Energy Sustainability Indicators for South Africa: 2004 Report

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Summary

This dissertation considers South Africa's energy sustainability using eight indicators designed by Helio International's Sustainable Energy Watch, an international organisation that promotes energy sustainability. South Africa's performance on the indicators is modest, as shown in Table 2, which is a summary of South Africa's performance on the indicators.

The best performance for South Africa (see Table 2, p15) is in indicators 3 (access to electricity), 5a (non-renewable energy exports as a share of total exports), 5b (non-renewable energy imports as a share of non-renewable TPES) and 6 (burden of energy sector investments) for which South Africa scores fairly close to 0, the ideal.
The worst performance for South Africa is in indicators 1 (Carbon Emissions per capita) and 7 (Energy intensity), for each of which South Africa scores about 2 – off from the unsustainability level by a factor of approximately 2.

South Africa's energy sector is showing a move toward greater sustainability in the following indicators: carbon emissions (indicator 1), access to electricity (indicator 3), burden of energy sector investments (indicator 6).
Although presently scoring well, South Africa appears to be presently moving away from greater sustainability according to this indicator: non-renewable energy imports as a share of non- renewable TPES (indicator 5b).
In the following indicators, South Africa is showing no discernible trend towards or away from sustainability: level of most significant local pollutant (indicator 2), Investment in clean energy (indicator 4), non-renewable energy exports as a share of total exports (indicator 5a), energy intensity (indicator 7), deployment of renewable energy (indicator 8).

South Africa's transport sector is endowed with comprehensive infrastructure and has great potential, but is not performing well due to policy and management issues surrounding road versus rail transportation and the lack of public transport in general. The indicator results show the effect of the problems in the transport sector.

Positive developments in the last few years which will help South Africa's energy sustainability are the energy sector legislation and environmental legislation, the volume of published statistics and other energy management initiatives, and the beginning of the implementation of air pollution monitoring stations. Further required government interventions in the energy sector that should improve the indicators include: promoting deployment of the already economically viable renewable and clean energies including solar water heaters and energy efficient buildings; increasing the renewable energy target to ensure economies of scale that would support local manufacture; facilitate the increase in the size of the tertiary sector of the economy, through interventions to make telecommunications, transport and the food sectors more economically efficient in order to lower energy intensity (MJ/$) of the economy.

If South Africa is to achieve a more sustainable energy path, development planning in South Africa will have to address three issues: paying attention to the earth's environmental limits; eliminating extremes of wealth and poverty – thus eliminating the knock-on effects of this phenomenon; promoting the establishment of an adequate world government system, and meanwhile supporting democratic global institutions such as agencies under the UN General Assembly - particularly UNCTAD, because they offer the best hope for a sustainable future.

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Glossary

BEE – Black Economic Empowerment.
DALY – Disability-Adjusted Life Years.
DME – Department of Minerals and Energy (of South Africa).
DSM – Demand Side Management.
GDP – Gross Domestic Product.
Indicator metric – the value of an indicator in terms of the metric units in which it is measured.
Indicator vector – the value of an indicator in terms of a normalised sustainability scale.
IPP – Independent Power Producer.
PM10 – Air pollutant consisting of small particles with an aerodynamic diameter less than or equal to a nominal 10 microns.
PPP – Purchasing Price Parity.
RED - Regional Electricity Distributor.
TPES - Total Primary Energy Supply.

1. Problem Statement

This dissertation looks at South Africa's energy sustainability through a number of indicators used by Helio International's Sustainable Energy Watch to determine a country's energy sustainability in the context of sustainable development. There are eight indicators covering various aspects of energy sustainability. The indicators are updated from a previous report (Spalding-Fecher, 2002) and an effort made to further improve the quality of the data used to determine the indicators. The calculations of the indicator values are done on a separate spreadsheet available from the University of Cape Town's Energy Research Centre (See Winkler, H in 'Contacts' after the 'References' near end of the report). This report merely presents the results and discusses them.

The eight Helio International indicators are generally global in nature, so they are able to give an indication of South Africa's energy sustainability in a global context. The indicators are evenly spread between three areas typical of sustainability consideration: environmental, social, economic, with technological considerations added. The first indicator for example, is environmental and gives an indicator value for South Africa's carbon emissions intensity (kgC/capita) by comparing it to two reference values: the unsustainability reference, which is the international average carbon emissions intensity (kgC/capita) in 1990, the base year, and the sustainability reference, which is a 70% reduction in the international average carbon emissions intensity (kgC/capita), also in the base year, 1990.

The challenge is to use indicators that are informative, easy to interpret, and will have accessible data to allow determination of the indicator. The indicators should also allow easy comparison with other countries.

Energy is very close to the centre of humanity's preoccupation with immediate survival. At the same time, choices made by some of humanity to ensure immediate survival heavily influence the choices that will have to be made by some in current generations, and all in future generations. This dynamic is at the core of the pursuit of sustainable development.

The changes in South Africa's political dispensation coincided with political changes in certain other parts of the world: notably, the early 1990s were immediately preceded by the easing of 'Cold War' between the communist East Block and Capitalist West. This Cold War and its associated problems, had defined much of the world since the Second World War. In the decade from the early 1990s, the optimism which followed the end of the 'Cold War' has for some turned into concern at the least, and outright pessimism in many cases. This is compellingly true for the political and socio-economic global outlooks, examples being the continued prevalence of war, and the lack of meaningful economic progress in parts of the world such as the former East bloc and the majority of countries that were colonies of others in the early 20th century.

