Energy sector policies in Botswana and their implications for global climate change

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Abstract

Like most African countries, Botswana contributes almost insignificantly to global greenhouse emissions (GHGs). In this context, some have argued that energy policy and legislative measures to regulate emissions in Botswana should not be accorded high priority. This is a misguided view when one considers that each country, no matter how under-industrialized, contributes to the overall global emission problem. Moreover, the least developed countries will have to industrialize in order to meet the increasing economic and social needs of their growing populations. For rapidly growing economies like Botswana, whose annual energy demand is projected to increase by about 4% for the next ten years, the importance of compiling accurate inventories of sources and sinks of GHGs and formulating environmentally-friendly policies can hardly be over- emphasized. The United Nations Framework Convention on Climate Change (UNFCCC) provides the ideal basis for the country-by-country investigations and management of global climatic change; specifically its nature, properties, directionality, characteristics and probable consequences. Botswana was a founding signatory of UNFCCC in 1992 and ratified the Convention in 1994. The country is also involved in regional cooperation efforts, within the Southern African Development Community, to enforce regulatory mechanisms to minimize GHG emissions from the energy sector. There exist certain energy-related institutions, policies, and regulations in the country which could mitigate the impact of GHG emissions on global warming. This paper, based on government and other relevant documentation, critically analyses Botswana's energy sector policies in as far as they affect climate change. It is clear that much still needs to be done about energy policies in terms of proper formulation, monitoring, co-ordination, energy pricing and the exploration of energy alternatives to mitigate potentially negative impacts on climate change.

Introduction

Anthropogenic GHGs emissions threaten to cause rapid and substantial change in the global climate, and the energy sector is a major contributor to this problem. It is estimated that energy accounts for about half of the emissions of GHGs globally (Karekezi and Mackenzie, 1993, p. 1).

The energy sector is also the main source of GHG emissions in most African countries through energy production, conversion and use (Field-Juma and Karani, 1993, p. 133). Wood, charcoal, coal and refined petroleum products are used for the primary and secondary production of the energy used in industry, transport and households.

Presently, Africa accounts for about 10% of GHG global emissions. However, when the continent's economies begin to grow and the development process becomes more sophisticated, in terms of both technological input and the supporting service infrastructure, emissions of GHGs are expected to increase correspondingly. While African countries may not be net contributors to the build-up of CO_2 in the atmosphere individually, the increased concentration of CO_2 and other GHGs in the atmosphere remains a serious trans-boundary problem, with worldwide negative consequences on climate (Karekezi and Mackenzie, 1993, p. 2). Moreover, the annual average population growth, currently estimated at over 2%, will add further emissions of GHGs through increased energy consumption, landuse cover change and other anthropogenic activities (Okoth-Ogendo, 1995, p. 1).

The United Nations Framework Convention on Climate Change (UNFCCC) marks an important milestone in international environmental governance by providing a policy mechanism for exchange, negotiation and institution -building to redirect development efforts towards more efficient use of resources, especially energy (Okoth-Ogendo 1995, p. 1).The Convention serves as a broad policy instrument for the investigation and management of global climate change, specifically its nature and properties, directionality, characteristics and probable consequences on both managed and natural ecosystems. Notwithstanding the significance of the UNFCCC, the successful resolution of the problem posed by climatic change, due to GHG emissions, will depend ultimately on individual country perceptions, policies and principles on how best to respond to climate change issues.

Botswana does not have a dedicated policy to respond to climate change. However, the global climatic impacts from the energy sector, which is a large source of greenhouse gases emissions, is acknowledged by the Government of Botswana. To this end, Botswana is a signatory to the UNFCCC. Its commitment is to provide reports of its greenhouse gas emissions and strategies to reduce their levels. Studies to this effect have been conducted since 1994. Recently, a National Committee on Climate Change, under the Department of Meteorological Services (DMS), has been established. The Committee serves as a national focal point for meeting Botswana's obligations under UNFCCC. Its mandate includes planning and coordination of the elements and activities on climate change, communication with stakeholders, and public awareness raising. Botswana is also signatory to regional efforts, in the Southern African Development Community (SADC), to develop environmentally-friendly energy technologies. The country's participation in the pilot Industrial Energy Conservation and the Industrial Energy Management projects demonstrates its willingness to cooperatively explore ways of utilizing energy sources sustainably.

As is the case with most other African countries; enhanced research capacity is still required to develop coherent environmental policies, accurate national inventories of anthropogenic sources and emissions of GHGs, predictive models, standards and regulations, and the effective monitoring of compliance so as to fulfill the objectives of the conventions aimed at minimizing global warming (Field-Juma and Karani, 1995, p. 172).

This study, on Botswana, is intended to examine the national energy policies and the extent to which they could be used to minimize energy outputs from impinging negatively on climate. The paper has three main parts. The next part provides the contextual background of the study by discussing energy supply and demand by sector and their GHG emissions. The second focuses on energy sector policies and their implications for climate change. The third is the conclusion. It summarizes the major issues dealt with in the paper and suggests a way forward for energy and related policies which could mitigate negative climate change.

