

The Eight Indicators

►Indicator 1: Per capita energy sector carbon emissions

According to the Initial National Communication to the United Nations Framework Convention on Climate Change Botswana is a net sink for CO₂ emissions as emissions resulting from burning of fossil fuels in 1994 were relatively small and balanced by large uptake of carbon by trees (Ministry of Works, Transport and Communication, 2001).

Table 3: Summary of CO₂ emissions and removals in 1994 (Gg/year)

GHG sources and sinks	CO ₂	CH ₄	NO ₂
Energy	3,028	25	1
Industrial Processes			0.7
Agriculture			5
Land use change and forestry	-38 734		
Waste		8	
Total (net national emission/removal)	-35734		7

Source: MWTC 2001.

Relative to the African continent, Botswana's GHGs emissions from energy use is equivalent to only 7% of the continent's total GHGs (MWTC 2001). Therefore the country is a minor contributor to the problem of global warming and climate change, though it will be significantly impacted by climate change.

Botswana's per capita energy sector CO₂ emissions are less than the global average of 0.87 kg/capita (Table 3b). The relatively low energy intensity is largely due to low level of industrial development. Most of the energy is consumed in the residential sector (42%).

Table 4: Comparative per capita CO₂ emissions

COUNTRY/REGION	CO ₂ per capita (tonnes/cap)	CO ₂ /GDP (kg/1990 US\$)
Botswana	1.86	0.6
South Africa	8.54	2.82
Africa	0.96	1.31
World	3.86	0.87

Sources: World Resources Institute 2000- 2001, EAD 2000, Spalding-Fecher 2001

The 1990 global average of carbon emissions from fossil fuels was 1,130 kg C/capita which has been assigned the value 1. To define a sustainable level, SEW selected a sustainability objective of a 70% reduction relative to 1990 emissions. This translates into 339 kg C/ capita or 3/10 of the world average in 1990. This level has been assigned a value of 0.

In 1990, Botswana's CO₂ emissions stood at 2 415 000 tonnes (World Resources, 2000-2001). With a population of 1 300 999 (CSO, 2001) this translates into 1 856.27 kg CO₂/capita or 506.21 kg C/capita. By 2000, CO₂ emissions from fossil fuels were about 3 940 138 tonnes or 650.69 kg C/capita (EAD 2000 & MWTC 2001). The estimates are based on fossil fuel consumption. The emission levels are comparable to the 1994 levels of 3 038 000 tonnes of CO₂ reported in the Initial National Communication.

Metric (actual data) for 1990: 506.21 kg C/capita and for 2000: 650.69 kg C/capita

Vector value for 1990 is 0.21 and for 2000 is 0.39

Discussion

The most recent official data on GHG emissions were compiled under the National Communication to the Framework on Climate Change and pertains to 1994. In the absence of recent official data, international organisations such as the World Bank, UNDP and World Resources Institute have been used as source of data. Existing data on consumption of fossil fuels was also used to estimate CO₂ emission levels.

For the 1990 vector calculation, data was obtained from the World Resource Report (2000-2001) whereas for the current year (2000), the emission levels were estimated based on the national energy consumption data and emission coefficient that were used for the national communication for 1994. Due to time constraint, it was possible to reconcile the method used in the World Resource Report with that was used for estimating the 2000 emissions. However the CO₂ emissions levels for the two years were compared with the one reported during the 1994 National Communication to see if they are reasonable or consistent. It should be noted that the only available official statistics on CO₂ emissions for 1994 are reported in the National Communications.

Based on the calculations, the vector values have increased by 86% from 1990 to 2000, largely because of the annual increase in energy consumption. This trend is likely to continue as currently the government is seriously considering expanding the current power generation capacity from coal. This means that the consumption of coal will increase together with the associated emissions. The government is also promoting the use of coal as a substitute for fuelwood in the residential sector and small industries. However the latter is not likely have much impact in terms of emissions although the trend should be monitored.

Notes to SEW for next year's Observer- Reporter

The only official statistics available from the National Communication is for 1994 and there is no indication as to when it will be updated. Hence the other option is to estimate CO₂ based on the energy statistics. The energy statistics is available from the Energy Affairs Division Office. For the next year, the Observer should in consultation with HELIO International establish the best or mutually acceptable method to estimate CO₂ emissions from yearly energy balances.