In another light, however, we see that while the world political and socio-economic realm is not typified by optimism, there is contrastingly a seemingly unstoppable advance in science and technology, affording humanity frequent moments of hope, if only celebrated briefly as the other, less pleasant realities continue to preoccupy issues of the human collective. This dichotomy of technological advances versus the political and socio-economic malaise appears to be of great relevance to the issue of sustainability as it seems to shift the question from whether we have technical ability, to whether we are able to muster the collective vision and will to make a meaningful change.

Over the decade since the implementation of a democratic state, South Africa has become economically and socially integrated into the global system. There have been benefits. Among the economic ones is the relative ease with which South Africa can now export to the world, compared to the previous decade. There have also been challenges such as being subject to global economic cycles, foreign currency price fluctuations and unfair trade practices such as subsidies, which are often an international issue between various countries and economic blocs. A case in point is the trade disagreement between the USA and the European Union over steel tariffs and export tax breaks (CBS, 2004). There is also the phenomenon of agricultural subsidies and tariffs in developed countries preventing economic growth in developing countries (Guardian, 2003). World trade is seemingly far from fair or ideal. There have been many social effects due to what are seen by the 'Washington Consensus' to be global imperatives for economic growth – privatisation and liberalization of financial markets, capital markets, and trade. South Africa's environment is under pressure as South Africa makes efforts to become economically competitive, while certain export goods (such as stainless steel) bring the requirement, from developed nations who are customers, that production must meet certain environmental standards.

The turmoil evident the world's social, economic and environmental systems is clear in its manifestation in the global energy system. Humanity is seemingly unable to make the changes necessary to the global energy system, at a satisfactory rate, to address the looming challenges such as climate change, other types of pollution, environmental degradation and resource limitations, eg water, firewood, oil supplies, as well as the prevailing extremes of wealth and poverty in the world, with their manifold implications. Debeir et al (1991) express the situation as follows:

> "Since 1986, the tendency towards the changing of the entire energy system has been confirmed. Sixty years ago, Antonio Gramsci, describing the great depression of 1929, wrote 'the crisis erupts when the old is not yet dead and the new is not yet born; many morbid symptoms emerge during such an interregnum'. This description fits the current world energy picture perfectly. The complex and contradictory system which ties the energy structures of the most advanced countries to those of the most impoverished societies is slowly falling apart, yet it is still impossible to make out even the broadest lines of the system that will replace it in the coming decades."
>
> (Debeir et al, 1991:231)

There is clearly a crisis in the global energy system, concurrent with that in global socio-political affairs. An analysis of South Africa's sustainability must take into account the state of the wider planet. Planet earth at the beginning of the 21st Century is characterised by contradictions between its social, economic, environmental and technological systems on the one hand, which are, if not united, at least connected without much concern for national boundaries, and its governance systems on the other hand, which have remained almost entirely nationalistic. This dynamic is outlined in an essay by John Kenneth Galbraith, the Paul M. Warburg Professor of Economics Emeritus at Harvard University, who states:

> "There must also be international action to protect and coordinate the welfare measures of individual States - unemployment security, social security, health care, education, and the budget and budget deficit, to mention only the most obvious needs. Such coordination, ...must be a larger international action. Only

> this will keep the larger internationalism from being in conflict with the national commitment to social well-being. There is no conflict it is more essential that we avoid, ..." (Galbraith, 1997)

In a more direct reference to the problem and a possible solution, Galbraith states:

> "The several agencies of the United Nations-the Economic and Social Council, the Department of Humanitarian Affairs-and the outlying work of the World Bank and the International Monetary Fund and yet other international agencies do not reflect and respond in any unified and adequate way to the modern reality. The United Nations agencies have discussion, but alas not power. This we must now correct." (Galbraith, 1997)

Some of the effects of this inadequacy in international institutions are:
- a continued inability to resolve political and violent conflicts,
- the failure to stem the tide of degradation of the natural environment as well as,
- the inability to solve the socio-economic problems plaguing the planet.

This report evaluates energy sustainability. It is therefore mostly concerned with the last two of the three points just mentioned. The first mentioned point, however is very relevant in its effects on attempts to solve energy-related problems on the globe: as matters stand, the worlds peoples are depending not on the rule of law, but on the good will of countries, especially the militarily strong, when it comes to resolving disputes with political implications (Deller, 2002). The indicators used here attempt to paint a picture of South Africa's internal position and its contribution to this global crisis.

2. Methodology – Introduction to the Indicators

Helio International's "General methodological approach" is to choose the indicators (already done in the previous report in this case); estimate the indicators for the country surveyed; do a comparative analysis of the indicators; attempt to identify factors explaining the changes in the period under review; recommend measures to improve sustainability where sustainability is not increasing; and using cases where indicators showed improvements to evaluate factors explaining success stories (Helio International, 1997). This methodology is followed in this report.

In this review of the eight sustainability indicators, the eight indicators used had already been pre-defined in a previous report (Spalding-Fecher, 2002). The estimation of the indicators was a result of collecting relevant data from a variety of sources and entering it into a comprehensive spreadsheet.

Sources of data were varied and among others included: A local (Cape Town) environmental reports on air pollution (City of Cape Town, 2003), South Africa's Department of Minerals and Energy (2000, 2002a, 2003b), the South African Reserve Bank (2003), the International Energy Agency (IEA, 2003), Statistics South Africa (1998, 1999, 2003a), associations such as SAPIA - the South African Petroleum Industry Association (SAPIA, 2003) and the South African Chamber of Mines (COM, 2002a) among others.