Energy supply and demand by sector and GHGs emissions

In recent years, energy consumption of all forms in Botswana , has increased rapidly in response to population and economic growth. The energy resources used reflect the country's economic and social structure which closely resembles that of its regional partners within the Southern Africa Development Community (SADC) (Republic of Botswana, 1997, p. 205). See Table 1.

Although its relative importance has declined slightly from 60% in 1991,wood still constitutes the major primary energy source. The change reflects the switch to other primary sources which has been taking place with improving incomes. The pattern is comparable to other countries within SADC, except South Africa, where a negative correlation between biomass use and per capita Gross Domestic Product (GDP) has not yet been observed (Moyo and Sill, 1999, p. 10). Studies which identify the key energy transition variables are a necessary prerequisite to an effective energy and environmentally- sustainable development policy (Arimah and Ebohon, 2000).

Table 1. Primary Energy Supply Pattern, Botswana 1994/95.

Source	%
Wood	58.0
Coal	23.1
Petroleum	18.5
Electricity	0.5

Source: NDP8 205.

Table 2 summarizes emission estimates by type and fuel source for Botswana.

The major GHG gases are CO_2, CO, NO_x, CH_4, and N_2O.

CO_2 has non-biogenic sources such as coal which constitute a net addition to the atmospheric pool of GHGs gases. It also derives from biomass combustion. It is normally assumed that this biogenic form may not lead to net additions provided that wood, which is a sink for CO_2, is harvested sustainably. Botswana is regarded as a major net sink for CO_2 emissions due to the large uptake of carbon by trees (Republic of Botswana, 2001b, pp. 11, 12).While there are local examples of fuelwood overharvesting, the natural national re-growth rate in biomass stocks exceeds the amount harvested. Fuelwood, petrol, and diesel are the main sources of CO.

Petrol and coal are the main energy sources of NO_x and N_2O.

Table 3 shows that, between 1994/95 coal accounted for 50% of GHG emissions, mostly in the form of CO_2.

CO_2 emissions contributed 61% of all emission energy sources. Petrol contributed 23% of GHG emissions, mostly in the form of CO_2, NO_x and CO, respectively.

Wood contributed 14% of GHG emissions, mostly in the form of CO and CH_4.

Diesel contributed 11% of GHG, mostly in the form of CO_2 and NO_x.

Table 4 shows final energy demand by sector.

Fuelwood is used by 90% of rural households and 55% of urban households (Republic of Botswana, 1997, p. 220). It is used for cooking and heating, mostly in the residential sector. The rural population relies on candles and paraffin for lighting while some urban households also use electricity. Only 3% of the rural households and 24% of the urban households use electricity.

Some Government institutions and small to medium-sized commercial enterprises also use fuel wood. Fuelwood demand is projected to increase from 1,443 kilotonnes in 1992 to 2,078 kilotonnes by 2004 in Botswana (Kgathi *et al.*, 1997, p. 39). The quantities are based on the following assumptions: (a) stumpage royalties will be levied on fuelwood traders; (b) fuelwood will be depleted in the vicinity of set-

Table 2. Emission estimate (tonnes) by emission type and fuel (1994/95).

Energy carrier	Emissions (tonnes)							
	CO_2	CO	HC	CH_4	NO_x	SO_x	TSP	N_20
Coal	2,015,536.0	273.9	31.9	267.5	8,215.5	17,800.3	4,564.2	547.7
LPG	38,805.0	315.6	39.4	0.5	25.6	0.3	0.1	17.9
Aviation gas	4,643.1	3.8	55.3	2.0	5.3	–	–	1.5
Jet A	14,402.6	24.9	16.0	0.0	59.9	–	–	4.4
Petrol	536,867.1	66,776.3	5,180.5	774.7	8,531.2	217,201.2	57.0	170.4
Paraffin	36,505.6	576.2	1,268.5	11.5	6.9	195.9	46.1	11.3
Diesel	419,554.2	1,742.0	447.3	9.0	1,830.6	1,052.6	538.8	147.2
Wood	–	133,881.3	10,041.1	12,049.3	1,071.1	669.4	13,388.1	64.3
TOTAL	3,066,313.6	203,593.8	17,080.1	13,114.5	19,746.1	236,919.6	18,594.3	964.7

Source: Environmental Statistics CSO 2000, 110

Table 3. GHG emission estimates in carbon dioxide equivalents (%) by fuel source 1994/95.

	GHG Emissions in CO_2 Equivalents (tonnes)					
Energy Carrier	CO_2	CO	CH_4	NO_x	N_2O	Total
Coal	39.98	0.02	0.11	6.52	3.37	49.99
LPG	0.77	0.02	0.00	0.02	0.11	0.92
Aviation gas	0.09	0.00	0.00	0.00	0.01	0.11
Jet A	0.29	0.00	0.00	0.05	0.03	0.36
Petrol	10.65	3.97	0.32	6.77	1.05	22.76
Paraffin	0.72	0.03	0.00	0.01	0.07	0.84
Diesel	8.32	0.10	0.00	1.45	0.91	10.79
Wood	–	7.97	5.02	0.85	0.40	14.23
TOTAL	60.82	12.12	5.46	15.67	5.93	100.00

Source : Environmental Statistics, CSO 2000, 110

Table 4. Final energy demand pattern, Botswana 1994/5.

