

ENERGY APPLICATIONS IN BOTSWANA

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Abstract—Botswana depends heavily on imported petroleum products for all premium applications. However, there is an abundant reserve of coal and other alternative sources of energy. This paper presents the energy trends and the various options for harnessing the resources. The importance of energy conservation is also discussed.

Energy availability Alternative energy resources Botswana

1. INTRODUCTION

Botswana is a land locked country located between 18 and 27°S lat and 20 and 29°E long and lies mainly within the Kalahari desert. About three-quarters of the land is situated north of the Tropic of Capricorn. The country is characterized by a rather low population density and over 70% of the people are involved in both agriculture and pastoralism [1].

For several years, imported petroleum was the main source for conventional energy applications so that a severe burden was imposed on the balance of payments. The oil crises of 1973 and 1979 worsened the situation, and the country was compelled to embark on energy diversification programmes. Policies were articulated to employ local energy resources as far as possible. Research and development of non-conventional energy, such as solar and wind, was encouraged. Contingency plans were also developed to reduce the consequences of any possible disruptions in the supply of imported petroleum. Consequently, the patterns of both fuel supply and utilization have gradually changed.

Electrical power generation is now primarily by medium thermal systems using pulverized coal fuel. Figure 1 shows the annual electricity consumed by various users. However, less than 20% of the population obtains electricity from the national grid. Small dedicated diesel stations serve the needs of a few remote communities. Consequently, others depend on fuel wood for their domestic activities. Figure 2 depicts the energy index (electric energy consumed per capita) over an 8 yr period. There was a rapid growth between 1987 and 1989. The flat rate since 1990 may be due to several local and international factors. It is interesting to note, however, that the standard of living in Botswana continues to have an upward movement [2]. In many developing nations, improved standard of living is usually characterized by increased energy consumption.

2. ALTERNATIVE ENERGY

2.1. Solar

Solar energy is abundant in Botswana, and the maximum extraterrestrial radiation is about 43 mJ/m²-day. Figure 3 depicts the daily global insolation for six synoptic stations [3]. The solar resource has been employed for various applications. Solar water heaters have been developed and are manufactured locally for domestic purposes. However, there are no national regulations to guide both the manufacturing standards and the installation practices. The operational units also have not been subjected to long term monitoring to determine the durability and efficiency of the individual components and the complete system. However, there is an ongoing investigative study

by the Botswana Technology Centre to determine the performance of the hot water heaters installed on some of their staff houses [4].

Opportunities for using solar energy, both for water purification and common salt production, are vast. Water from boreholes, especially in the Kalahari area, is too saline for direct human and animal consumption. Portable solar stills have been designed by the Rural Industries Innovation Centre (RIIC).

The geographical nature of the country makes it either impossible or uneconomical to connect all prospective consumers to the national grid. Photovoltaic systems are, thus, finding increasing use for various purposes such as lighting, water pumping, telecommunication repeater stations, refrigeration, railway signalling and other appropriate applications.

2.2. Wind energy

Wind energy has been used on a small scale to supply water both for livestock and irrigation in Botswana. In many of these applications, it serves only as a secondary resource to diesel engines. The most common design has been installed by the Rural Industries Innovation Centre (RIIC). This windmill has 20 blades of 4.3 m dia installed on a 12 m tower.

Although there is a dearth of information on the wind energy characteristics of Botswana, it seems that wind speeds are generally low. Preliminary results from a study [5] suggest that low speed aerogenerators can be operated for various domestic applications such as milling of grains, pumping water and even for lighting purposes in small remote villages around Botswana. It is