References:

The following provided useful reference material:

- i. CSO (Central Statistics Office) 2001. Statistical Bulletin. Government Printer. Gaborone.
- ii. MWTC (Ministry of Works, Transport and Communication) 2001. Initial National Communications to the UN Framework on Climate Change. Printing and Publishing Company. Gaborone.
- iii. World Resources Institute 2000-2001, Emissions from Fossil Fuel Burning and Cement Manufacturing. www.wri.org.
- iv. R. Spalding-Fecher 2002. Sustainable Energy Watch Report for South Africa. www.helio-international.org

►Indicator 2: Most Significant Energy - Related Local Pollutant

The Atmospheric Pollution Act prescribes the maximum permissible emissions levels that each industrial process may release into the atmosphere. Under this provision the Department of Mines has set emissions levels and monitors levels for CO, NO₂, O₃ and SO₂.

Botswana does not have many industries and according to the 2000 Air Pollution Control Annual Report (DOM 2000) the major sources of air pollution are:

- BCL copper nickel smelter in Selibe Phikwe
- Botswana Power Corporation power station at Morupule
- Soda ash plant at Sua-Pan

Monitoring of major sources of air pollution in 2000 showed that industrial processes emissions were within acceptable levels except for the copper nickel smelter in Selibe Phikwe. Measurements recorded at Selibe Phikwe Secondary Schools showed mean concentrations of SO₂ of 98 ug/m³ compared to the recommended government guideline of 80 ug/m³.

Table 5: SO₂ concentration levels measured at different sites in 2000.

	Selibe Phikwe	Madinare	Tonota	Palapye	Francistown
SO ₂ (ug/m ³)	98	26	1	16	9

Source: DOM 2000.

However it is evident from Table 3c that in general SO₂ emissions in the country are within acceptable level.

The high SO₂ levels have the potential to negatively impact on the health of the students (e.g. respiratory problems) and for this reason the SO₂ concentration in the school premises have been used as a key indicator. The smelter uses coal.

For this indicator, the value for 1 on the vector is the World Health Organisation guidelines (60ug/m³) and value for 0 on the vector is 20% of the WHO guidelines or 12 ug/m³.

According to the Air Pollution Annual Reports (1991 and 2001) mean SO₂ concentration at the school were 100 and 98 ug/m³ for 1990 and 2000 respectively.

Metric (actual data) for 1990: 100 g/m³ and 2000: 98 ug/m³

Vector value for 1990 is 1.83 and for 2000 is 1.79

From the vector calculations it can be concluded that the SO₂ concentration level at the school in Selibe Phikwe is unsustainably high and between 1990 and 2000 the levels have remained more less constant.

Discussion

The Air Pollution Control Division of the Department of Mines has fairly detailed information of average annual SO₂ concentration for many years in Selibe Phikwe. However data recorded by the mine and the Department of Mines is not the same for the same sites. For this report, data from the Department of Mines have been used as they are considered to be official. However this discrepancy needs to be investigated.

Since the 1990 and 2000 SO₂ concentrations in Selibe Phikwe are way above the WHO guidelines, the vector values are high indicating low sustainability. The vector values

have remained fairly constant over the past decade i.e. very little change has occurred (2%).

According to the Air Pollution Report (2000), the problem of high SO₂ concentrations in Selibe Phikwe is being addressed by putting hoods over converters and ducting fumes to the 153m chimneys. While this will not reduce the pollutants it will allow them to be discharged at high altitude with the possibility of dilution of concentrations to acceptable levels before reaching the ground.

References:

The following documents were used to calculate this indicator:

- i. DoM (Department of Mines) 2000 &1990, Air Pollution Control Annual Report. Government Printer. Gaborone.
- ii. Ricardo Cunha da Costa 2001. Generic Formula for calculation of energy sustainability indicators. HELIO International.

►Indicator 3: Households with access to electricity

Like most of the developing countries, Botswana has low access to electricity by households. In 2001, the rate of national access to electrification was 24% while for urban and rural areas access was 43% and 18% respectively (Energy Affairs Division, 2001). Over the years access to electricity has been increasing substantially due to government efforts to accelerate rural electrification although this is far from the ideal of 100% access to electricity.

Table 6: Access to electricity in Botswana

Year	Urban	Rural	National
1993	28	3	9
1999	37	8	16
2001	43	18	24

Source: Matshameko, T. 2002.

The value for 1 on the vector is 0% access to electricity while value for 0 is 100% access.

Metric (actual data) for 1993: 9% and 2001: 24%.

Vector value for 1993 is 0.91 and 2001 is 0.76

Discussion

As of the end of 2001, 186 out of a total of 395 villages were electrified. Since 1993 on average the government has been electrifying 14 villages per year. However during the period 1999-2001 government embarked on an accelerated rural electrification programme whereby 72 villages were connected to the grid. After 2002/2003, the government will revert back to electrification of 14 villages per year. To increase connections in electrified villages, government introduced a financing scheme for rural connections in 1990. Initially individuals wishing to connect to electricity paid 40% down-payment and the balance was paid over a period of 10 years. In 1995 the down-payment was reduced to 10%.