Once the collected data was entered into the spreadsheet as already mentioned, it was, where possible then checked for reasonableness against other sources of data on the same phenomenon. An example here was the value of merchandise exports from South Africa, which could be obtained from a variety of sources, including the South African Reserve Bank (2003) and the Chamber of Mines (COM, 2002a). Another method of checking the data used is to check for the congruency of the data when compared with other indirectly related data.

The results for the indicators, together with appropriate graphs and other illustrations, as well as a summary of factors surrounding each particular indicator, are in the next chapter – chapter 3.

Eight indicators used in this report are international in nature, not specific only to South Africa. Each indicator compares a present metric such as percentage of households with access to electricity against a sustainability target (for example, 100% for (household) access to electricity), and a reference for unsustainability (for example, 0% for (household) access to electricity).
There are four categories or sustainability dimensions of indicators, each with two indicators to give measure to them. They are:

- **Environmental:** measured by energy sector emissions per capita, and level of most significant energy sector local air pollutant,
- **Social:** measured by share of households with access to electricity, and investment in renewable energy and energy efficiency investment as a share of total energy sector investment,
- **Economic:** measured firstly by resilience to trade impacts (with two sub-indicators, firstly reflecting non-renewable exports as a share of total export value, and secondly reflecting non-renewable energy imports as a share of total primary energy supply), and secondly by

an indicator reflecting public sector investments in non-renewable energy as a share of GDP.

- **Technological:** measured by primary energy consumption per unit of GDP, and renewable energy supply as a share of total primary energy supply.

The results of the indicators from the spreadsheet were, after calculation, then exported to this report in the form of tables and plots for each indicator. The relevant metrics (non-normalised) values were also imported from the spreadsheet into this report as required. The table below summarises the category and definition of each indicator, its sustainability target and its unsustainability target.

Table 1: Sustainable Energy Watch Indicators and vector values

Sustainability dimension	*Indicator*	*Sustainability target (vector = 0)*	*Reference for unsustainability (vector = 1)*
Environmental	1. Global impacts: energy sector carbon emissions per capita	70% reduction from 1990: 339 kgC/capita	1990 global average: 1,130 kgC/capita
	2. Local impacts: level of most significant local energy pollutant	10% of 1990 value	1990 level of pollutant
Social	3. Households with access to electricity: share of households with access	100%	0%
	4. Investment in clean energy, as a proxy for job creation: RE and EE investment as share of total energy sector investment	95%	1990 level
Economic	5. Resilience to external trade impacts Exports: NRE exports as share of total export value Imports: NRE imports as share of total primary energy supply	Exports: 0% Imports: 0%	Exports: 100% Imports: 100%
	6. Burden of energy investments on the public sector: public investment in NRE sector as share of GDP	0%	10%
Technological	7. Energy intensity: primary energy consumption per unit of GDP	10% of 1990 value: 1.06 MJ/US$1990	1990 global average: 10.64 MJ/US$1990
	8. Deployment of renewable energy: renewable energy supply as a share of total primary energy supply	95%	1990 world average: 8.64%
Note: RE = renewable energy, EE = end-use energy efficiency; NRE = non-renewable energy			

Source: Helio International (2000), quoted in similar report by Spalding-Fecher, 2002

The data for indicator 2 has been newly defined for this report, as described in section 3.3.1. This indicator, which measures the level of the most significant local energy pollutant, specifically measures the level of PM10 (Air pollutant consisting of small particles with an aerodynamic diameter less than or equal to a nominal 10 microns). The unsustainability value was set at the 1995 value of the metric, i.e. 33 micrograms per cubic metre, as it is the earliest one recorded for the set of data used in this report. The 1990 value, which is the ideal one, is not known for this set of data. The sustainability target is therefore 3.3 micrograms per cubic metre.

The specific formulae for calculating the indicators are outlined in Appendix 1.

The indicators are quite suitable to giving an indication of energy sustainability in South Africa. The indicators are all fairly directly related to energy sustainability. A weakness in the indicators is that they do not give a deep enough understanding of social, environmental and economic issues, knowledge of which would make it easier to get an insight into the longer-term energy sustainability of South Africa. A way in which this could be overcome would be to get an idea of the energy consumption distribution for households in the country – answering such questions as: how much is the per capita modern energy consumption of the wealthiest 20% households compared to the poorest 20% of households? Such a determination would give an indication of inequality, which in turn is directly related to sustainability. The effects of inequality on growth, which under certain conditions is a prerequisite for sustainability, are noted by Stiglitz in his discussion of the failed transition of the 1990s in Russia, noting: "extremes of inequality impede growth, particularly when they lead to social and political instability" (Stiglitz 2002:155). A properly constituted indicator on household energy consumption, achieving the objective suggested, would in some ways rival the gini coefficient in usefulness, in that it could reflect living standards, not just income.

Another limitation inherent in the indicators is that they rely very much on good data. In some cases this data is very comprehensive and may not be easy to obtain. Surveys done by government department and other institutions are vital to the success of a survey of indicators such as this one. Indeed, there are countries in the developing world where it would be impossible to get a good reflection of the status of the indicators used here.

After the chapter presenting the results of the indicator updates with some comments on them, there is a chapter on 'Transport Energy Analysis' in South Africa, which delves into the dynamics of this sector that has implications for a number of the indicators. This is followed by a chapter 'Discussion of Results', which is a commentary on the trends observed in the indicators over time, and between indicators. Having discussed the results in chapter 5, chapter 6 is 'Interpretation of Results' which looks at the reasons behind the indicator values and trends. Chapter 7 then looks at some imperatives for improving the indicators. This discussion is followed by the conclusion in chapter 8 which summarises as well offers some prescriptive content.

3. South Africa's score on the indicators

3.1 Summary of Performance

South Africa's score on the indicators is summarised in the following table.