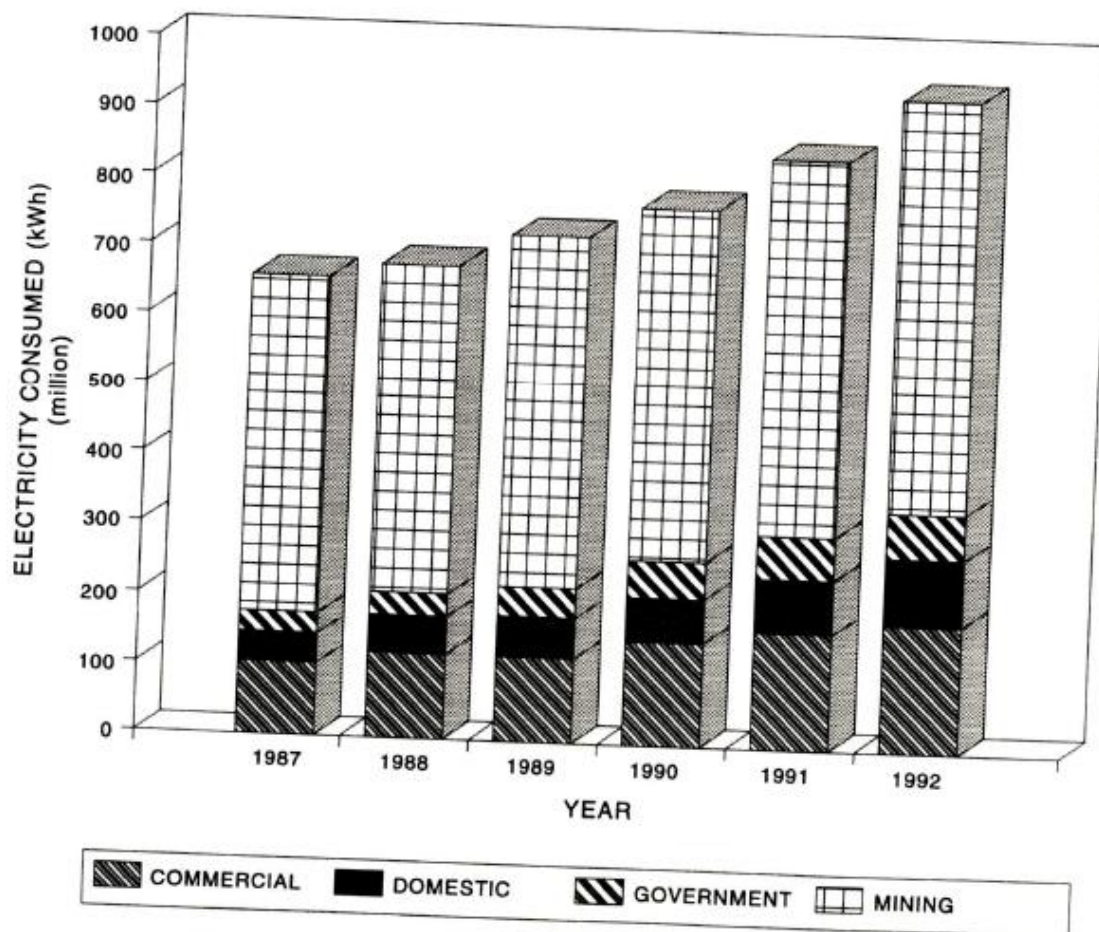


Fig. 1. Annual electricity consumption.

