Information on climate change in South Africa:
greenhouse gas emissions and mitigation options

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TOPIC 1

What is the current situation with regard to South African emissions, and what are the projections for the future?

CONTENTS

1. Current and historical emission trends

There have been three official analyses of South Africa's greenhouse gas (GHG) emissions to date; the published 1990 and 1994 GHG inventories and the 2000 GHG inventory which is currently under review (DEAT 2009). These official inventories, however, only reflect the country's emissions in specific years and do not give the full picture of the past emissions. In an attempt to understand the country's past emissions, we have reconstructed the country's emissions profile from 1950, based on published historical energy and industrial process statistics. The findings of both the official inventories and our own reconstructions are presented below.

1.1 Official 1990, 1994 and 2000 (under review) inventories

The total national emissions for 1990, 1994 and 2000 are 347, 380 and 435 million tons of CO_2-equivalent respectively. Figures 1 and 2 below show the emissions for the three inventory years disaggregated by gas and by sector.

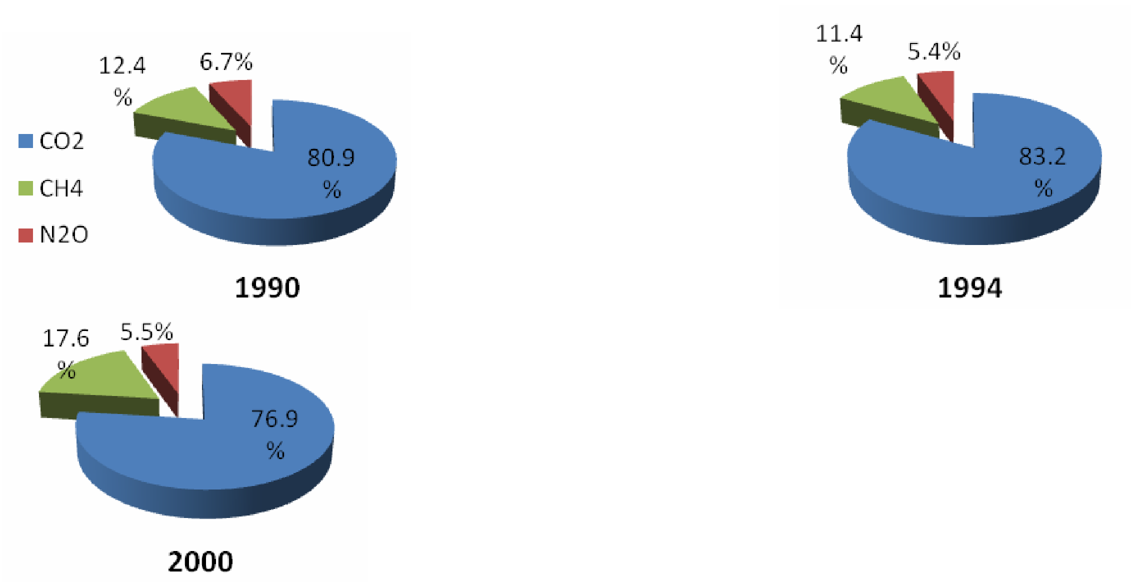

Figure 1: Composition of the official 1990, 1994 and 2000 GHG inventories (DEAT 2004; DEAT 2009)