Sector	%
Residential	50,2
Transport	23,0
Industry	18,3
Government	4,7
Agriculture	1,2

Source: NDP 8 207

tlements; (c) use of fuel by institutions will be prohibited and (d) the fuelwood substitutes will be subsidized (Kgathi *et al.*, 1997, p. 39).

Industry, commerce, transport and agriculture account for over 85% of the country's non-fuelwood energy consumption. Coal is the primary source of electricity generation for these sectors. 93% of the domestically-generated electricity is from coal (Republic of Botswana, 1997, p. 205). Coal and electricity are mainly consumed in the industrial sector, particularly mining. In terms of relative importance, the Botswana Power Corporation (BPC) consumes 70%, the Bamangwato Concessions Limited (BCL) 17%, and Botswana Ash 10%, of coal-based energy (Republic of Botswana, 1997, p. 212). Coal use is gradually gaining access into manufacturing industry, Government institutions and, to a minimum extent, households. Technical and extension efforts of the Expanded Coal Utilization Project (ECUP) have been instrumental in promoting an increase in consumption by industrial, commercial and Government institutions.

Petroleum products are mainly consumed in the transport sector, particularly by the railway and road vehicles. Transport energy, mainly petrol and diesel, accounts for more than 40% of non-wood energy. Although some agricultural and domestic users still rely on diesel-generated electricity, demand has been gradually declining because some of the Centralized Supply Systems (CPSS) have now been closed down in favour of grid connections (NDP8, 1997, p. 205). Medium and high income households use liquefied petroleum gas (LPG) and electricity. Because of its convenience and the increasing scarcity of fuel wood, LPG is gradually being adopted as a fuel source in low income and Self Help Housing Authority (SHHA) areas (Ibid.).

Table 5 shows the main contributors to energy emissions from the demand sectors.

Electrical generation is the highest contributor to GHG emissions, in the form of CO_2, NO_x, and N_2O.

Second is the transportation sector which contributes to emissions in the form of CO_2 and NO_x and CO; third comes the household sector in the form of CO, CO_2 and NO_x; and fourth is industry in the form of CO_2, NO_x and N_2O.

Energy sector policies and climate change

Energy and industrial development policies need to be re-examined from their capacity to influence the growth of GHG emissions and their capability to influence climate change. In this context, Africa finds itself in a dilemma. There is an urgent need for promoting economic growth and social development on the continent. Africa will thus have to increase its energy consumption if the continent is to emerge from its current state of underdevelopment, to address the need for improving living standards for its people (Sokona, 1993, p. 39). However, because of increasing international concern with global warming, it will have to

seriously take into account the impacts of these activities on the environment by instituting appropriate energy sector policies.

Energy demand in Botswana is increasing in response to a growing population and a rapidly expanding economy. Emissions of greenhouse gases from fuel combustion are projected to grow at around 4% per annum for the next decade (Republic of Botswana, 2001b, p. 12).Most general circulation models predict a rainfall decrease in semi-arid Botswana due to global warming (Ibid., p. 12). It is therefore important to understand the nature of relevant institutions and policies that are in place to deal with the climate changing impacts of these developments.

Institutional framework for managing the energy sector

A distinctive feature of the energy sector in sub-Saharan Africa, in the wake of independence, was a virtual absence of any coherent institutional structure for energy policy formulation, analysis, monitoring and implementation (Karekezi and Mackenzie, 1993, p. 11). Botswana's initial Development Plans similarly had no policy on the energy sector or its impact on the environment. Perhaps this reflects the fact that there were more pressing socioeconomic concerns then, to the exclusion of environmental ones. Also the linkage between economic development, energy utilization and environmental degradation was not fully appreciated both locally and globally.

Before the present national energy policies and their potential for impacting on climate, can be effectively analyzed, the country's institutional framework within which those policies are conceived, formulated, implemented, monitored and evaluated needs to be stipulated.

The crucial role of institutions and human resource capacities to formulate and effect energy policies has been acknowledged in several national Government planning statements.

In NDP7 it was noted that '*Experience has shown that the greatest challenge to successfully implementing comprehensive national energy policies stems from the institutional, rather than from the methodological side of an energy plan'* (Republic of Botswana, 1985, p. 232).

Both the NDP8 Energy Sector Policy and Strategy, the Integrated Energy Planning (IEP) also emphasize that policy implementation effectiveness, *'has a direct bearing on institutional structures and capabilities and requires capable staff that understand the whole economy'* (Republic of Botswana, 1997, p. 215). and that *'One key requirement for effective implementation of energy policy is to have in place appropriate institutional structures and clear institutional roles, enhanced by relevant professional and administrative capacity'* (Republic of Botswana, 1997, p. 216).

The above observations illustrate the essence of having proper institutions, adequate human resources and proper coordination mechanisms in place in order for energy policies to achieve their objectives, whether they are aimed at mitigating global warming or not.

The management of energy resources will require the effective and coordinated efforts of Central Government, corporations, private sector and the NGOs which are described below.

In 1984, the Energy Unit in the Ministry of Mineral Resources and Water Affairs (MMRWA) was established, with a mandate to serve as Government's focal point for national energy policy and for operational matters pertaining to energy resources. The MMRWA formulates, directs and coordinates national energy policy through the Energy Affairs Division (EAD). The Division is now also expected to participate in developing Botswana's policy on greenhouse gas emissions and abatement.