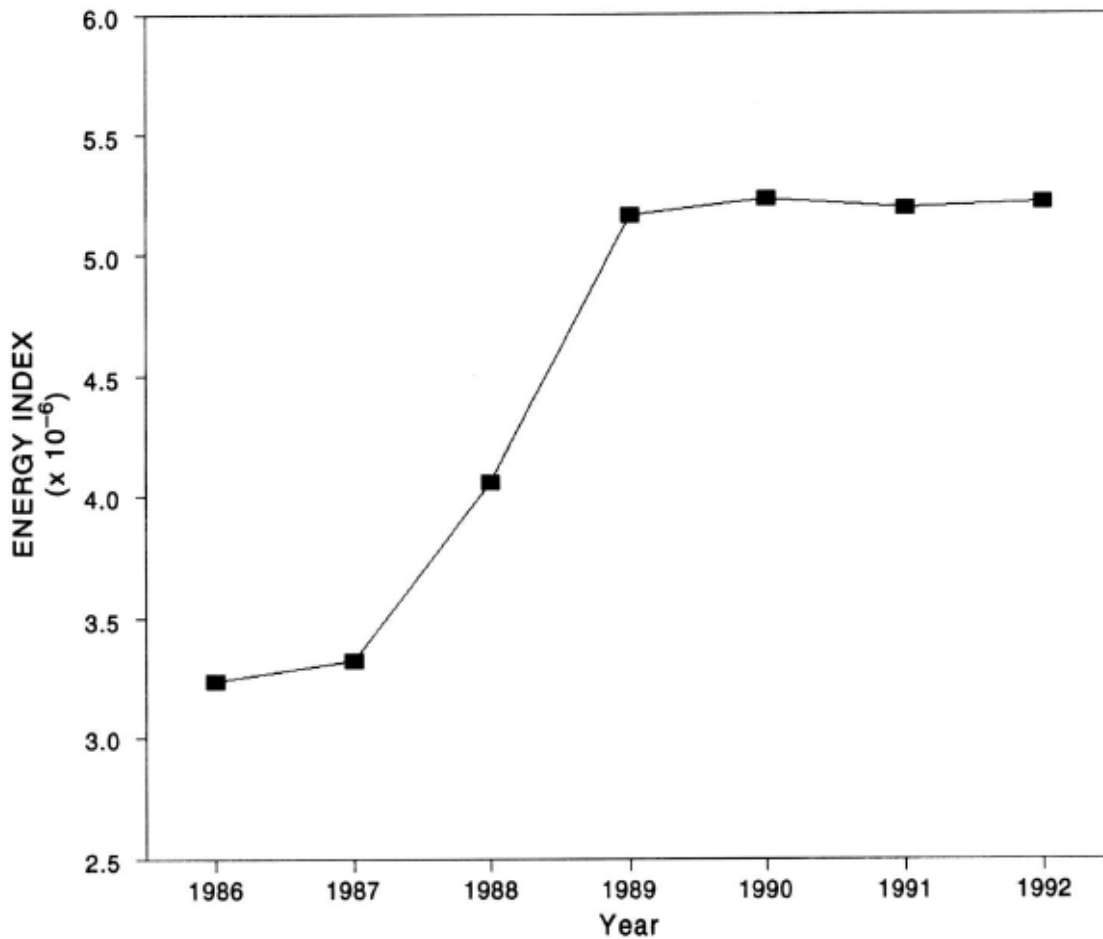


Fig. 2. Variation of energy index.

particularly suited to water pumping as intermittent wind could still supply the needs when an adequate storage facility is incorporated.

2.3. Biogas

Methanogenesis is the production of biogas when there is anaerobic decomposition of fermentable organic matter in a digester. Animal dung is readily available in various districts of Botswana because the country is well endowed with a large number of cattle. Using the characteristics of mature non-stressed animals, Table 1 depicts the average annual yield of biogas which would have been produced from the cattle dung scattered all over the country. It can be observed that over 60% of the national electricity demand could be met by biogas alone. However, because of the enormous scatter of cattle dung and the associated problems of its collection, the available quantity would be reduced. Also, the cattle are bred mainly in rural areas so that biogas could make a significant contribution to the energy mix in these zones.

2.4. Wood fuel

Wood is the commonest source of energy in the rural areas. These communities constitute over 75% of the population. Many people in urban areas also depend on wood for various domestic activities. Thus, wood fuel is an important energy income in Botswana. The agro-ecological zones and vegetation in Botswana could yield large quantities of wood. However, the density of the preferred species of wood is in acute supply. Thus, women and children who always collect the

