Chapter 4: Atmosphere and climate

4.1: Introduction

The atmosphere consists mainly of nitrogen (78%) and oxygen (21%), and traces of water vapour, carbon dioxide, argon and other gases (1%) (Enviropaedia, 2002). Anything that disturbs this normal chemical balance of the air can be considered as a form of pollution.

Pollution can either be of natural or anthropogenic (man-made) origin. Both natural and anthropogenic activities increase the atmospheric concentrations of gases (e.g. carbon dioxide) above the normal range. Anthropogenic activities include vehicle use, industrial processes and burning of fossil fuels. Natural sources of these pollutants would include veld fires. However, veld fires can also occur from human activity as is evidenced in the Eastern Cape Province. Extensive veld fires in the summer rainfall areas of the Province (with savanna and grassland vegetation) mostly result from human activity (Landman, *pers comm.* 2003).

During the Southern African Fire-Atmosphere Research Initiative (SAFARI-92) and the recent Southern African Regional Science Initiative (SAFARI 2000) it was apparent that South Africa shares its air mass with other countries in the region. Smoke and haze can be transported from the tropics across southern Africa and extend into the Eastern Cape Province (Swap *et al*, 2003). Thus regional pollution sources, especially biomass burning, may be responsible for episodes of poor air quality across the entire province.

The Eastern Cape Province has nine different climatic regions. These nine climatic regions range from areas with late summer precipitation, through to those with frost during winter, to areas with rainfall throughout the year. Agricultural activities include both livestock and crops. The availability of water for these practices is closely linked to rainfall, temperature, management and land use practices (DEAT, 1999). It is predicted that the Eastern Cape Province will be one of the areas worst affected by climate change in South Africa (Rogers, 2003).

Carbon dioxide is considered the most important greenhouse gas (based on emission quantities per year). According to the United Nations, South Africa is the third highest producer of carbon dioxide per capita in the world (Enviropaedia, 2002). Unnaturally high concentrations of carbon dioxide in the earth's atmosphere has amplified the naturally occurring greenhouse effect. This has led to an increase of 0.6 ℃ in the earth's surface temperature, most of this increase occurring after 1975.

One of the biggest environmental threats to human health in South Africa is domestic fossil fuel burning. In 2001, 610 000 households in the Eastern Cape Province were not electrified and therefore relied on fossil fuels for domestic purposes (NER, 2003). In addition to the use of fires for domestic purposes, they also have a cultural significance (Lents and Nikkila, 2000). Indoor air pollution is thus of utmost importance in the Eastern Cape Province. Studies in a highly polluted industrialised area in South Africa showed that particulate matter in the ambient air (about 70%) was mainly from domestic fuel use and dust, and that industry and motor vehicles contributed only 30% (Terblanche, 1998).

Pollution dispersion in an area is largely influenced by climate and topography, but also the height at which emissions are released. Emissions released at ground level, such as would occur during domestic fuel use, are not easily dispersed and tend to cause fairly severe but localised pollution episodes. Pollution released higher from chimney stacks is more easily dispersed but is also affected by the presence of inversion layers. Pollutants emitted under normal conditions are warmer and less dense than the surrounding air, and as a result they rise and are easily dispersed into the atmosphere. In an inversion situation, the pollutants rise only to the point where they reach a warmer layer of air. When this layer of warm air is near to the ground (as it is in an inversion layer), the pollutants accumulate near the ground (Zunckel *et al.*, 2002). An inversion layer will therefore result in elevated pollution levels close to the ground.

The Coega area in Port Elizabeth is the largest industrial area in the Eastern Cape Province. The highest ground level concentrations of pollutants may be expected at Coega during the months of May to July (Zunckel *et al.*, 2002) when inversions are more frequent.

4.2: Key Indicators

Six indicators have been selected for monitoring and reporting on the atmosphere and climate of the Eastern Cape Province. These indicators include:

- Ambient sulphur dioxide concentration;
- Ambient particulate matter concentration;
- Ambient nitrogen dioxide concentration;
- Quarterly clinic admissions for respiratory infections by type of infection;
- Trend in household energy use per energy type; and
- Annual rainfall deviations relative to the mean annual rainfall period 1961-1990.