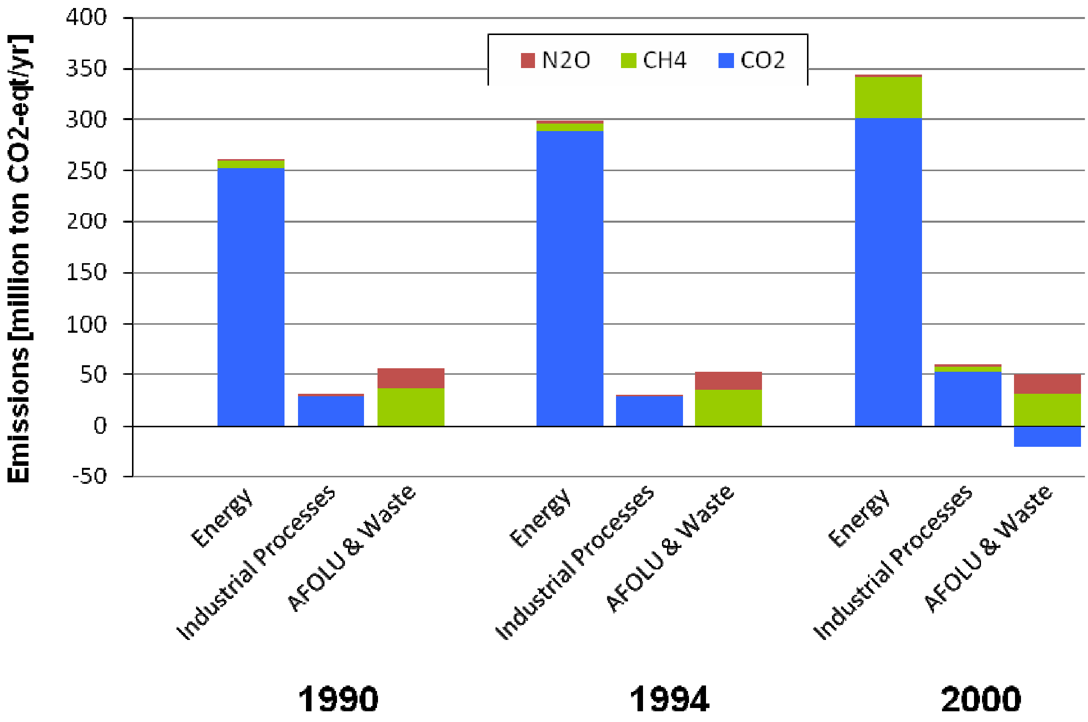

Figure 2: Official 1990, 1994 and 2000 GHG inventories disaggregated by sector and gas (DEAT 2004; DEAT 2009)

1.2 Our own reconstructions

Here the IPCC tier one method of estimating GHG emissions was used. Historical energy statistics and industrial process activity data gathered from government resources, NGO databases and industry databases were multiplied by the relevant emission factors to determine emissions of the three main GHGs – CO_2, CH_4 and N_2O.

1.2.1 Energy emissions

Using national energy balance data from the International Energy Agency (IEA 2005), the IPCC reference approach was used to estimate fossil energy emissions. The following assumptions were made based on the 1996 IPCC guidelines:

- Emissions of fuels stored in marine bunkers do not contribute to the national inventory.
- Coal and oven coke used in the iron and steel industry were not included in the energy inventory because they are accounted for in the Industrial Processes section.
- Some of the carbon contained in products used for non-energy purposes remains stored and the extent of storage is determined by the following storage factors:

Product/fuel	***Fraction of carbon stored***
Lubricants	0.5
Bitumen	1.0
Coal oils & tars (6% of Coking coal)	0.75
Naphtha as feedstock	0.75
Coal as feedstock in Petrochem industry	0.75
Natural gas as feedstock in Petrochem	0.33

- The fraction of oxidized carbon was assumed to be 0.98 for all primary fuels.

Figures 3 and 4 below present our reconstructions of the reference approach absolute and per capita historical fossil energy CO_2 emissions respectively, and compares them with historical profiles reconstructed by other institutions. One set of data is from the Climate Analysis Indicator Tool (CAIT), developed by the World Resources Institute (WRI 2005), while the other set is obtained from the United States' Energy Information Administration database (IEA 2005).

