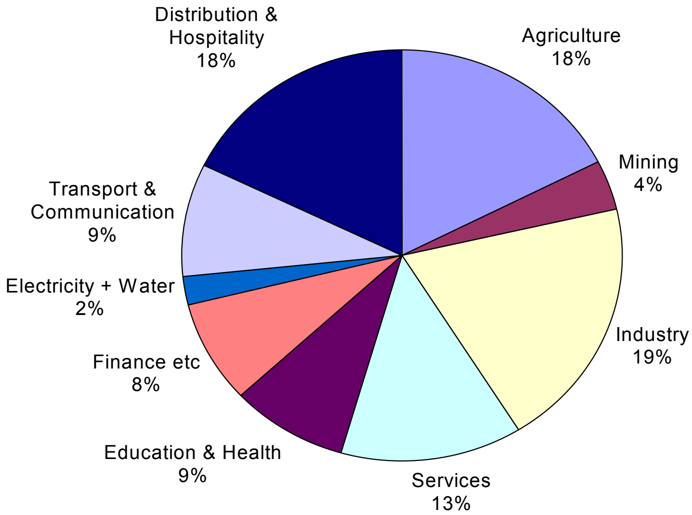


Figure 5: Sectorial contribution to GDP in Zimbabwe

Contribution to Zimbabwe GDP is based on agriculture, mining, industry, distribution and hospitality and transport. The first three sectors make use of heavy machinery and in the case of Zimbabwe the machinery is outdated and inefficient energy-wise. Recent studies have shown that energy efficiency in these sectors will result in energy consumption in these sectors being reduced by close to 40% [SCEE, UNDP-GEF : 2001, Energy Efficiency studies in Zimbabwe]. Energy in the country has been very cheap for some years and even subsidised in some cases. This has resulted in most of the sectors not factoring in the energy cost component in their production costs. Recent increases in the cost of energy have however forced many sectors to review their energy use patterns. Simple housekeeping measures and technological upgrades have so far resulted in success stories. Despite of these achievements, the need for a culture of energy efficiency remains critical to the country.

▸Indicator 8: Renewable Energy Deployment

Although the potential of renewable energy resources in the country is just unlimited, the deployment of these renewable energy technologies remains rudimentary. Below is a table comparing renewable energy potential in the country to what is being used in the country.

Table 6: Renewable energy situation in Zimbabwe

Technology	Current Situation	Technical Potential
Solar PV (SHS)	• Annual insolation of over 2200 kWh/m^2 • 3117 sunshine hours p.a. • 1.2 MWp installed & 10000 systems	• >>300 MW over 2 million houses can be electrified
PV water pumping	• 35 systems installed since 1980	• unlimited potential • horticulture & gardens
Solar Water heaters & cookers	• 50-1000 litres units available • cost US$1000 • 10 000 units installed	• 1 million systems can be installed. • 500 solar cookers in use
Mini Hydro	• 8 schemes in place producing 1.2 MW • 7 stand alone & 1 connected to the grid	• 13 MW potential. • 5 MW from existing irrigation dams • 8 MW from other bigger sites and dams
Biogas	• 5.5 million farm animals • dung with energy content of 100PJ is produced annually but is scattered. • Only 250 small scale units of the Chinese, Indian & Carmatec types	• 10 000 units potential • large farms • agricultural produce processors
Wind	• average wind speed of 3m/s countrywide • specific locations have great potential	• 4-7m/s @ 20m • 3 MW measured potential at specific sites
Bagasse based cogeneration	• 45 MW generated seasonally • 1.5 million tonnes of bagasse produced annually. • bagasse burnt inefficiently as a disposal measure.	• Current production is 30 % of the total potential. • >130 MW could be easily produced.
Power generation from sawmill waste	• 139 000 ha of commercial forests • 750 000 tonnes of sawmill dust produced p.a. • 70 tonnes used for drying • 6.5 MWe under consideration	• current project can achieve 25 Mwe • 100MWe could be eventually produced.
Methane production at Municipal sewerage works	• 400 000 cubic metres of raw sewage treated daily. • 75 000 cubic metres of methane produced daily some of the gas used to preheat digesters but most is vented	• 3 MW can be produced continuously • 5MW could be produced intermittently.