Table 2: Summary of energy sustainability indicators based on either 2001 or 2002 data

Indicator	*1990 or ref*		*Latest*				*% change*	
	Metric	*Vector*	*Metric*	*Vector*	*final yr*		*Metric*	*Vector*
1. Carbon emissions intensity	2205	2.36	*2077*	*2.20*	*2001*		*-6%*	*-7%*
2. Local pollutant	*33*	*1.00*	*34*	*1.02*	*2002*		*2%*	*2%*
3. Access to electricity	35%	0.65	*67.9%*	*0.32*	*2002*		*94%*	*-51%*
4. Clean energy investment	0%	1.00	*0.44%*	*1.00*	*2002*		*N/V*	*0%*
5. Energy trade – exports	10.5%	0.11	*9.9%*	*0.10*	*2002*		*-6%*	*-6%*
- imports	15%	0.15	*23%*	*0.23*	*2001*		*49%*	*49%*
6. Burden of energy investments	0.64%	0.06	*0.51%*	*0.05*	*2002*		*-20%*	*-20%*
7. Energy intensity (PPP)	20.5	2.03	*19.6*	*1.93*	*2001*		*-4%*	*-5%*
8. Renewable energy	5.4%	1.04	*4.6%*	*1.05*	*2001*		*-14%*	*1%*

Source: From various data sources, compiled in a spreadsheet to facilitate calculation of the indicators by the author. Sources for each indicator quoted in relevant sections that follow in this chapter.

The following sections will now consider each indicator separately.

3.2 Indicator 1: Energy sector carbon emissions per capita

3.2.1 Results

As described in the section 'Problem Statement', this indicator measures the relative energy sector carbon emissions per capita of South Africa relative to the unsustainability target which is the 1990 global energy sector carbon emissions per capita, and against the sustainability target which is a 70% reduction in this latter value.

There has been a slight improvement in the value of this indicator since the 2002 report. Carbon emissions per capita decreased from 2,194 kgC (1999 value) to 2,077 kgC (2001 value) per capita. The corresponding shift in the vector was from 2.35 to 2.20. As a result the 2001 metric and vector values are 6% and 7% below the 1990 values respectively, as compared to 1% below the 1990 value for both, in 1999. Additionally, the change in the metric continues a consistent, though slow decline from 1995 onwards. However, the value of this indicator and its underlying metric, for South Africa, are more than twice the value defined as the 1990 global average carbon emissions per capita of 1,130 kgC/cap, which is also the reference value used for unsustainability. This clearly implies that South Africa, with only about 0.7% of the world's population (UNFPA, 2003), is responsible for about 1.4% of the worlds carbon emissions. The sustainability target, which represents a 70% reduction in the unsustainability value, to 339kgC/cap, has significance as it is believed to be the target to be achieved in order to stabilise the apparent present degeneration towards catastrophic global climate change, as stated by Winkler et al (2002):

> "Carbon cycle models (Wigley et al 1996) show that immediate stabilisation of the concentration of carbon dioxide at its present level could only be achieved through an immediate reduction in its emissions of 50%-70% and further reduction thereafter (IPCC 1996). Present levels are already elevated from pre-industrial levels and still imply some climate change due to the momentum of the system, because carbon dioxide stays in the atmosphere for 100 years on average." (Winkler et al, 2002)

The following is a plot of the indicator vector for the years 1990 to 2001:

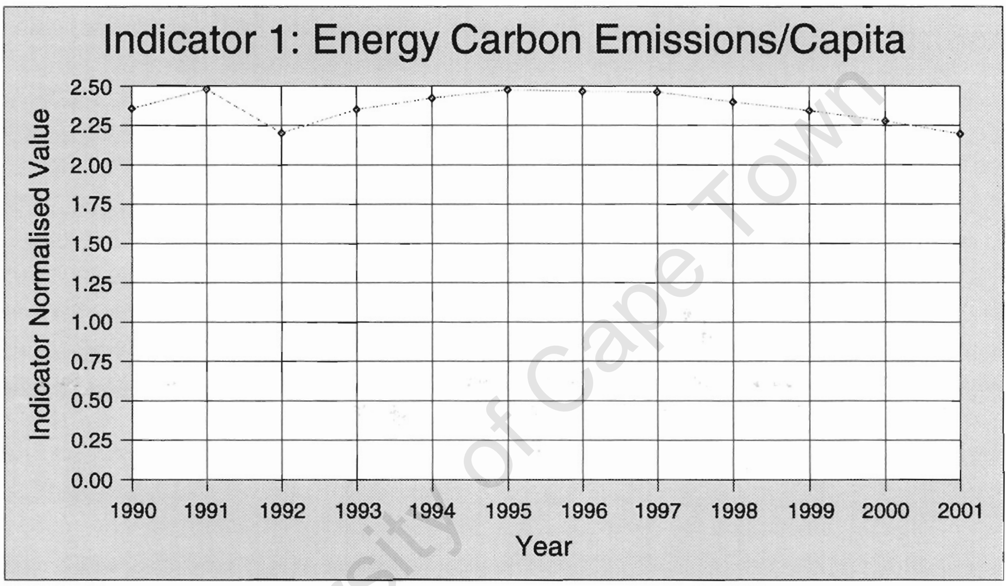


Figure 1: Plot for indicator 1

Source: IEA (2003) and Statistics South Africa (1998, 1999, 2003a).