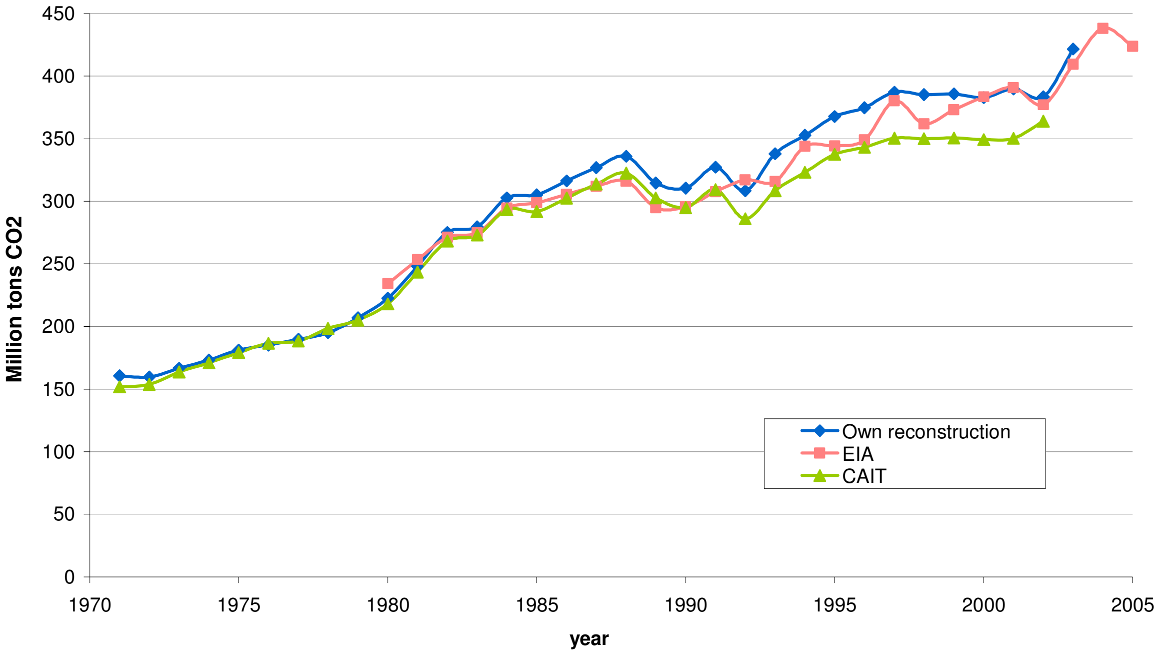

Figure 3: Fossil energy CO_2 emissions: Own reconstruction vs CAIT vs IEA

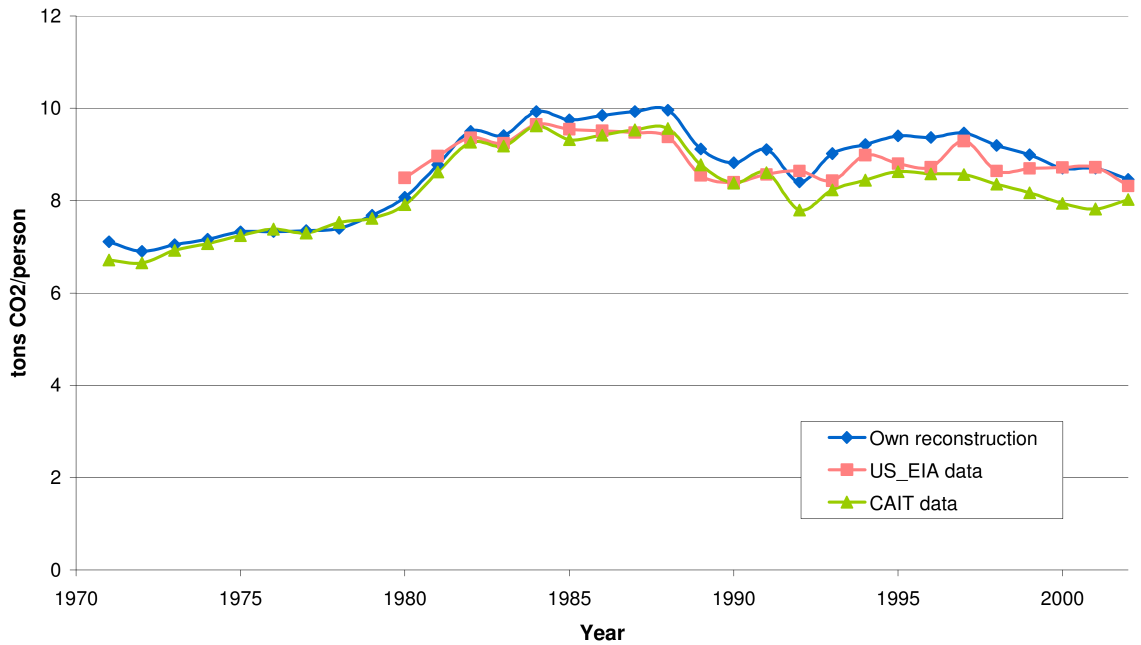

Figure 4: Per capita energy CO_2 emissions: Own reconstruction vs CAIT vs IEA

The reference approach energy CO_2 emissions of the three official inventories were compared to their respective sectoral approach CO_2 emissions, and the resulting average ratio was used to convert the energy CO_2 emissions of the of our own reference approach to sectoral approach emissions. This ratio of reference approach emissions to sectoral approach emissions was found to be 0.793.

1.2.2 Industrial processes

The reconstruction of historical GHG emissions from industrial processes was based on the baseline estimates (2003/2004) by Taviv et al. (2008). The main assumption made in this analysis is that the emission factors for all sources have remained constant over the years.

The nine major categories of industrial emissions analysed in this study are as follows:

- **Cement production**: This is a combination of CO_2 emissions from the calcination of limestone and dolomite, fuel firing and fuel consumption. Data on the production and sales of cementitious binders (1993-2007) was obtained from the Cement & Concrete Institute of South Africa (CNCI 2008), while production statistics for the period of 1980-1992 were obtained from a thesis by Persad (1994). A power trendline was used to extrapolate to from 1980 back to 1975.
- **Non-aggregate limestone and dolomite use**: This encompasses all CO_2 emissions from non-aggregate uses of carbonates, excluding cement production. Generally, these emissions are a result of the calcination of carbonate compounds or acid-induced release of CO_2 in a variety of industries. The most significant non-aggregate uses of carbonates are lime production, glass manufacturing, iron and steel production, ceramics, non-metallurgical magnesia production and other uses of soda ash (IPCC 2007). Statistics for non-aggregate use of carbonates (1975-2007) was obtained from the DME's South Africa's Mineral Industry report series (DME 2007).
- **Ammonia production**: The production of ammonia requires both nitrogen, which is usually obtained from air, and hydrogen, which is either obtained from natural gas or some other hydrocarbons. In the past, the country's major producer of ammonia, Sasol, used coal as a source of hydrogen, but has recently switched to natural gas. In the natural gas catalytic steam reforming process, the primary release of CO_2 occurs during the regeneration of the CO_2 scrubbing solution with lesser emissions resulting from condensate stripping (IPCC 2007). It was assumed here that the production of ammonia in the country is proportional to SASOL's synfuels production; hence the 2003 production data obtained from Taviv et al (2008) was extrapolated accordingly.
- **Nitric acid production**: This category reports the nitrous oxide (N_2O) generated unintentionally by the high temperature catalytic oxidation of ammonia during the production of nitric acid from the four operating plants in the country. The production of nitric acid in the country was therefore assumed to be proportional to that of ammonia, and the 2003 production data obtained from Taviv et al (2008) was extrapolated accordingly.
- **Iron and steel production**: This presents the CO_2 and CH_4 emissions from the production of iron, steel and metallurgical coke. Production statistics from 1990 to 2007 were obtained from the South African Iron and Steel Industries (SAISI 2008), while production data for the period 1975-1989 was obtained from the DME's South Africa's Mineral Industry report series (DME 2007).
- **Ferro-alloys and silicon**: The following ferro-alloys are included, together with silicon, in this category: FeCr, FeMn, FeSi and FeSiMn. In the production of ferroalloys and silicon, raw ore and slag-forming materials are usually mixed with coal and coke, and then heated to high temperatures releasing CO_2 or CO and small amounts of CH_4 and N_2O. Ferroalloy and silicon production statistics were obtained from the DME's South Africa's Mineral Industry report series (DME 2007).
- **Aluminium production**: This section estimates the CO2 emissions from the consumption of carbon anodes in the reaction to convert aluminium oxide to aluminium metal, and the perfluorocarbons (PFCs) emissions of CF4 and C2F6 during anode effects (IPCC 2007). Historical production data was obtained from the DME's South Africa's Mineral Industry report series (DME 2007).

- **Coal mining**: This section estimates the CO2 and CH4 emissions released during the mining of coal. Production statistics were obtained from the DME's South Africa's Mineral Industry report series (DME 2007).
- **Synfuels methane point source emissions**: This reports the methane emissions from SASOL's gasification processes at both Sasolburg and Secunda. Activity data of the production of synfuels was obtained from national energy balances reported by the International Energy Agency (IEA 2005).

Figures 5, 6 and 7 below show the emission trends of the most significant Industrial processes in the country, while Figure 8 shows the contributions of each of the above industries to IPPU emissions.