The large increase in access to electricity in rural areas from 8% in 1993 to 18% in 2001 can be attributed to the increase in the number of villages connected to the grid and to the existence of the financing mechanism for rural connections.. With the large investment in the 72 villages, government should ensure that these assets are utilised through marketing and making it easier and affordable for rural communities to connect eg. by an extension of the network in the villages.

Notes to SEW for next year's Observer Report.

Data from the government (Energy Affairs Division) should be checked against those of the utility, Botswana Power Corporation, to validate them. In the context of this study, access was used to mean the number of households who have actually connected electricity. In a lot of the rural villages very few households have connected electricity despite its availability.

Reference :

- i. Matshameko, T. Energy Affairs Division. Personal Communication, March 2002.

►Indicator 4: Clean Energy Investment (a proxy for employment)

Research has shown that investment in clean energy creates more jobs and faster economic growth than comparable investment in conventional energy sources. Typically conventional energy technologies are capital intensive and are less labour intensive compared to clean energy technologies. Therefore, all other things being equal one would expect nations to invest more in energy efficiency and clean energy technologies.

In Botswana the only significant renewable energy resource is solar energy, there is no hydro potential and wind potential is very limited due to low wind-speeds (average 3 m/s).

The major players in the energy sector are the government, power utility, and oil companies. Data on investment in energy are not readily available except from the government and the utility.

Outside government there is very little, if any, investment in renewable energy and energy efficiency. Therefore data used is primarily based on government's and other related institutions. Most of government investment has been geared towards extending the national grid to rural areas. Some of the investment is renewable energy equipment. In 1990, total investment in energy by government and utility stood at US\$ 1.25 million of which US\$ 0.01 million was on renewable energy (MFDP 1991, BPC Annual Report 1990). There was no investment in energy efficiency. In 2000, total energy expenditure was US\$ 21.8 million of which US\$ 0.34 million was spent on renewable energy (MFDP, 2001, BPC Annual Report, 2000). There is still no investment in energy efficiency.

Metric (actual data) for 1990 = 0.010 and 2000 = 0.016.
Vector value for 2000 = 0.99.

Discussion

Attempts to get data from private sector were not successful. There is substantial investment by the oil companies particularly on the distribution network and this has not been captured.

The vector value for this indicator is far from the sustainability value. Inclusion of investment by the private sector would further decrease the level of sustainability as most of their investment is in "non-clean" energy sources.

Reference:

Data was obtained from government and the utility and the following are the reference material:

- i. BPC (Botswana Power Corporation) Annual Report, 1990 & 2000. Gaborone.
- ii. MFDP (Ministry of Finance and Development Planning) 1991 & 2000. Project Review. Government Printer. Gaborone.

►Indicator 5: Resilience to External Imports: (Energy Trade)

Many countries are dependent on imports of energy and as a result are susceptible to price changes especially those of oil. Heavy dependence on energy imports also places burden on the economy. In Africa, oil importing countries typically expend 20-40% of export earnings on oil imports (Zhou, P. 1997).

Botswana is heavily independent on energy imports, all petroleum products requirement are met through imports, more than 50% of electricity is imported, mostly from South Africa. Therefore the country is vulnerable to distributions disruptions and changes in international prices of energy particularly petroleum. There are no exports of energy.

In 1990, non-renewable energy imports were 14,183 TJ whereas total non-renewable primary energy supply was 31,500 TJ (excluding biomass and renewable energy). In 2000 imports of non-renewable energy were 29,350 TJ (excludes 41 TJ for renewable energy based electricity) and total non-renewable primary energy supply was 52,143 TJ. Total primary energy supply was 74,885 TJ in 2000 (EAD 1990 & 2000).

There are imports of electricity from South Africa, Zambia and Zimbabwe. The bulk of the imports, which come from South Africa (98.6%) are assumed to be from non-renewable energy.

Table 7: Electricity imports in 1999 and 2000 (TJ)

Country	1990	2000	Source
South Africa		2,871	Non-renewable
Zambia and Zimbabwe		41	Renewable
Total		2912	

Source: EAD 2000, CSO 2001.

Imports from the other two countries are presumed to be renewable energy based.

Metric (actual data) for 1990 is 0.45 and for 2000 is 0.56.

Vector value for 1990 is 0.45 and for 2000 is 0.56.

Discussion

Since 1990, imports of non-renewable energy have increased by more than 100%. Substantial amounts of electricity are imported principally from South Africa, Zimbabwe and Zambia.

References:

- i. EAD (Energy Affairs Division) 1990 & 2000. Energy Statistics. Government Printer. Gaborone.
- ii. Zhou, P. 1997. Development of an Efficient Transport Sector in East and Southern Africa-Opportunities and Policy Implications under the UNFCC. Gaborone.