3.2.2 Government policy and the results for indicator 1

The improvement in this indicator in the latter half of the 1990s is not due much to deliberate policy-based intentions on the part of the South African government or private sector. There has been no direct legislation limiting carbon emissions intensity in South Africa at this point. There is, instead the 'White Paper on the Energy Policy of the Republic of South Africa' (1998). This is a guideline for energy policy, together with the 'White Paper on Renewable Energy (2003). According to the White Paper on Energy Policy, South Africa is looking at cost and access when it comes to energy supply, and the white paper states:

> "In order to fulfil the national energy policy of making clean, affordable and appropriate energy available to all sectors of the population, a balanced least-cost mix of energy supply is promoted. Coal will therefore dominate other energy sources in South Africa for many years to come." (Department of Minerals and Energy, 1998)

With regards to the need to address the threat to global climate change, this white paper states:

> "Government will monitor international developments and will participate in negotiations around response strategies to global climate change, in order to progressively balance its environmental responsibilities and development interests, along with health related local issues, in these processes.
>
> "The Department of Minerals and Energy will follow a 'no regrets' approach in the energy sector with regard to the potential global environmental impacts of energy activities." (Department of Minerals and Energy, 1998)

It is clear from these extracts that South Africa is waiting to see how the global scene will evolve in terms of response to possible global climate change.

In the White Paper on Renewable Energy (Department of Minerals and Energy, 2003a), the Department of Minerals and Energy does set a target for renewable energy deployment, but the target is very modest, at 4% of estimated electricity demand by 2013, as stated in section 3.9.2 (on indicator 8) below. However, this target could could contribute to slightly improving the indicator.

3.2.3 Possible drivers

A number of possible factors could have effected the decreased carbon emissions per capita indicated above. These include:

- The modernisation of industrial processes in order to keep up with global standards of quality and efficiency, in the interest of competitiveness.
- On-going improvements in automotive technology make cars less emissions intensive. Although there is a strong local car manufacturing industry, South Africa follows the global trend with regard to vehicle emission intensities. The global trend in reduced vehicle emissions is led by Europe and Japan, which both have an interest in lower local pollutant emitting vehicles. The technology for the cars built in South Africa is in most cases developed in Europe or Japan, and cars built in South Africa are often exported.
- A change in the energy mix by percentages, to a less carbon emissions intensive fuel mix.
- Population growth exceeding the growth in energy total primary energy supply by a margin enough to cause the carbon emissions intensity to fall.
- A possibility that could be eliminated is lower carbon emissions from electricity generation, as there is no marked improvement in the CO_2 emissions from Eskom's coal fired power stations. This is clear from Table 4 in the section on indicator 2 later.

A further discussion of the causes of a decline in carbon emissions is in chapter 5 - 'Discussion of Results' and chapter 6 - 'Interpretation of results'.

3.2.4 Importance of carbon emissions

Carbon emissions are one focus in this series indicators as they contribute most of the greenhouse warming potential of the earth. According to the 2001 IPCC Technical Summary of the Working Group I Report:

> "CO2 is the dominant human-influenced greenhouse gas, with a current radiative forcing of 1.46 Wm^{-2}, being 60% of the total from the changes in concentrations of all of the long-lived and globally mixed greenhouse gases."
> *(IPCC Technical Summary of the Working Group I Report, 2001, p.39).*

3.2.5 Developments related to Indicator 1

The April 1986, the Chernobyl nuclear plant meltdown increased anti-nuclear energy sentiment, dampening enthusiasm for nuclear energy, which is very low in greenhouse gas emissions relative to fossil fuels. In April 1994, South Africa's first democratic elections paved the way for a more transparent energy sector, with energy security being less of an issue. This development allowed better energy-related reporting, including greenhouse gas emissions reporting. The December 1997 Adoption of the Kyoto Protocol to the UNFCCC (UNFCCC, 2004) was a milestone in trying to have a global legally binding arrangement – to reduce greenhouse gas emissions. In what was thought to be tell-tale sign of global warming, in April 1998, A 40 km by 5 km piece of the Larsen B ice shelf in Antarctica broke off, confirming earlier predictions about this inevitability (Sciencedaily, 1998). In 1998, The South African DME issued the Energy Policy White Paper. The Energy White Paper does not make commitments in terms of limiting greenhouse emissions. One possible future option proposed in the White Paper is the use of appliance labelling in order to promote the use of more energy efficient appliances. A blow was dealt to attempts to cut greenhouse gas emissions when in March 2001 the USA withdrew from the Kyoto Protocol. This prevented the protocol from becoming legally binding in the foreseeable future at the time, due to the conditions in the treaty (BBC, 2001). A follow-up to the 1998 event in Antarctica occurred in March 2002 with another reduction in Antarctic ice, reported by WWF:

> "British scientists say that the 200-meter thick Larsen B ice shelf, with a surface area of 3,250 square kilometres, has broken apart in less than a month. US experts have described it as 'the largest single event in a series of retreats by shelves in the Peninsula over the last 30 years'" (WWF, 2002).

By December 2003, Russia was the only country, other than the US, that could bring the agreement into force, but it was still deferring decision to ratify Kyoto (BBC, 2003). This was followed by a promise in May 2004 by the Russian President's promises to move towards ratification of Kyoto Protocol (BBC, 2004a). Finally, in November 2004, following cabinet and parliamentary approval, Russia submitted its Kyoto Protocol accession papers to the United Nations Secretary General, and the date of 16 February 2005 was set as the date when the Kyoto Protocol was to become legally binding for its signatories (BBC, 2004b).