The Botswana Power Corporation (BPC), a company created by an Act of Parliament and completely owned by the State, and sponsored by MMRWA, operates the national grid. It is tasked with the responsibility of electricity-generation and distribution.

In spite of the central role which the electricity sector can play in the mitigation of GHG emissions, it is functionally fragmented. The key role players include the Botswana Power Corporation (BPC),the Department of Electrical and Mechanical Services (DEMS),the Energy Affairs Division (EAD) and the Ministry of Local Government Lands and Housing (MLGLH).The EAD is the ideal candidate to coordinate the sector and integrate its activities with the other development planning agencies. The country needs a clear, coherent and comprehensive framework for electrification to guide the respective role players. Only a properly coordinated sector can play a meaningful role in formulating and implementing a strategy intended to attain environmental sustainability.

Oil policy is the portfolio responsibility of the Ministry of Commerce and Industry which oversees the supply, storage and pricing of petroleum products. The private oil companies purchase and distribute petroleum products for commercial usage, and also manage strategic reserves.

The Ministry of Works, Transport and Communication ensures adequate power generation for the rural villages where grid power is not available.

The Ministry of Agriculture is responsible for forest and biomass management whereas the Ministry of Local Government, Lands and Housing is tasked, through the National Conservation Strategy Agency, to manage conservation and environmental issues.

Several NGOs play an active role in energy- related activities. The Rural Industries Promotions (RIP) develops, tests and disseminates mainly renewable energy technologies, through its Rural Industries Innovation Centre (RIIC). The Botswana Technology Centre (BTC) is involved in research and information dissemination in the field of solar energy. Both the Forestry Association of Botswana (FAB) and the Directorate of Research and Development (DRD) participate in long term research in the field of wood fuel energy and the productivity of natural woodlands.

Table 5. Total sectoral GHG emissions in carbon dioxide equivalents, 1994/95.

Sector	Emissions (tonnes)				Total GHG	
	CO_2	CO	NO_x	N_20	tonnes	%
El.Generation	1,638,041.4	930.2	267,322.2	138,521.6	2,049,329.0	40.6
Household	71,420.5	395,050.9	43,744.1	27,782.2	785,602.7	15.6
Agriculture	36,444.9	903.9	6,935.8	3,951.3	48,289.5	1.0
Industry	428,356.8	4,495.3	83,325.8	43,262.7	614,799.4	12.2
Trade and Hotels	3,997.5	146.2	136.9	461.3	4,767.2	0.1
Transport	720,727.1	180,577.6	344,652.7	73,235.0	1,333,764.4	26.5
Social and private Services	656.3	3,017.6	336.0	239.3	6,139.9	0.1
Government	112,669.1	25,659.9	43,391.5	11,603.9	198,730.0	3.9
Total	3,006,313.6	610,781.5	275,404.6	299,057.3	5,041,402.1	100.1

Source: Environmental Statistics CSO (000, p. 113).

Implications of primary energy source policies to climatic change

According to Botswana's Initial Communication to UNFCCC, there is currently no explicit and dedicated policy to respond to climate change in Botswana (Government of Botswana, 2001b, p. 42). However, the potential of the energy sector for affecting future climate change has been acknowledged in NDP8, within the context of pursuing sustainable development. Nonetheless, environmental concerns, related to energy, are still not perceived as posing a serious threat (Ibid., p. 44). NDP8 claims that energy-related environmental problems are not yet serious in Botswana (Republic of Botswana, 1997, p. 224). Botswana's Energy Master Plan nonetheless contains policies to guide the energy sector towards achieving national social and economic goals. It also recommends the promotion of efficient use of energy, the diversification of energy supplies, and the inclusion of social and environmental costs in the price of energy. Although such considerations have relevance for climate change, climate change is not explicitly addressed by the Plan. The following section of the paper will examine the specific energy sectors and their respective policies with the view of analyzing their impacts on climate change and how these could be mitigated.

Fuelwood

NDP8 policies for the biomass sector are meant:

- To ensure a sustainable supply of fuelwood;
- To establish an effective institutional framework to regulate its use.

Attempts to achieve the objectives of the first policy have normally been stipulated in terms of developing carbon sequestration programs, factoring environmental costs in fuelwood pricing, using energy efficient end-uses, using alternative energy sources, and the establishment of the Fuelwood Inventory and Monitoring Programme (FIMP). All these have strong implications for strengthening carbon sinks and curtailing GHG emissions from fuelwood. Aforestation programmes, such as the Around-The-Home Tree Planting Programme, sponsored by the Forestry Association of Botswana, should also be given strong support. To facilitate the achievement of the conservation policy will also require the establishment and support of R&D into cheaper and efficient end-use technologies coupled with an effective dissemination of results to properly targeted end-users. Useful lessons could be drawn from other African countries which have developed stoves with higher efficiency, enhanced combustion conditions and reduction of carbon monoxide emission (Turyareeba, 1993, p. 70). These end-uses need to be considered and appropriately designed to meet this country's specific needs and circumstances. Prospects and challenges facing the development of alternative energy sources to fuelwood will be examined in greater detail under Renewable Energy Technologies (RETS) below.