Information and data on these six indicators are presented in the sections that follow.

4.2.1: Ambient sulphur dioxide concentration

The ambient sulphur dioxide (SO_2) concentration will provide an indication of the level of air pollution from industrial development, as well as other sources such as domestic fuel use. Knowledge of the atmospheric level of air pollution is important for understanding the impacts of these pollutants on both human and ecological health.

A monitoring programme for SO_2 is in place in the Nelson Mandela Metropolitan Municipality (NMMM). This programme is a continuation of the 'National Network for Monitoring Smoke and SO_2' that was phased out in the early 1990's. Much of this data is only available as raw data that has not yet been processed, analysed or interpreted. There are also gaps in the data. Trends are therefore not readily available from this monitoring programme.

Table 4.1 shows the available annual average SO_2 concentrations for selected sites in Port Elizabeth, Uitenhage and Despatch. The World Health Organisation (WHO) annual SO_2 guideline value of 50 $\mu g/m^3$ was exceeded in 2000 at DoraNginzi and in 2003 at the Perseverance industrial and Despatch residential sites.

Table 4.1: Annual average SO_2 concentration in Port Elizabeth, Despatch and Uitenhage – 1999 to 2003 (µg/m^3) (Slabbert, *pers comm.* 2003)

Location	1999	2000	2001	2002	2003 (up to Oct)
City Hall (CBD)	16.2	13.2	A	A	14.9
Neave Industrial	10.8	C			
DoraNginzi (township)	18.2	52.4	A	C	
Deal Party (Industrial)	30.3	36.5	A	A	33.2
Perseverance (Industrial)	8.1	13.5	A	A	72.1
Markman Industrial	33.3	A	C		
Bluewater Bay (residential)	27.9	A	A	A	C
Despatch (residential)	D	D	D	A	(E)104.1
Uitenhage Park (residential)	D	D	D	D, A	15.6
Uitenhage (industrial)	D	D	D	D, A	13.6

A Results missing for > 2 months
B Station non-existent for part of the monitoring period
C Station closed
D Data not processed yet
E High values possibly due to burning at pallet works

The NMMM also uses OPSIS (an open-path mobile station) to continuously monitor SO_2 at the corner of Kempston and Uitenhage roads in Port Elizabeth (Slabbert, *pers comm.* 2003). Results indicate that values were well below the South African and WHO 24-hour guideline values of 50 µg/m^3 (WHO, 1999; DEAT, 2001). The annual averages from the same stations (years for which adequate data was available) were as follows:

Table 4.2: Annual average SO_2 concentration in Port Elizabeth – 1999 to 2001 (Slabbert, *pers comm.* 2003)

Year	Concentration (µg/m^3)
1999	16.1
2000	13.0
2001	14.1

SO_2 monitoring is also undertaken at Coega, with stations located at Amsterdamplein, Saltworks and Motherwell. Results indicate that during 2001 the highest sulphur dioxide concentrations were found with land breezes and stable atmospheric conditions. Concentrations at all three stations were well below the current South African and WHO 24-hour (125 µg/m^3) and annual (50 µg/m^3) guideline values, with the maximum 24-hour concentration of 10.4 µg/m^3 measured at Amsterdamplein in June 2001 (Guastella, 2002; WHO, 1999; DEAT, 2001). During 2002 the highest SO_2 concentration of 16.1 µg/m^3 was again measured at Amsterdamplein (Guastella, 2003).

4.2.2: Ambient particulate matter concentration

Airborne particulate matter is a complex mixture of pollutants released from many sources. It is normally found in a range of sizes. Ambient particulates resulting from motor vehicle emissions, combustion processes and domestic burning practices are normally classified as fine particulate matter (particulate matter with an aerodynamic diameter of less than 2.5 µm) (Wilson and Mage, 2000). Coarse particulates ($PM_{2.5\text{-}10}$) are mostly generated by mechanical process such as industrial processes. Particles with a diameter below 10 µm, and particularly those of less than 2.5 µm in diameter, can penetrate deep into the lungs and appear to have the greatest potential for damaging health (Hubbard, 1998). Total suspended particulate matter (TSP) refers to all airborne particulates, without particle size differentiation (Van Leeuwen & Hermens, 1995).