►Indicator 6: Burden of Energy Investment

This indicator assesses the level of government investment in non-renewable energy as a fraction of GDP. High level of investment in non-renewable energy as a proportion of GDP means that less resources are available to the nation for other productive uses and social services e.g. education, health etc.

Government investment on non-renewable energy in 2000 was P35.6 million or US\$ 5.6 million. The GDP in 2000 was P28.88 billion or US\$ 5.392billion (CSO 2001).

Metric (actual data) for 2000 = 0.0012.

Vector value for 2000 = 0.012

Discussion

Government investment is mainly for grid network expansion either to connect new villages to the grid or expand distribution network in electrified villages. Investment in non-renewable energy as a percentage of GDP is low which means that the government is spending less on energy. This is the only indicator which is reasonably close to sustainable value. However this does not mean that government is spending more on renewable energy or energy efficiency and it might be that the government is under-investing in the energy sector. The low access to electricity, particularly in rural areas, is reflective of the low investment in energy. Therefore this indicator must also be viewed together with the level of investment on energy efficiency and renewable energy.

Reference :

- i. EAD (Energy Affairs Division) 1990&2000. Energy Statistics. Government Printer. Gaborone
- ii. CSO (Central Statistics Office) 2001. Statistical Bulletin. Government Printer. Gaborone

►Indicator 7: Energy Intensity

This indicator provides a yardstick of the country's progress in terms of obtaining more economic output per unit of energy consumed. Reduction of energy input without compromising economic output will entail improving energy use. Besides direct economic loss due to inefficient energy use the following argument can be put forward in support of adopting energy efficient practices:

- Energy supply infrastructure is costly and inefficient use of energy will lead to investment in energy supply facilities in excess of what is actually required. This leads to sub-optimal allocation of scarce resources.
- Efficient energy use can assist in reducing environmental problems associated with burning of fuels to generate more energy.
- Excessive energy consumption increases costs of goods and services and this reduces the country's competitiveness in the global market.

In line with the guidelines for observer-reporter both the conventional GDP output at current prices and purchase power parity have been used to calculate the indicators. GDP was US\$ 5.3 billion in 2000 (World Bank, 2001). From the same report GDP (PPP) was US\$ 11.87 billion. Total primary energy supply was 74,885 TJ.

Metric (actual data) for 2000 = 14.04 MJ/US\$ of GDP or 6.31 MJ/US\$ of GDP (PPP).
Vector value for 2000 = 1.35 or 0.55

Discussion

Botswana's current energy intensity of 6.31 MJ/US\$ GDP (PPP) is below the 1990 global average of 10.64 MJ/US\$ GDP, but 6 times the SEW sustainability objective of 1.06 MJ/US\$. Consequently the vector value of 0.55 is above the sustainability value of 0.

The country's energy intensity is projected to increase as the country continues its efforts of economic development and, in the absence of effective energy efficiency initiatives, it is unlikely that the current vector value will move away from the sustainability value.

References:

- i) EAD (Energy Affairs Division) 2000. Energy Statistics. Government Printer. Gaborone.
- ii) World Bank 2001. World Development Indicators Database. www.worldbank.org/data.

►Indicator 8: Renewable Energy Deployment

It is widely considered that technologies based on renewable energy sources provide options for GHG mitigation in the energy sector. Globally the use of renewable energy sources is increasing ~~faster than conventional energy sources~~ although in absolute terms their contribution is still low, averaging 2% in 1998 (HELIO International 2000). Increasingly many countries have initiated programmes to promote the use of renewable energy.

Total primary energy supply in 2000 in Botswana was 74,885 TJ and renewable energy supply (primary energy supply including biomass) was 22,743 TJ. Therefore 30% of the energy was derived from renewable energy.

Metric (actual data) for 2000 = 0.30

Vector value for 2000 = 0.75

Discussion

About 30% of the total primary energy supply is derived from renewable energy, the bulk of which is biomass (99.9%). However data on biomass consumption is based on estimates as collection of data is not readily captured in data collection system. Contribution of the renewable energy sources such as solar energy is small (0.1%). Most of the renewable energy is consumed in the residential sector.

Although biomass has been considered to be renewable there are indications that in some parts of the country it is harvested in an unsustainable manner. Therefore the classification of biomass as renewable may reflect a misleading indication of sustainability

References :

- i) EAD (Energy Affairs Division) 2000. Energy Statistics. Government Printer. Gaborone.
- ii) HELIO International 2000. Guidelines for Observer-Reporter.
www.HELIO.international.org/anglias/reports/reports2000.html