In order to establish an effective institutional framework to regulate fuelwood use, there exists a need to ensure consistency among the various legislative implementers concerning the exploitation of fuelwood resources. There is also a need to realize that there exists a strong linkage between energy policies and other national development policies.

At Central Government level, policy formulation around general natural resources management is being developed. Also the review and reformulation of the Forestry Act and Forestry Policy is under way. The intention is to widen the scope and mandate of the Department of Crop Production and Resources (DCPF) to cover all woodland resources instead of just forestry resources only. Simultaneously, the Agricultural Resource Conservation Act, with its broader framework, than the Forest Act, is also under review. These measures will enhance the role of biomass as a CO_2 sink.

What remains uncertain, however, is the capacity of DCPF to effectively maintain the sustainable exploitation of fuelwood. The institutional framework to effectively coordinate and implement local and central government efforts towards the sustainable fuelwood management is still weak. At the communal land level, regulations restoring certain powers to traditional leaders, with regard to exercising their rights over the proper exploitation of natural resources, in areas under their jurisdiction, should continue being supported. The Community-Based Natural Resource Management approach must be encouraged because experience has shown that successful energy programmes in the SADC region are those in which local initiatives play a dominant

role (Davidson and Karekezi, 1993, p. 15; Sibanda, 2000; Katerere, 1999). Similar observations have also been made by Moyo and Sill who emphasize that resource conservation solutions should have a 'bottom-up' component, involving the active involvement of rural families to complement centralised programmes (Moyo and Sill, 1999, p. 10). This point has also been underscored in recent studies conducted in Mali (Becker, 2001).

Also, since the problem is multisectoral, there needs to be effective coordination of planning among the relevant ministries and agencies. Contradictory and detrimental development policies to biomass conservation such as the Accelerated Rainfed Agricultural Program (ARAP) must be curtailed. This program entailed the clearing and burning of thousands of acres of woodland for arable agriculture, thus threatening the sustainability of the natural GHG sink.

Rarely has the relationship involving biomass conservation, population growth, population concentration and poverty alleviation been considered. As long as population growth and redistribution, and employment creation are not given adequate attention, the biomass conservation policy is not likely to succeed in the long term. For example, whereas the percentage of households using firewood decreased from 86% in 1981 to 64% in 1991 due to fuel switching, there was an absolute increase in the number of households using fuelwood due to population growth (Kgathi *et al.*, 1997, p. 39). Increasingly, population is also being concentrated around the large settlements and thus putting additional pressure on the surrounding biomass. The proposed end-use alternatives are currently affordable only to the relatively better-off social groups, and institutions. The poor cannot afford them. Any legislation which deals with the symptoms of environmental stress rather than its primary and interactive causes needs to be revisited and reassessed critically.

Fuelwood is currently an open access commodity and pricing policies do not reflect its true social and environmental costs. A levy on logging operations would provide some funding for reforestation programs.

Like most developing countries, Botswana thus requires fuelwood energy policies which place a premium on up-to-date data on fuelwood in terms of demand and supply, accurate pricing, adaptation to fuel scarcity and energy transitions (Soussan, 1992, quoted by Kgathi, 1997, p. 1). The relationship of fuelwood utilization with other national development policies also needs to be appreciated to facilitate informed and holistic planning which will enhance the preservation of biomass resources and mitigate GHG emissions.

Coal

For NDP8, the policy on the coal energy sector will continue to be:

- To promote local utilization in government institutions, industries, and commerce where appropriate;
- To promote measures designed to put coal in a competitive position vis- a- vis other energy options;
- To establish and monitor technical standards for coal burning.

The review of the supply energy sectors earlier on illustrated the significant contribution of coal to GHGs. The government's policy intention to promote the use of this energy source is demonstrated through the Expanded Coal Utilization Project (ECUP). Unless the cleaner technologies are enforced by the demand sector and at the Morupule Power Generation Station, the increase in coal use will further add to the atmospheric CO_2 and N_2O. Unfortunately, in the Revised Industrial Development Policy (1997), control of emissions is not explicitly considered. The use of integrated gasification combined cycle (IGCC) plants with a higher combustion efficiency of 45%, compared with that of 35% for conventional plants, should be considered to minimize GHG emissions (Field-Juma and Karani, 1994, p. 168). Beneficiation of coal to minimize its polluting qualities should be given priority. For the household sector, low-smoke coal in place of fuelwood is being contemplated. This would enhance the potential biomass CO_2 uptake considerably. Conversion to and uptake of such alternative sources of energy has in the past been however constrained by poverty among the low income households in the urban and rural areas. A mix of strategies involving poverty alleviation and energy subsidization for the poor needs to be considered in order to enable them to afford such alternative forms of energy. Information dissemination on the use of and the potential monetary and time savings associated with adopting new innovations, must be targeted to end-users. For example, studies by Kgathi *et al.* showed that potential users in certain parts of Botswana had not substituted fuelwood by coal because of their lack of knowledge about the resource and lack of appropriate user facilities (Kgathi *et al.*, 1997). The environmental health effects of using coal among poor households within their confined poorly ventilated premises also needs to be thoroughly investigated. The fatal exposure to CO experienced among such households using improvised indoor coal heaters (*imbaula*), in South Africa should be avoided. The monitoring of the quantities of emissions from squatter settlements to the atmosphere is important for producing valid and reliable inventories.