The NMMM monitors particulate matter (PM_{10}) continuously using the OPSIS system (Slabbert, *pers comm.* 2003). Limited results are available as a result of technical problems associated with the monitor. The annual average particulate matter concentration of 40.3 µg/m^3 for 2001 is well below the South African annual PM_{10} guideline value of 60 µg/m^3 (DEAT, 1998).

PM_{10} has also been monitored in East London since March 2003 to gather background data as part of the Industrial Development Zone (IDZ) initiative (Turnbull, *pers comm.* 2003). No results were available from this initiative.

Continuous monitoring of particulate matter (TSP and PM_{10}) is conducted at Coega (Port-Elizabeth), specifically at Amsterdamplein (TSP), Saltworks (TSP) and Motherwell (PM_{10}) (Guastella, 2002). Results are provided below in Table 4.3. The number of exceedances of relevant guideline values are indicated in Table 4.4.

Table 4.3: Maximum 24-hour TSP concentration measured at Coega – 2001 to 2002 (Guastella, 2002; Guastella, 2003)

Year	Compound	Maximum concentration (µg/m^3)	South African guideline value	Location
2001	TSP	79	300	Amsterdamplein
2002	TSP	139	300	Amsterdamplein

Results in Table 4.3 indicate that the maximum 24-hour concentrations of TSP during 2001 and 2002 were below the current South African 24-hour guideline value of 300 µg/m^3 (Guastella, 2002; Guastella, 2003).

Table 4.4: Number of exceedances of South African and US-EPA 24-hour PM_{10} guideline values at Motherwell, Coega (Guastella 2002; Guastella, 2003; US-EPA, 1996)

Year	Guidelines exceeded (µg/m3)	Number of exceedances	Location of exceedances
2001	SA: 180 US-EPA: 150	4 6	Motherwell
2002	SA: 180 US-EPA: 150	1 2	Motherwell

During 2001 concentrations of PM_{10} exceeded the South African 24-hour guideline value of 180 µg/m^3 four times at Motherwell, while the US-EPA guideline value of 150 µg/m^3 was exceeded six times (Table 4.4) (Guastella, 2002). During 2002, the South African guideline value was exceeded once, while the US-EPA guideline value was exceeded twice (Guastella, 2003).

4.2.3: Ambient nitrogen dioxide concentration

Nitrogen oxides are emitted mainly from the burning of fossil fuels, and are generally emitted in the form of nitric oxide (NO). In the atmosphere, nitric oxide is rapidly oxidised to nitrogen dioxide (WHO, 1997). Nitrogen dioxide may also be released to the atmosphere from industrial processes, including the manufacture of nitric acid and fertilizers, motor vehicle exhaust fumes and domestic fuel burning. Nitrogen dioxide is the main precursor of ozone (O_3), and thus a major component of oxidant air pollution. The sum of nitric oxide (NO) and nitrogen dioxide (NO_2) are generally referred to as nitrogen oxides or NO_x (WHO, 1997).

The NMMM uses OPSIS (an open-path mobile station) to monitor NO_2 on a continuous basis as a measure of motor vehicle emissions (Slabbert, *pers comm.* 2003). No exceedances of the WHO hourly guideline value of 200 $\mu g/m^3$ was found (WHO, 1999). The only available annual average of 13 $\mu g/m^3$ for 2000 is well below the South African annual guideline value of 94 $\mu g/m^3$ (DEAT, 1998).

Monitoring of NO, NO_2 and NO_x have also been conducted in East London since March 2003 to gather background data as part of the IDZ initiative (Turnbull, *pers comm.* 2003). No results were available.

4.2.4: Quarterly clinic admissions for respiratory infections by type of infection

This indicator, in conjunction with the first three indicators, assists in providing an indication of how air quality is affecting the incidence of acute respiratory infections, particularly amongst children and the elderly. Much of the Eastern Cape population can be considered a sensitive population group (below 15 or above 65 years of age) (Statistics South Africa, 2003). About 10.2% of the total Eastern Cape population is below 5 years of age (Statistics South Africa, 2003). This age group is considered particularly vulnerable to air pollution related diseases.