3.2.6 Future Prospects

The future prospects for the improvement of this indicator are dependant on the following: Firstly, South Africa is actively seeking to establish itself as a world player in power generation technology through the Pebble Bed Modular Reactor (PBMR) project, which promises an affordable technology to reduce greenhouse emissions worldwide, using small nuclear reactors. The PBMR is seen as viable because it offers sites almost anywhere in the world a small nuclear reactor – cheaper to build, quicker to build (2 years), nuclear weapons proliferation secure (as far as the reactor operators are concerned), generates very little medium or low level waste and is more likely to have all of its capacity (114MW) taken up soon after installation (Kemm, 1999). It is, however, similar to conventional nuclear reactors in that there is no easy way to dispose of the fuel waste generated, apart from storage. The literature on the PBMR however, predicts fuel waste amounts which are very modest in the volumes they occupy (the fuel waste from the 30 year operation of one 114MW unit would fill a cube shaped room with a side only 3 metres long). Although a number of groups are trying to stop the development of the PBMR, as of late 2004, the project planning and implementation were continuing, with the support of the South Africa's Department of Minerals and Energy (PMG, 2004).

Secondly, the ratification of the Kyoto Protocol, by countries with enough 1990 greenhouse emissions to make it into international law, was achieved, as of November 2004. This should have a two-fold effect on South Africa. Firstly, sooner or later South Africa will become subject to greenhouse emissions targets, and secondly, it will potentially become more affordable for South Africa to switch to a lower emissions economy by taking advantage of the CDM mechanism of the Kyoto Protocol. Although nuclear energy projects are not included in CDM during the first Kyoto Protocol commitment period (2008 to 2012), another outcome of Kyoto enforcement, that South Africa would hope for, is that the Pebble Bed Modular Reactor would become more economically viable through a healthy orders book, thanks to a greater demand for the lower greenhouse emissions characteristics of the technology. Another future probable future development is that future dramatic climatic events, if seen to be the result of global climate change, will affect the actions of global organisations and governments worldwide in the direction of a lower greenhouse emissions path. More is said on this issue in later, in chapter 6 'Interpretation of Results'. A further, very important probable future development would be a shift in global geopolitics to a regime whereby democratic global institutions are more powerful than any one country. This would enable the implementation of international agreements for the benefit of all humanity. Tackling greenhouse gas emissions is one problem which could be addressed more effectively in such a regime. More on this in chapter 7 – 'Some Imperatives to Improving the Indicators' near the end of the paper.

3.3 Indicator 2: Level of most significant energy-related local pollutant

3.3.1 Update on changes to indicator

This indicator is based on measurements of the level of PM10 (particulates in the air that are smaller than 10 microns in diameter). It reflects the level of what is seen as the most significant local pollutant, due to the percentage of the population that is adversely affected by this pollutant. PM10 is the product of various industrial processes, car engine exhaust output, as well as the output from power generation using coal and sugar cane bagasse. More significantly though, it is the product of domestic fires for millions who use coal or biomass (firewood, animal wastes etc.) for cooking and space heating purposes.

A development to note for this indicator in the current report is that the data has been acquired from a different source. The previous source (Soweto Air Monitoring Project) was not easily available, nor was it very representative of the national picture. For the current report, a survey was done from a source of information that would allow the report to be consistent and fairly reliable. The result was that the 'State of the Environment Report' of the City of Cape Town was used. This report has been continuously produced from 1998, with data for average annual PM10 particulate matter available from 1995. The data collected for the report is from three sites around the metropolitan area of Cape Town, including the down town area, a busy commercial area close to industry while also surrounded by residential area (Goodwood), and a township location (Khayelitsha). PM10 average readings from the three sites are averaged for this report to give a value for the metric. As it is more readily available, and the monitoring continuous, this data was seen as an improvement over the previous source and thus adopted, even though the shortcoming of national representativity still remains.

The results for this indicator are shown on the next page.

3.3.2 Results for indicator 2

Below is the plot for Indicator 2.

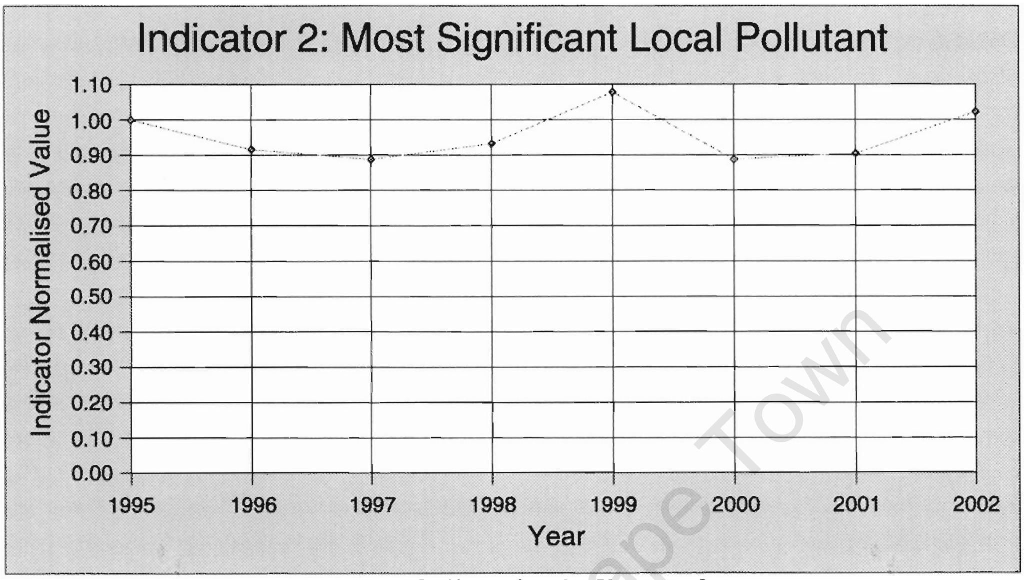


Figure 2: Plot for indicator 2

Source: City of Cape Town, 2003.