Petroleum products

In Botswana, the transport sector which relies exclusively on petroleum products, is the second most important contributor to GHG emissions. The closest policy statement to climatic considerations is one related to improving safety aspects of liquid petroleum gas (LPG). The significance of its adoption and promotion, with regard to mitigating GHG emissions, lies in the fact that it could be an important alternative to biomass and coal. The five other policies on petroleum place emphasis on monitoring economic efficiency and ensuring the adequate availability of petroleum products.

The transport sector is the most important final demand sector for petroleum products. Carbon dioxide is the main GHG emitted. Botswana's petroleum energy policies of ensuring adequate availability of petroleum products need to consider ways of mitigating GHG emissions from the transport sector, especially private vehicles. The single passenger

car has been estimated to have the highest relative intensity of passenger vehicles (Eriksen, 1995, p. 203). Energy intensity reflects energy consumption per unit transport, which again is an indication of the levels of GHG emissions in the various fossil-fuel consuming modes of transport.

There are two major ways of minimizing emissions from motorized road vehicles, namely, reducing the number of vehicles on the road and/ or reducing the emissions from each vehicle. Mass public transport, including rail transport, needs to be encouraged to minimize the effect of this sector on climate. Measures need to be put in place to ensure that the current tendency for the road-related modes of transport to replace rail transport are controlled through appropriate fuel- pricing mechanisms. Evidence from Brazil demonstrates that up to 25% savings in fuel consumption can be secured through shifting car travellers to direct route buses (Eriksen, 1995, p. 218). Similarly evidence from the Seychelles, Algeria, and Ghana indicates that higher gasoline and diesel prices tend to limit fuel consumption (Eriksen, 1995, p. 225), promote greater efficiency in energy utilization and the reduced emission of CO_2. Conversely, low prices of energy encourage excessive consumption and impedes the introduction of energy efficiency technologies (Ibid.) in terms of, for example, car size and types of fuels used. The present pricing policy of petroleum products in Botswana, and the move towards private car ownership paradigm, facilitated by generous public sector private car loan schemes, can only exacerbate GHG emissions.

Botswana, due to its relative affluence, has one of the highest car-ownership rates in sub-Saharan Africa. Recently, there has also been an upsurge in the importation of cheap second-hand cars from Japan because of a reduction in import duties. Unfortunately, such cars pose maintenance problems because they lack spare parts. Also there are inadequate qualified mechanics to service such imported cars efficiently. This poses a real danger in terms of GHG emissions. Faulty car engines are not environmentally-friendly. Direct emission control, through a stricter enforcement of the Road Traffic Act (1987) and the testing of vehicles could be implemented from government-designated depots. The government of the Seychelles has, for example, set up a vehicle-exhaust-emissions testing centre to ensure that vehicles are fit to be on public roads, as required by the road transport regulations (Eriksen, 1995, p. 227). Similarly, in Ghana, the Ministry of Energy established a project to establish the types and levels of pollutants emitted from various anthropogenic sources, and their relative contribution to air pollution. The results of the project formed the basis for establishing standards for limits on the emission of pollutants from the various energy sources, including vehicles (Wereko-Brobby, 1993, p. 30). Botswana could benefit from adapting such experiences to the local situation.

Of late Botswana's economic boom has also translated itself spatially, in the form of urban growth by fission. This is especially noticeable in the case of its rapidly developing satellite dormitory suburbs of Gabane, Phakalane, and Motsemothlabe. Urban design standards should ensure the realization of agglomeration economies by minimizing travel distances among the urban components. Zoning of landuse can be instituted through limiting urban sprawl, infilling, creating concentrated sub-centres with good transportation links, integrating and intensifying landuse (Eriksen, 1995, p. 228). Proper road engineering designs should be adopted to optimize traffic flow. Provisions should be made to accommodate non-motorized traffic. Parking meters could be installed to discourage private vehicle congestion/emissions, reduce local pollution, and earn revenue for urban councils. Environmental Impact Assessment of transport projects and well-designed urban road networks should provide the answer to efficient traffic management procedures, energy conservation, emission minimization and preserving biomass (Ibid., 1995, p. 219).

The petroleum energy policy also seeks to ensure availability of petroleum products countrywide. This might assist in the conversion from biomass in remote areas. However, certain problems currently face this policy. First, the petroleum distribution network presently does not cover the majority of rural areas, where effective demand is low because markets are small and the population remains relatively poor. Such areas do not offer significant profit motives to the distributing companies. The pursuit of energy policies which enable maximization of benefits through private sector participation, as stipulated by the Integrated Energy Policy, could work against widespread adoption by the poor households. Government should provide mechanisms to evaluate the situation in terms of employment creation to boost demand and meet consumer needs. Secondly, there is little control of prices for illuminating paraffin in rural areas. Higher prices could work against efforts of conversion from biomass to paraffin use for lighting among the poor in the rural areas. Thirdly, paraffin remains both a poison and fire hazard. Suitable measures need to be implemented to solve these problems if adoption is to be facilitated and extended to additional rural users and promote the expected conversion to alternative energy sources which would minimize GHG emissions.