Lower respiratory infection rates for children under the age of 5 years could only be obtained for the Nelson Mandela Metropolitan Health District. These are indicated in Table 4.5.

Table 4.5: Lower respiratory infection rate for children under 5 years of age in the Nelson Mandela Metropolitan Health District (Greene, *pers comm.* 2003)

Period	Rate	Total number of new cases
March 2003	2.8	805
April 2003	2.3	707
May 2003	2.7	836
June 2003	3.4	1 064
July 2003	2.7	841
August 2003	2.3	190

The prevalence of acute respiratory infections in children under 5 years of age (defined as children who were ill with a cough, accompanied by short, rapid breathing during the 2 weeks preceding the survey) are indicated in Table 4.6. The Eastern Cape Province is compared to the KwaZulu-Natal Province, which had the highest prevalence rate.

Table 4.6: Prevalence and treatment of acute respiratory infection (ARI) in children under 5 years of age – 1998 (DOH, 1998)

Province	Percentage children with ARI	Among children with ARI, % taken to health facility or health care provider	Total number of children
Northern Cape	15.1	71.6	97
Eastern Cape	**15.6**	**73.2**	**690**
KwaZulu-Natal	25.9	77.5	1 022
Free State	20.9	79.0	244
Gauteng	21.5	84.1	911
Mpumalanga	20.4	73.2	361
Northern Province	14.5	68.6	691
Western Cape	15.0	(54.9)	396
North West Province	14.0	(70.7)	327

Note: Figures in brackets are based on 25 to 40 un-weighted cases.

The percentage children with acute respiratory infections in the Eastern Cape Province (15.6%) is lower than in most other Provinces. It should be noted that these figures will also include non-air pollution related infections such as influenza.

4.2.5: Trend in household energy use per energy type

In addition to knowing the potential for air quality impacts on the ambient environment, it is important to address any potential impacts on the indoor air quality in communities in the Province. One of the major factors affecting indoor air quality is the dominant household energy source. Figures 4.1 to 4.3 show the number of households per District Municipality using various different types of energy for different domestic purposes (Municipal Demarcation Board, 2003).