The latest metric value of this indicator is 34 micrograms/m^3, and the value of the indicator vector is 1.02. There is no clear trend in this indicator with time. In the eight year period under review (1995-2002), the value of the metric for this indicator varies between 30 and 35 micrograms/m^3. Consequently, the vector value varies approximately between 0.9 and 1.0 during this period.

3.3.3 Indicator 2 and health in South Africa

While the PM10 pollution readings obtained in Cape Town seem to be well within the requirements for the United Kingdom (50 micrograms per cubic metre), which is cited in the Cape Town State of the Environment report for 2002. It must be noted that the main reason for the use of this pollutant for this indicator is the health effects of domestic fires in many low-income homes throughout South Africa. As already mentioned above, many millions in South Africa use coal or biomass (firewood, animal wastes etc.) for cooking and space heating purposes. These are mainly the residents of poor households, informal settlements as well as traditional dwellings. The measured of amounts of PM10 in outdoor air thus partly becomes a proxy for measuring the effects of air quality inside poor households. In order to get a better picture of what is happening in poor households, PM10 air pollution values in poor areas need to be looked at separately. In this case, the values for Khayelitsha (50 micrograms per cubic metre for 2002) are noticeably higher (about twice as much) compared to those for downtown Cape Town or Goodwood.

A World Health Organisation (WHO) report on the 'Impact of Household Energy and Indoor Air Pollution on the Health of the Poor', cited the following of household PM10 pollution:

> "Typical 24-hour mean levels of PM10 in homes using biofuels may range from 300 to 3,000+ mg/m3 depending on the type of fuel, stove, and housing – Annex A (9, 12). Concentration levels measured depend on where and when monitoring takes place, given that significant temporal and spatial variations (within a house, including from room to room), may occur (8, 9, 13). Ezzati et al. (8) for example have recorded concentrations of 50,000 ug/m3 or more in the immediate vicinity of the fire, with concentration levels falling significantly with increasing distance from the fire. These small particles are able to penetrate deep into the lungs and appear to have the greatest potential to damage health (14)."
>
> (Von Schirnding Y et al, 2002:8).

According to the 2001 South African census results, from which Table 3 below is taken, the number of households housed within 'shacks' or informal housing structure is 1,836,232, probably representing at least 7,344,928 South African residents – at the 2001 overall South African average rate for 4 people per household (Statistics South Africa, 2004). Poorer households generally have a higher number of people per household. In percentage terms, 16% of South African households are in 'shacks' and a further 15% are in traditional dwellings (Statistics South Africa, 2004). This brings the total number of households potentially exposed to biomass-effected indoor air pollution in 2001 to, 3,491,019, or 31%.
Also according to the 2001 South African census results, 24% of South African household use firewood, coal or dung for cooking (Statistics South Africa 2004).
This information, as well as comparison of 2001 values with 1996 values is shown in Table 3 below.

Table 3: Household characteristics related to fuel use

Characteristics	Households SA	
	1996	2001
Total Population	40,583,573	44,819,778
Number of Households	9,059,571	11,205,705
Average Capita per Household	4.48	4.00
Shack dwelling number	1,453,015	1,836,232
Shack dwelling percentage	16%	16%
Traditional Dwelling number	1,644,388	1,654,787
Traditional Dwelling percentage	18%	15%
Shack + Traditional Dwelling	3,097,403	3,491,019
Shack + Trad Dwell percentage	34%	31%
Cooking with wood, coal, dung	2,500,117	2,713,702
Wood, coal, dung percentage	28%	24%
Cooking with paraffin	1,943,862	2,394,919
Paraffin percentage	21%	21%

Source: Statistics South Africa, Census 2001: Primary Tables South Africa, Census '96 and 2001 compared (Statistics South Africa, 2004).

Khayelitsha is one area where there is a high concentration of households which use coal and biomass. As already mentioned, for data for this indicator, Khayelitsha shows values of PM10 pollution which are higher than that for the other two areas: Goodwood and downtown Cape

Town. This is true for the three years for which data is available for Khayelitsha (1999, 2000, and 2002). In fact, the Khayelitsha value for PM10 in 2002 equals the United Kingdom guideline of 50 micrograms per cubic metre. The indoor value for the pollutant amount is usually significantly higher if the source is cooking or space heating without adequate ventilation. This implies a bleak reality for the people of Khayelitsha. The negative implications affect the residents of many townships and rural households across South Africa. The health effect of indoor air pollution, most evident in the high incidence of respiratory diseases among the dwellers of poor South African households, certainly weigh heavily on the health system, as emphasized in this quote referring to the South African township of Soweto:

> "Coal combustion causes the most serious indoor pollution. And the level of exposure to airborne particles in Soweto exceeds the maximum allowance permitted by the World Health Organisation by 96 percent. It costs South Africa's Department of Health about R360 million a year to treat respiratory diseases caused by coal combustion..."
>
> (Health-e, 2004)

3.3.4 Indicator 2 and world health

The importance of indoor air pollution in developing regions of the world as compared to its importance in industrialised countries is shown in Figure 3 below. The chart allows comparisons of how each region/group of countries fares in terms of outdoor pollution, as well as looks at the total disease burden – DALYs (Disability-Adjusted Life Years) for each group of countries.

As can be seen from the plot, the disease burden, as a percentage of total health risks, due to urban air pollution is highest in China and Latin America while the disease burden due to indoor air pollution is highest in India, Sub-Saharan Africa and China. Sub-Saharan Africa, followed by India, are the leaders in total disease burden, measured in DALYs per million people. India's total disease burden is about 50% more than the average for other regions except Africa, while Africa's total disease burden is about 2.5 to 3 times as much as the average for other regions except India. Clearly, relative to other regions in the world, indoor air pollution is relatively very important in Sub-Saharan Africa in terms of its total disease burden contribution, measured in DALYs.