[Mhlanga A, 2002, State of Renewable Energy in Zimbabwe].

As can be noted, a lot can be realised by the exploitation of these resources in Zimbabwe. The deployment of RETs to date has been promoted for two reasons. Firstly, the government viewed the deployment of RETs in rural areas as a way around its rural electrification drive, which was critically hampered by lack of resources. Resultantly, most efforts to promote RETs were directed at rural areas with the aim of economically develop such areas. Secondly the deployment of these technologies was promoted by the business involved. Equipment selling and servicing of these technologies provided business to a number firms in the country.

Calculation of the vector:
(information here is from the 1990 and 1998 Zimbabwe energy balances from DoE)

1. Total renewable energy consumption in 1990 = 136 PJ
   in 1998 = 147 PJ

5. Total primary energy supply in 1990 = 380 PJ
   in 1998 = 421 PJ

6. Renewable energy fraction in 1990 = 136/380 = 35.79%
   In 1998 = 147/421 = 34.92%

7. 1990 vector = (0.95-0.3579)/0.8636 = 0.686
8. 1998 vector = (0.95-0.3492)/0.8636 = 0.696

Discussion:

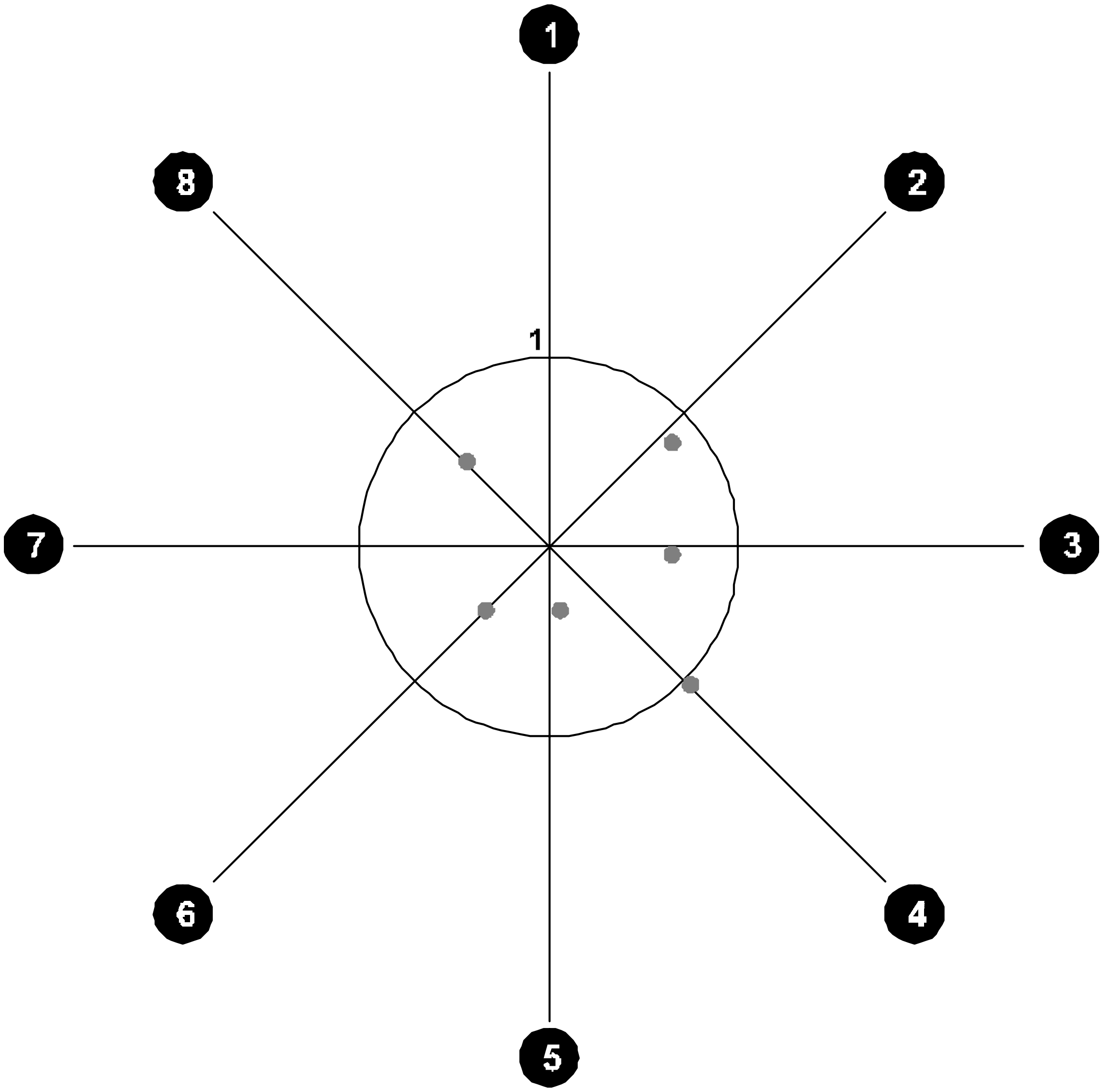
Between 1990 and 1998 both the country's renewable energy consumption and total energy consumption have increased. In 1990, renewable energy was mainly accounted for by woodfuel in residential areas mostly in rural areas and hydroelectricity generated from Kariba power plant. In 1998, we considered all renewables that are in place like solar home systems, bagasse-based cogeneration, micro-hydro systems, etc. that are however about 5% of the total renewable energy consumed. While more renewable energy technologies are now in use, compared to the total energy consumption in the country, their energy production is still insignificant compared to the national total supply. As more technologies are being deployed in the country especially for mini-hydro systems, cogeneration, solar PV, it is envisaged that the contribution of renewables to the national energy mix will increase.