Electricity sector

The Mid-term review of NDP8 highlights two policies for this sector:

- To reduce the level of self- sufficiency, to the extent that imported power can augment supply at a reasonable cost;
- To increase uptake in the use of electricity at household level;
- To continue with the Rural Electrification Programme (Republic of Botswana, 2000, p. 123).

The Botswana Power corporation is mandated to spearhead activities to fulfill these aims. These activities include: increased local power generation from the Morupule Thermal Power Station and the purchase of power from the Southern African Power Pool (SAPP) countries of Namibia, South Africa, Zambia, and Zimbabwe. What are the potential impacts of the electricity sector objectives on climate change? First, the increased local generation of electricity from the Morupule Power station implies increased GHG emissions, unless mitigating measures are put in place. A coal benefi-

ciation study completed in 1998, showed that prior washing of Morupule coal could improve its quality and reduce pollution (Republic of Botswana, 2000, p. 122).The report however concluded that establishing a washing plant would be non-viable from an economic point of view. There is an urgent need to assess viability to incorporate social and environmental costs and benefits in order to come up with a realistic assessment. Moreover, R&D need to be enhanced in order to come up with mechanisms to minimize GHGs emissions from Morupule coal.

Botswana intends to increasingly import some of its electricity from SAPP. For example whereas in 1994, the ratio of local electricity generation to import of electricity was 75:25, the shift was expected to be 44:56 in 2000.

The relaxation of the self-sufficiency policy requirement on electrical power will have mixed implications for climate change. Botswana will obtain cheaper and cleaner hydro- generated electricity from Zambia. This will not only assist in minimizing GHGs emission but also promote sub-regional economic and political cooperation. However, imports from coal-based Matimba thermal station in South Africa imply negative environmental impacts for climate change.

The objective of increasing uptake in the use of electricity is critical to the process of switching from fuelwood. Available evidence indicates that the number of consumers connected to the grid was 25,591 as of March 31st 1992. By March 31st 1996, these had increased by 93.3% to 49,465 (Republic of Botswana, 2001a, p. 155). By and large, these were urban-based private sector, institutional and relatively better-off households. Rural households, who are mostly responsible for biomass GHG emissions, have found it very expensive to adopt electrification. This could be partly due to the scattered population distribution pattern. There exist low load densities and long distances requiring long transmission lines or reliance on local small high-cost generation stations. End-users of electricity could continue to face high connection fees, and the high costs of appliances. All these factors tend to negatively affect uptake at the household level and increase the use of biomass due to population increase and its spatial concentration into the large settlements.

The most significant step towards providing rural areas with electricity to-date is the Rural Electrification Programme. Between 1992–97,the objective was to supply at least 7 villages per annum. This target was increased to 14 villages during the NDP8. Then an accelerated rural electrification programme aimed at 72 villages was started in the 1999/2000 financial year. So far 8 villages have benefited from that scheme. The success of the programme should contribute significantly to biomass conservation and the reduction of GHG emissions.

In spite of a wide range of concessions, the uptake of electricity at household level still remains slow mainly due to low incomes among the rural population. A multi-pronged strategy involving elimination of rural poverty, subsidies from government revenues and BPC surpluses, customization of power provision, reduction of capital costs and reduction of up-front payment of connection fees will go a long way towards promoting energy switching from biomass to electricity.

Renewables

As is the case in the rest of sub-Saharan Africa, energy policies in Botswana do not assign adequate significance to renewable forms of energy. Currently, renewable energy contributes only about 1% to total energy consumption. However, its potential vis-à-vis the scattered rural population and its environmentally benign nature makes it ideal for meeting the future needs of this country and minimizing GHG emissions from the rural household sector. It is the ability to supply electricity reliably to remote locations which makes renewable energy far more valuable than its absolute value in units of energy would suggest (Dube, 2001). Unit costs of such projects have tended to be higher than grid connections in other countries. However, the higher costs must be offset against the probability of non-connection to the grid, and continued reliance on biomass (O'Keefe, 1999, p. 85).

There are three policy objectives for New and Renewable Sources of Energy in Botswana. These are:

- To promote increased use of photovoltaic (PV) electrification in an orderly way with adequate coordination, institutional support, financing and technical standards;
- To promote use of solar water heating systems where appropriate;
- To take advantage of regional and international developments in research and development (Republic of Botswana, 1997, p. 222).

The policy objectives place much importance on the development of solar energy and justifiably so. Botswana is rated as having some of the highest radiation levels in the world. As a result of its clear skies and minimal industrial air pollution, the country experiences insolation of up to 3,200 sunshine h per annum. Two or more cloudy days with solar irradiation of below 10 MJ m^{-2} per day are infrequent. The monthly average solar irradiance on a horizontal surface in Gaborone varies from 26,4 MJ m^{-2} per day in December to 14,9 MJ m^{-2} in June (Botswana National Atlas, 2001, p. 153). Botswana is therefore well-suited for the development of solar energy. The viability of applying solar in Botswana is attested to by the Manyana Pilot Project which is being replicated nationwide.

The achievement of the first two set of objectives would reduce reliance on diesel and coal generated electricity. This would minimize GHG emissions. Currently the scattered rural population relies almost exclusively on biomass energy to meets most of its domestic energy requirements. If PV electrification were to be extended at affordable cost, switching from biomass to solar energy would minimize GHG emissions from fuelwood combustion.