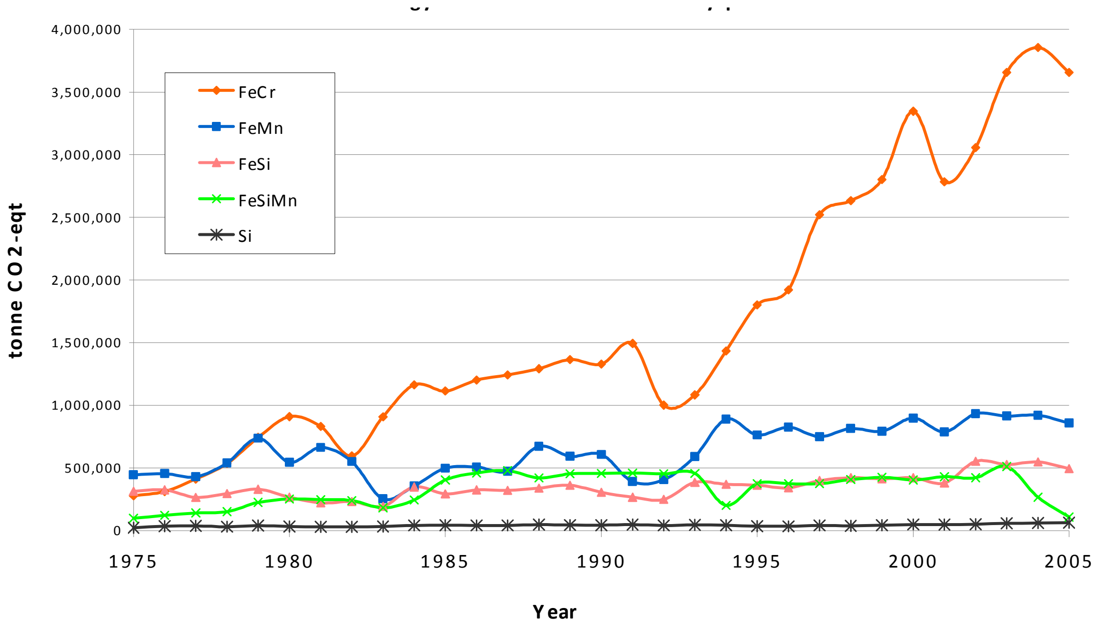

Figure 5: GHG emissions from ferro-alloy production

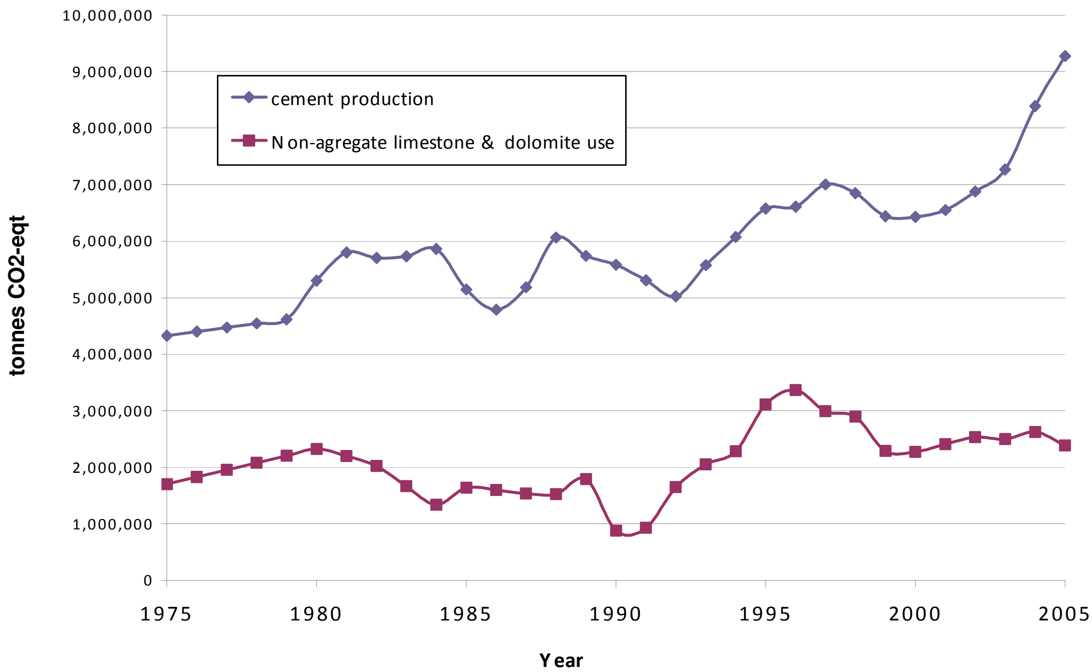

Figure 6: $CO_{2\text{-eq}}$ emissions from non-aggregate use of carbonates

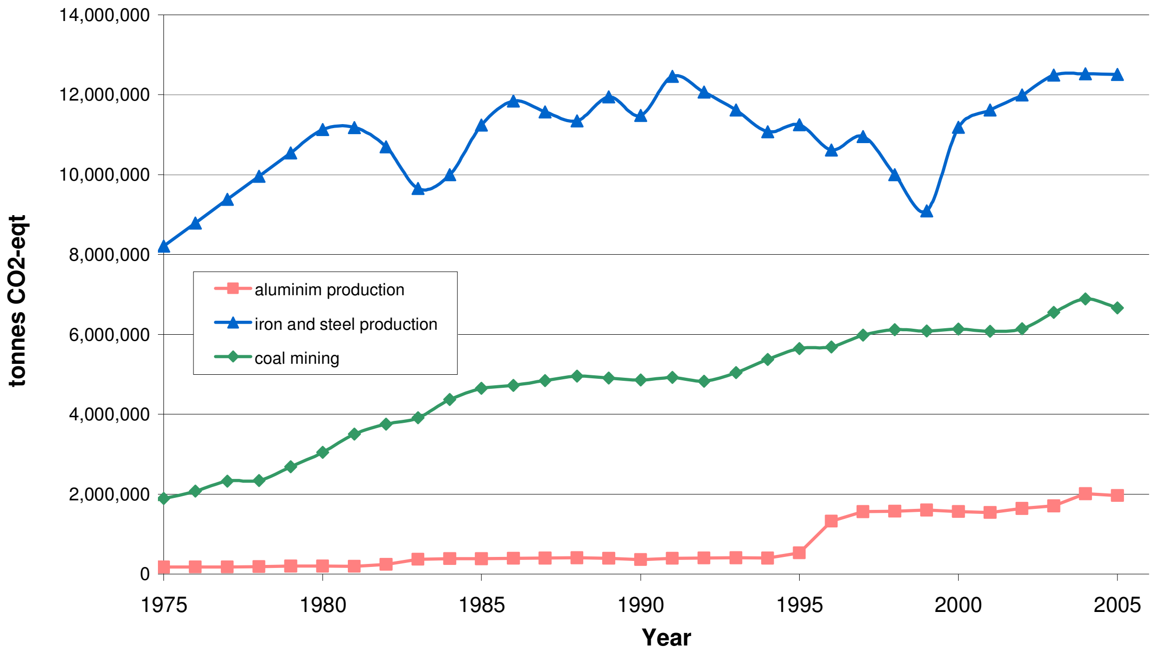

Figure 7: GHG emissions from the production of aluminium, iron and steel and coal mining

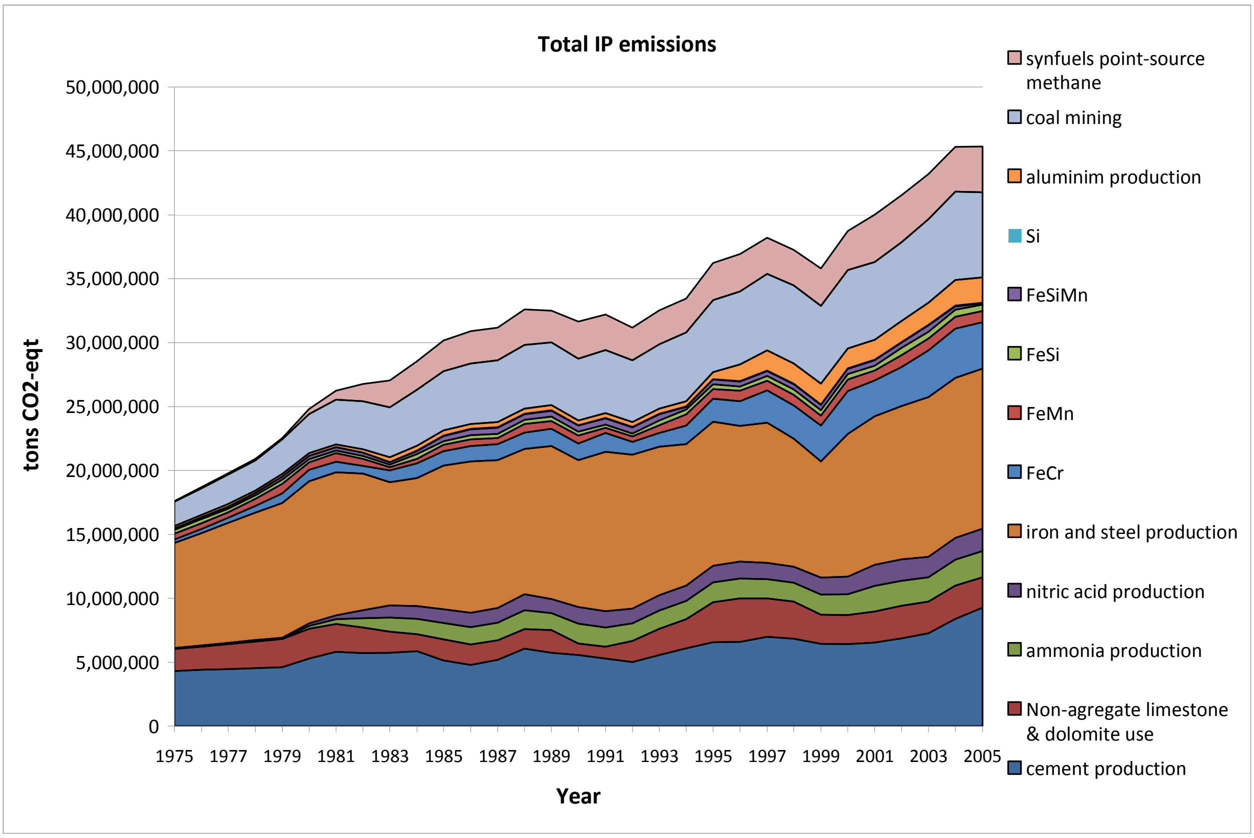

Figure 8: South Africa's GHG emissions from industrial processes

1.2.3 Agriculture, land use change, forestry and waste

The emission trends from agriculture, land use change and forestry and waste were constructed based on the baseline emissions reported in the 1994 national GHG inventory (Taviv, Mwakasonda et al. 2008). It was then assumed that these emissions have been growing proportionally to the country's economy; hence the 1994 emissions were extrapolated in both directions (1993-1975 and 1995-2002) using the country's GDP (in constant 2000 dollars) for those years. Historical GDP values for South Africa were obtained from the World Resource Institute's Climate Analysis Indicator Tool (CAIT 2005). Figure 9 presents the extrapolated emission trend for agriculture, land use change and forestry and waste.