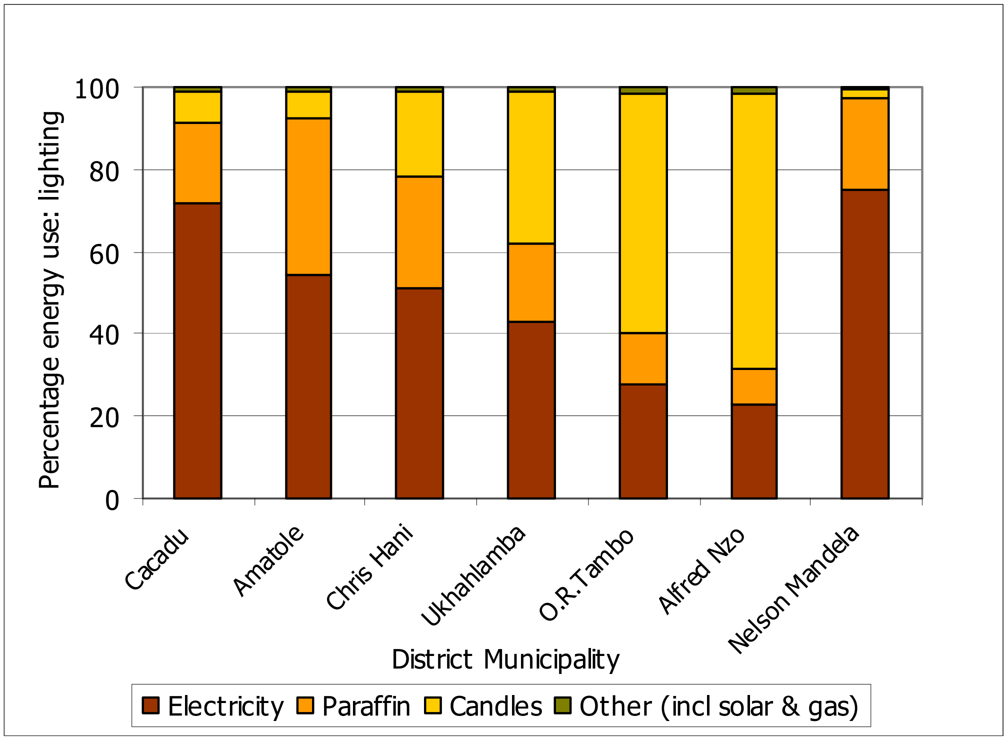

Figure 4.1: Energy use for lighting in the Eastern Cape Province – 2001 (Municipal Demarcation Board, 2003).

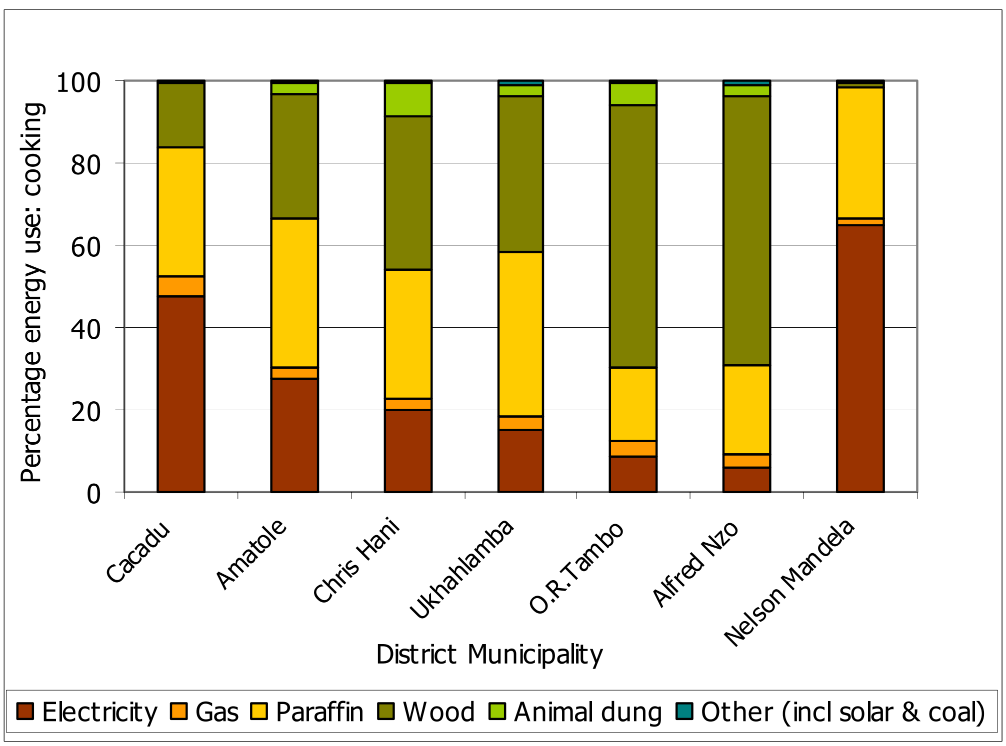

Figure 4.2: Energy use for cooking in the Eastern Cape Province – 2001 (Municipal Demarcation Board, 2003).