Comparing the vector for the years 1990 and 1998, it can be observed that it has changed for the worse, despite of the fact that more renewable energy technologies are in use in the country. This is due to the increased fossil-fuel based energy consumption in the country from petroleum products and electricity generated from coal fired power plants.

Zimbabwe's Star chart

All the indicators are as shown in table below. The indicators are also shown in the star chart below. It was decided not to present indicators with negative vectors on the chart.

Indicator	Vector
1. CO_2 emissions	-0.032
2. SO_2 emissions	0.83
3. Access to electricity	0.64
4. Clean energy investment*	0.997
5. Energy trade – exports	0.33
6. Burden of energy investments	0.42
7. Energy Productivity	4.08
8. Renewable energy	0.696



Conclusions

By Sub-Saharan Africa's standards, the country's level of people with access to electricity is encouraging. The recently introduced EREP will in the near future increase access to electricity in the country. Carbon emissions per capita for the country are actually below global average. The need to increase access to electricity and reduce energy imports to the country will however hurt indicator 1 since increased local generation capacity will mean more coal fired thermal power plants. Thus there is need for a trade off between some indicators.

The 7th indicator is more than 1 since the country is generally more energy intensive that the global average. The deployment of renewable energy in the country, where the majority of the rural population is forced by circumstances to use woodfuel, remains quite rudimentary. Deployment of renewable energy will also increase access to electricity in remote areas thereby raising living standards. Air pollution caused by energy use and transformation poses a very big health risk to the country. Levels of SO2 in the country's capital have been observed to be well above WHO standards. There is therefore a need to reduce pollution levels from vehicles by either introducing a 'cycling culture' that also calls for associated infrastructural development or developing an efficient public transport system. While every effort was made to get all the information required to calculate the different indicators, some could not be obtained due to other problems and time limitation. It was realised that there is a need to sustain this information collection 'culture' so that it is constantly updated thereby reflecting the correct position of the country's energy sector.

For future Observers

Gathering information that is required for the purpose of this report is quite a task. Government ministries and departments are not in the 'habit' of compiling annual reports and in some cases, information pertaining to the same issue is housed in different ministries and may be differently defined. It remains to the observer to try to get to the correct information. A DANIDA funded project to monitor air pollution levels in Harare which is in most cases related to energy issues and selected parts of the country is currently underway. The information from this project could be useful in future. The same applies to a lot of other activities that are not documented, which calls for a lot more effort to get the information together. Discrepancies exist between information from international organisations and the information from the government. In such cases preference was given to information from the government. Every effort was made, in this report, to reference all sources of the data used for calculating the indicators. This was meant to help the compilers on the next report. There are solid promises from different organisations including embassies to provide requested information to help future reports compilation.

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