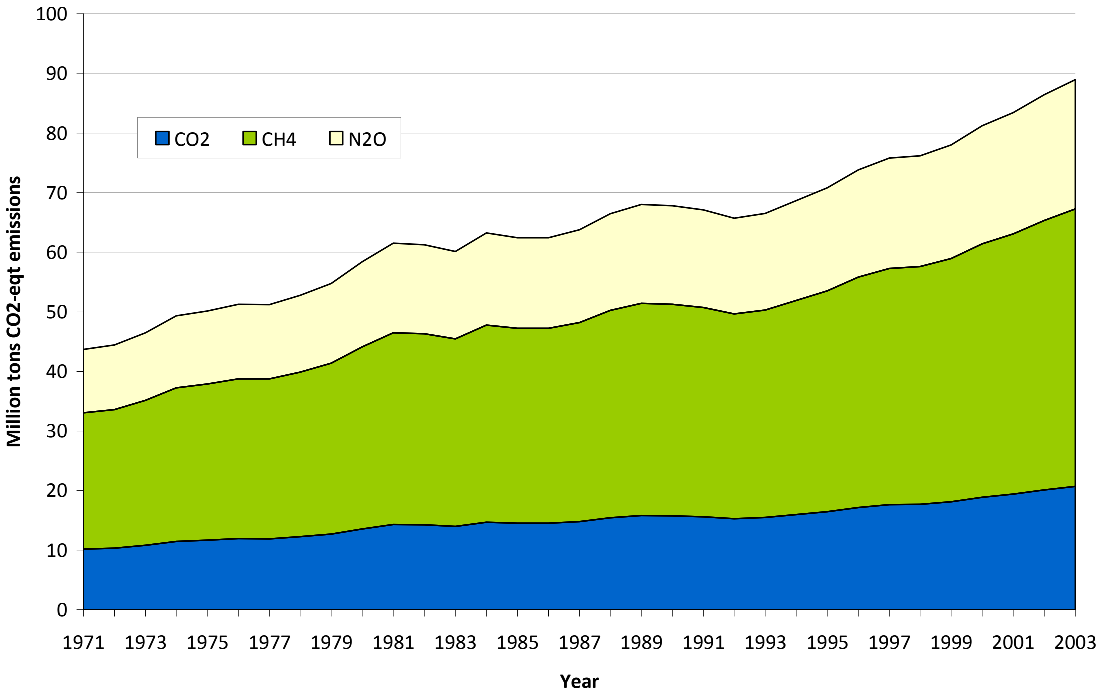

Figure 9: Historical emissions from agriculture, land-use change and forestry, and waste

1.2.4 Total emissions

Figure 10 presents our reconstruction of the total sectoral emission trend for South Africa from 1975 to 2003. The figure shows the relative contributions of the different GHGs from the various sectors.

In Figure 11, the country's 1990, 1994 and 2000 emissions of the three major GHGs from our own reconstruction are compared to those from the World Resource Institute's CAIT and the official values reported in the national GHG inventories.