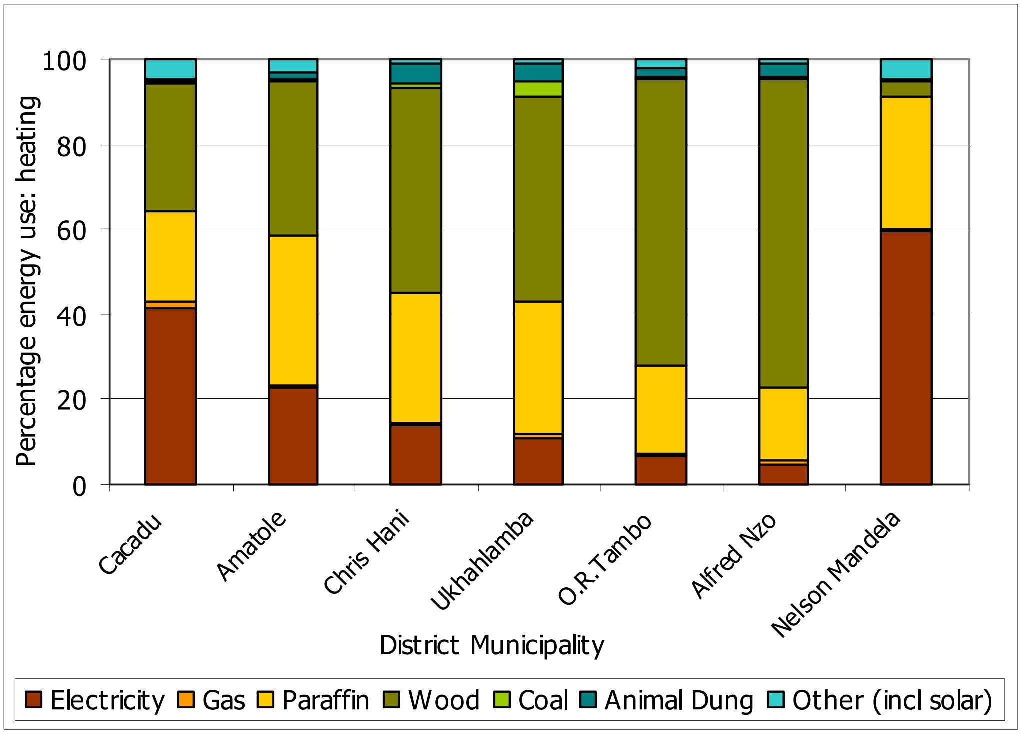

Figure 4.3: Energy use for heating in the Eastern Cape Province – 2001 (Municipal Demarcation Board, 2003).

These graphs indicate that electricity is the predominant energy source in the NMMM, with wood use for cooking and heating being the most prevalent energy source in O.R. Tambo and Alfred Nzo District Municipalities. The NMMM is a predominantly urban area whereas O.R. Tambo and Alfred Nzo District Municipalities are more rural in nature.

The trend in household energy use in the Eastern Cape Province has also varied over time, as shown by Figure 4.4. The figure shows information on energy use as collected during the 1996 and 2001 national Census.