The third policy objective urges the country to draw from experiences elsewhere to promote the use of renewable energy resources. Currently, efforts are being made to promote affordability of PV systems such as through the application of the SADC Programme for Financing Energy Services for Small Scale Uses. A similar program such as the Financing

Energy Services for Small Scale End-use (FIESSE) in Asia could provide an investment focus for public-private sector partnerships in RETS technologies (O'Keefe, 1999, p. 86). Neighbouring countries such as South Africa have the expertise in using methane from landfills. Current landfill designs in Botswana do not facilitate the harvesting of methane. Expertise from South Africa could assists in the appropriate engineering design of new landfills for large settlements by the Department of Waste Management. Methane would then be an ideal substitute for fuelwood. Lessons could be drawn from other developing countries on the use of biogas. With a cattle population of about 2 million, biogas has a vast potential, especially for water pumping and household use in Botswana. Currently, there are only 13 biogas digesters countrywide. R&D program must continue to develop this important energy alternative. At the moment, fuelwood-depleted areas such as Goodhope are burning cattle dung for fuel. The adoption of biodigesters would eliminate GHG emissions from cattle dung and slurry could be used as fertilizer.

The following preconditions will have to be considered seriously before sustainable (Renewable Energy Technologies) RETS can be provided to the rural population on a sustainable basis:

- Identification of rural energy needs and payment capabilities;
- Designing of flexible financing options;
- Involvement of local organizations and provision of local operational support;
- Knowledge of the full, life-cycle costs of all energy options.
- Development of technical standards and codes, through the Botswana Bureau of Standards, for the design, installation and expected performance of RETS.

Rural communities must be continually sensitized on the socioeconomic and environmental importance of RETS, through formal and informal education. Fagbeule has recently emphasized the need for R&D as well as demonstration, dissemination and diffusion of renewable energy technologies (Fagbeule, 2001).

The successful implementation of the energy policies on renewable forms of energy will assist the country greatly towards fulfilling its commitment to the UNFCCC.

Conclusion

Botswana's energy sector emits a relatively small quantity of GHGs. However, even this eventually adds to the global pool of emissions. Quantities will increase in the future due to expansion in industrialization and commercialization.

Botswana has so far adopted energy policies which address climate change issues only indirectly, through targeting the achievement of sustainable development. The country has however recently demonstrated a tangible interest towards developing energy policies which will mitigate GHG emissions. Internationally, it has ratified the UNFCCC. To this effect, it has conducted studies on GHG emissions for the years 1990 and 1994, and submitted its Initial National Communication to UNFCCC,based on the guidelines provided of the Intergovernmental Panel on Climate Change (IPCC, 1996). It has participated in regional efforts aimed at formulating policy on mitigating GHGs from the energy sector. Recently, a National Committee on Climate Change, under the Department of Meteorological Services, has been established in Botswana.

The paper has addressed Botswana's current national energy policies and their implications for climatic change. Several challenges related to current energy sector policies and their potential impact on climate change have been identified. The need to develop an explicit and coherent energy policy, which addresses climate change, cannot be overemphasized.

Several of country's energy sectoral policies indicate some willingness to adopt environmentally-benign energy options. However, at times, the lack of either appropriate supportive institutions or human resources have tended to frustrate the realization of sustainable energy utilization. These need to be developed in order to ensure the systematic coordination and enforcing stipulated standards on emissions. Where suitable instruments are in place, there may be problems of conflict or lack of consistency among the potential implementers of policy. Organizational and implementation structures specifying the roles of the respective Ministries and Departments are required to enforce the policies which are aimed at sustainable development. R&D needs to get stronger support for research into New and Renewable forms of Energy. The Division of Energy Affairs will have to play a more decisive role in ensuring that the objectives of the National Committee on Climate Change are realized.

Although environmentally-desirable, switching to cleaner and sustainable energy forms appears to be unaffordable to the majority of rural households. The irony is that although Botswana is currently ranked as one of the richest countries in Africa, it faces the problem of income disparities. Government needs to initiate realistic and sustainable programmes to achieve equitable income redistribution to improve access to services and goods to its entire population. Once the standard of living of the bulk of the population is improved, the adoption of cleaner energy options will lead to biomass conservation and the mitigation of GHG emissions.

There is a need to increase public awareness, through formal education and Information Education and Communication (IEC) programmes of the potentially negative effects of GHG emissions on the environment. The general public needs to be sensitized, for example, on the economic and environmental advantages of using public transport, non- motorized transport and RETS. Botswana should take advantage of its well-established public participation institutional structures to involve all the stakeholders in the adoption and promotion of the energy policies which minimize GHG emissions.

The fulfillment of Botswana's national development goals will require substantial energy inputs, most of which are not environmentally-friendly at the moment. Population

growth and the increasing spatial concentration of population in large settlements will continue to place a heavy ecological burden on the adjacent biomass resources. Switching to alternative energy resources is currently constrained by technological, financial, and human resource limitations. Explicit and properly-coordinated energy policies for mitigating the negative impacts of GHG emissions on climate cannot be overemphasized.

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