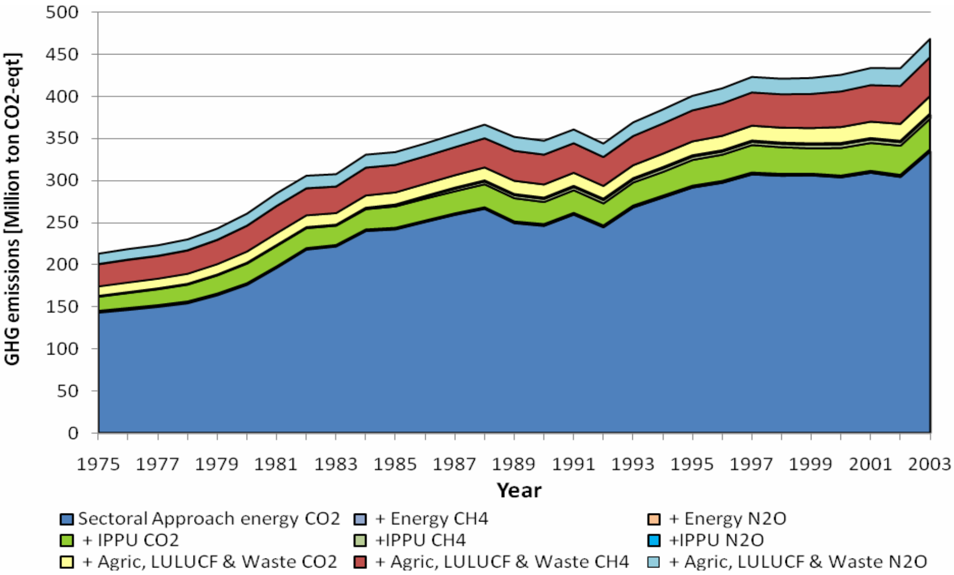

Figure 10: Own reconstruction of total historical emissions for South Africa

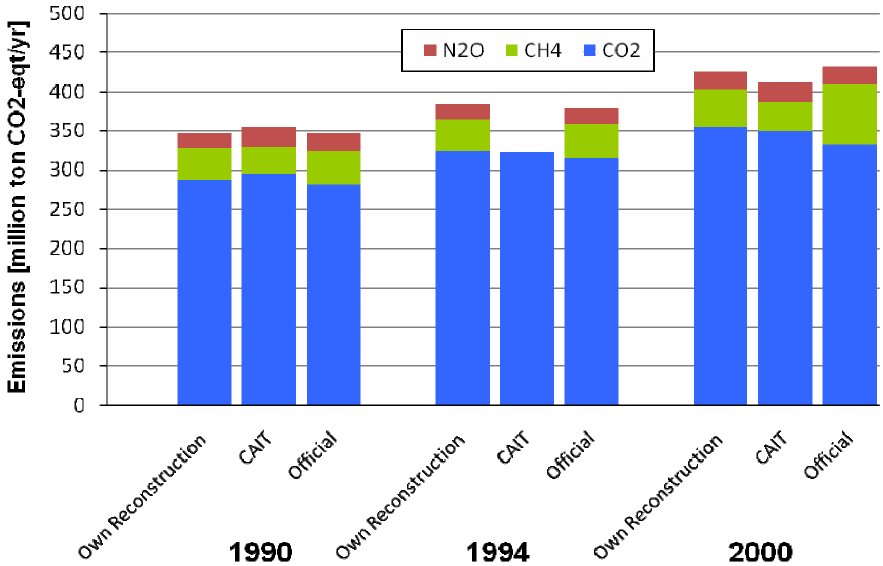

Figure 11: South Africa's 1990, 1994 and 2000 emissions of the three major GHG gases – own reconstruction vs CAIT vs official

2. Projections of future emissions

The projections of South Africa's emissions were carried out in the Long Term Mitigation Scenarios (LTMS) process. In the LTMS this baseline projection of the emissions is called the Growth Without Constraints (GWC). GWC represents a scenario where there is no damage to the economy resulting from climate change, no significant oil supply constraints, where choices to supply energy to the economy are made purely on least-cost grounds, without internalizing external costs. GWC assumes that not even existing policy is implemented (Scenario Building Team 2007).

Figure 12 below shows the projected GWC emission trend together with our reconstructed historical emissions and the three official GHG inventory trend.

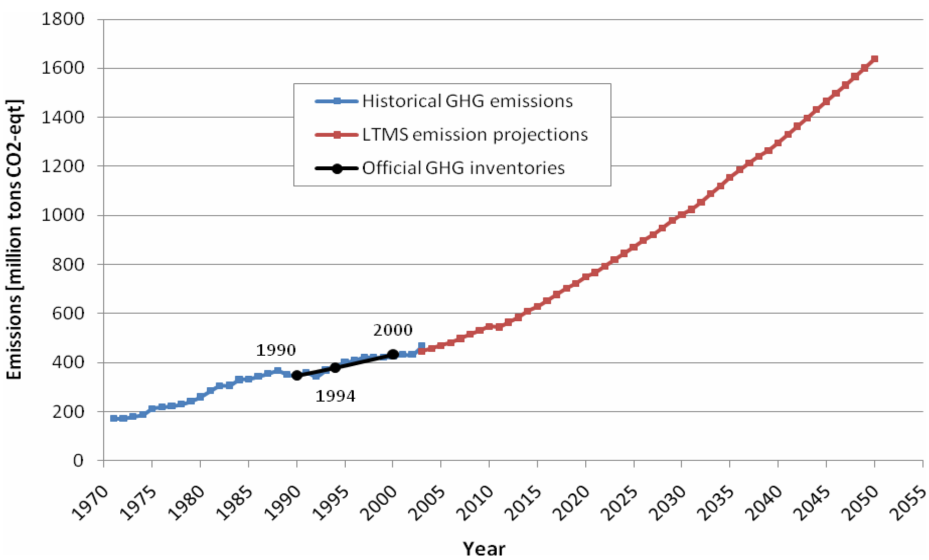

Figure 12: South Africa's historical and projected GHG emissions

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