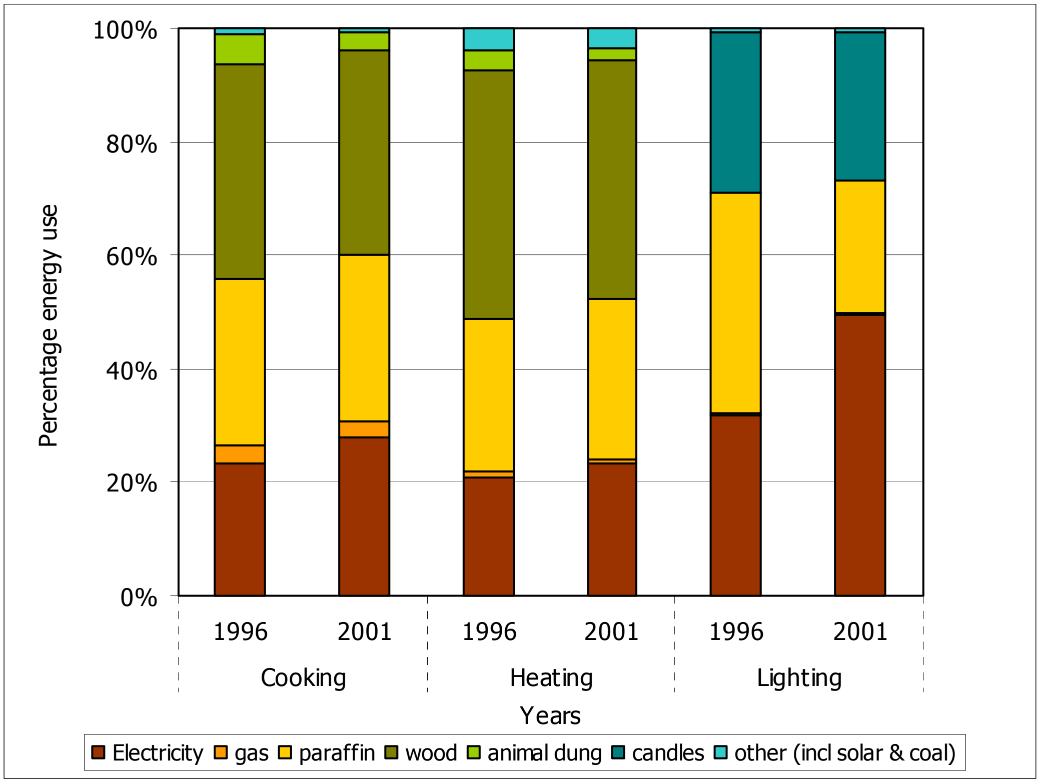

Figure 4.4: Energy use by Eastern Cape households for cooking, heating and lighting – 1996 vs. 2001 (Statistics South Africa, 1999; Statistics South Africa, 2003).

In South Africa, just over half (51%) of all households use electricity as the main source of energy for cooking, while about one fifth use paraffin (21%) and wood (20%) respectively (Statistics South Africa, 2003). In the Eastern Cape Province, commonly regarded as one of the poorer Provinces in South Africa, approximately 51% of households use sources other than electricity for lighting (see Figure 4.4) (Statistics South Africa, 2003). Approximately 77% of households still use sources other than electricity for heating, including biomass (Statistics South Africa, 2003). Biomass smoke contains many thousands of airborne substances, many of which are harmful to human health (Brauer, 1998). Approximately 28% of the population uses electricity for cooking, while 36% uses wood (Statistics South Africa, 2003). The use of electricity for lighting has increased from 32% in 1996 to 50% in 2001, with only a 4% increase in its use for cooking and heating (Statistics South Africa, 1999; Statistics South Africa, 2003). The use of solar energy, reported in the 2001 Census, is still low with less than 1% of households in the Eastern Cape Province using this energy source (Statistics South Africa, 2003).

4.2.6: Annual rainfall deviations relative to the mean annual rainfall period 1961-1990

As no gradual rainfall trend for the past 10 years relative to the climate reference period 1961-1990 was evident, it was not possible to demonstrate any steady increase or decrease in rainfall in recent times. Data over a longer time period may or may not determine statistically whether changes are merely the result of natural cycles or resulting from climate change.

4.3: The state of the atmosphere and climate in the Eastern Cape Province

Atmosphere and climate issues in the Eastern Cape Province are not considered priority issues, as is evidenced by the amount of data and information that was not available for presentation in this chapter. Few large industrial areas exist, with the largest being the Coega industrial zone in Port Elizabeth.

As no co-ordinated air quality monitoring network exists in the Province, air quality monitoring is performed on a fragmented basis, concentrated mainly in the Port Elizabeth area. No comprehensive assessment of air quality is therefore possible for the Eastern Cape Province. Ad hoc studies show very few instances where measured atmospheric pollution concentrations exceed the available guideline values. This situation is primarily a result of the current but out-dated air quality legislation, the Atmospheric Pollution Prevention Act 45 of 1965. Once new air quality legislation has been introduced to South Africa, this situation will change.

Energy sources used in the Province are predominantly paraffin and wood, with rural areas relying more heavily on these fuels than urban areas. Electricity, where available, is used mostly for lighting only. One of the reasons for this could be the high capital cost of purchasing electrical appliances for cooking and heating. More households used electricity in 2001 than in 1996. Indoor air quality is therefore likely to present a problem in those households not using electricity. Although not quantified, the effects from indoor air pollution are expected to be fairly high. A South African study involving informal households using paraffin for cooking revealed that sensitive individuals in all of the households were at risk of experiencing adverse health effects from exposure to NO_2 emissions (Muller et al., 2003).

Little information was available on clinic admissions for respiratory infections in the Eastern Cape Province. It is therefore not possible to provide an assessment of the impacts of air quality on human health in the Province.