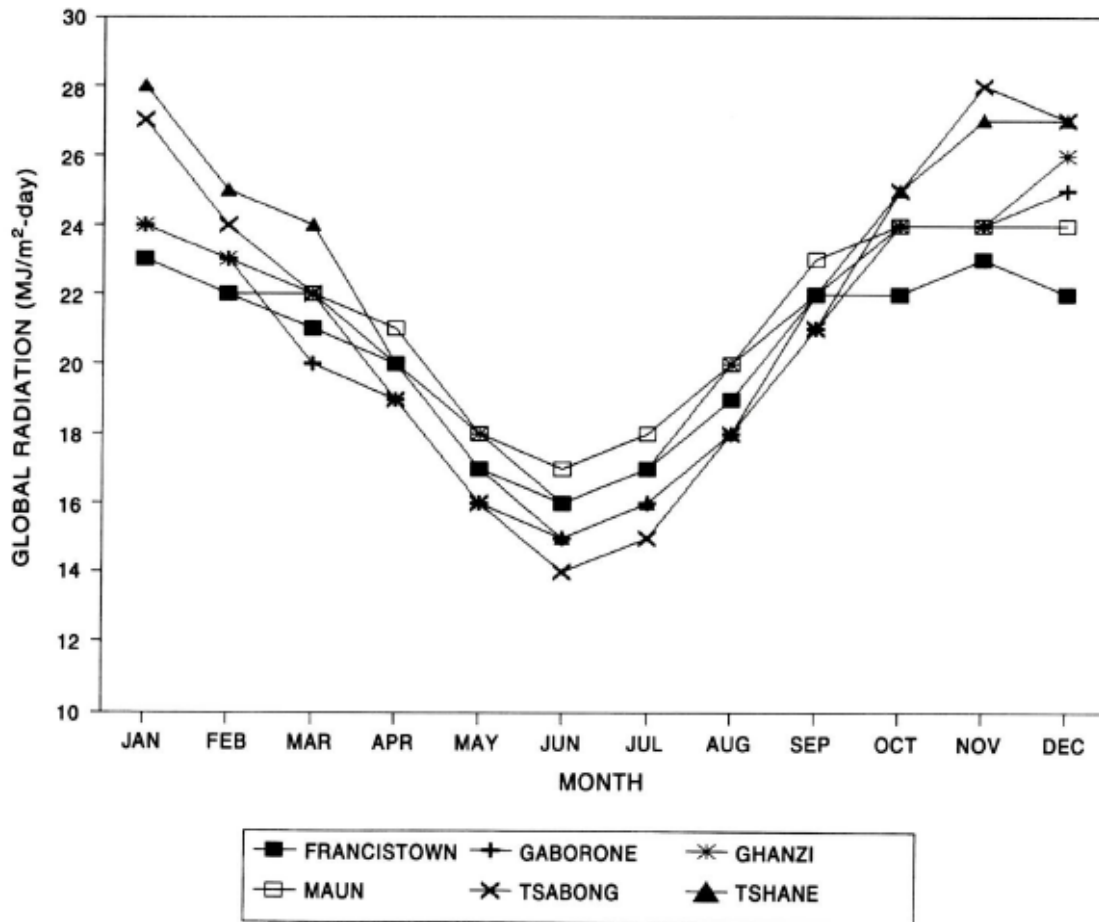


Fig. 3. Variation of global radiation.

wood fuel have to walk far distances in search of it. The resource has also become increasingly scarce due to deforestation and incessant drought. Consequently, intensive reforestation programmes are required to prevent a localized energy crisis.

3. NON-RENEWABLE ENERGY

3.1. Coal

Botswana has about 17×10^9 tonnes of proven coal reserves. The conservative estimate of economical reserves is about 4×10^9 tonnes. Thus, the country has one of the largest recoverable

Table 1. Estimates of biogas production

Year	Biogas (10^9 m^3)	Electricity consumed (10^8 kWh)	†Biogas estimate/ electricity consumed
1986	3.6	6.8	0.79
1987	3.5	7.4	0.70
1988	3.7	7.9	0.70
1989	3.9	8.6	0.67
1990	4.1	9.2	0.67
1991	4.4	10.0	0.65
1992	4.6	11.0	0.63

†1 m³ of biogas \approx 1 kWh of electricity.

coal estimates in Africa. At 10 times today's local production rate, the reserve would still not be depleted for at least 400 yr. The uneconomical reserves may also become attractive depending on the future situation of world energy in terms of costs and guarantee of supply. Thus, coal is a dependable source of energy in Botswana. Consequently, the Government has encouraged its use for various applications, including power production. Coal gasification is an attractive use for the local coal, especially as there is no proven reserve of natural petroleum gas.

4. ENERGY CONSERVATION

All non-renewable energy resource uses are capital expenditures so that their availability is finite. Even when renewable energy is utilized, the initial capital cost can be high. Thus, the energy release from any power system must be used optimally. It is, therefore, necessary to eliminate waste in every form by introducing energy conservation practices. The overall efficiency of thermal equipment and units can be improved by good house-keeping practices and heat recovery techniques.

Hybrid systems consisting of two or more renewable energy options can also be employed to reduce the total consumption of fossil fuels.

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