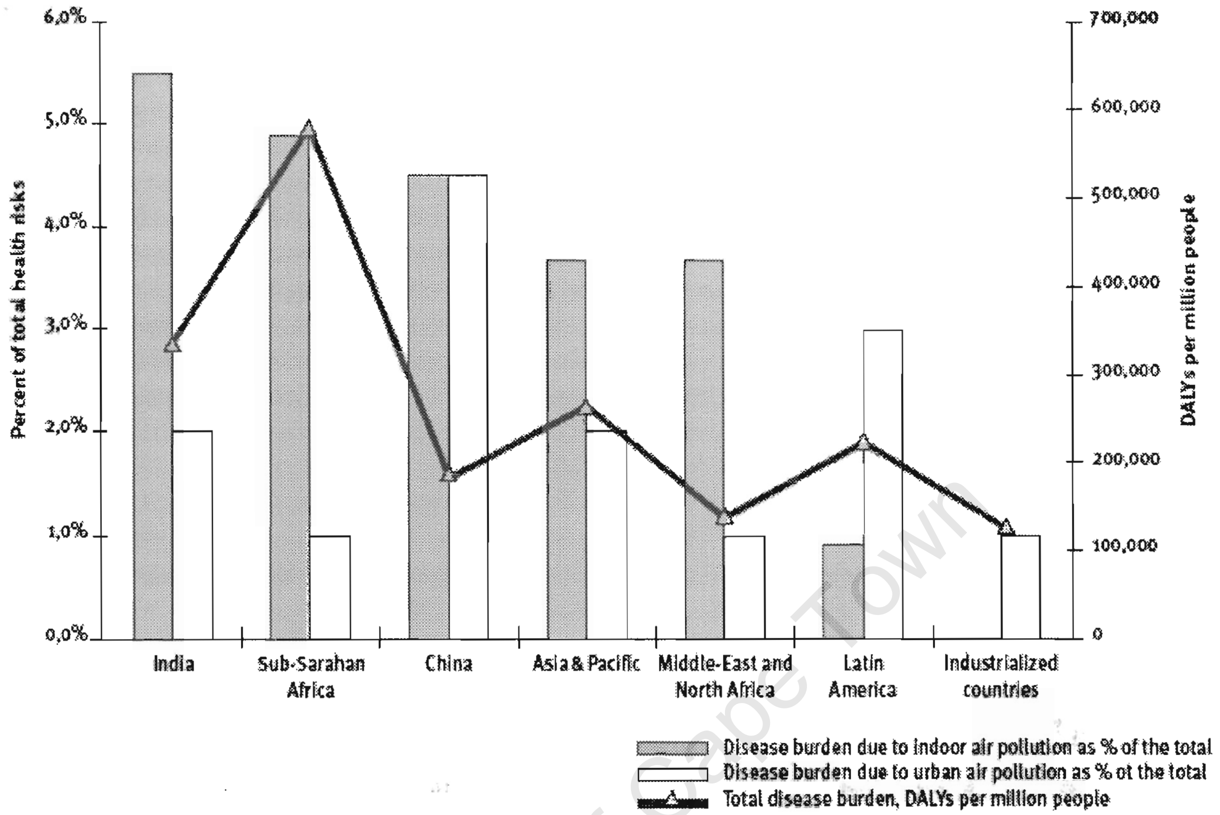


Figure 3: Total disease burden and disease burden arising from indoor and urban air pollution

Source: World Bank, Quoted by Von Schirnding Y et al, 2002.

3.3.5 PM10 in context with other local air pollutants

Eskom - the national electricity utility, is the largest single emitter of local pollutants in South Africa. Van Horen (1996) presents an estimate for the cost of local air pollution from Eskom's coal fired power plants (Van Horen, 1996). The estimate is based on looking at the cost of physical health damages of the following local pollutants: total suspended particulate (TSP) emissions, which include PM10; sulphur dioxide (SO2) emissions; nitrous Oxides (NOx) emissions. The estimate does not include other damages such as those resulting from acidic (rain) deposition or reduced visibility, and is therefore conservative. All these local pollutants are generally present in indoor air pollution due to low-quality fuel combustion.The estimate is for the 1994 emissions from Eskom's power stations, and is stated as follows:

> "The valuation results for the nine coal power stations... with total damages of R805 million in the central estimate (R583 m and R992 m for the low and high estimates). These translate into external costs of 5.43 mills or 0.543 cents per kWh in the central case."
>
> (Van Horen C, 1996a, p.79)

The central estimate stated corresponds to about 2.5% of the 1994 domestic tariff and about 5% of the 1994 bulk industrial tariff, both estimated from 1999 tariffs from ISES (ISES, 2005). The addition of other external costs would raise these estimates.

Indoor air pollution has a greater aggregate health impact by virtue of:

a. (As already quoted from WHO publications) pollutant concentrations being higher as there is less ventilation in an indoor setting.

b. Unlike the pollution from power stations, the effects of indoor air pollution are not limited to areas in proximity to power stations (mainly parts of Mphumalanga Province and the populated areas around Vereeniging, south of Johannesburg). The effects of indoor air pollution are distributed throughout South Africa, in poor townships and rural areas.

The following table shows trends in the environmental implications of using electricity, as reported by Eskom. It is useful in showing trends in local pollution for certain parts of South Africa.

Table 4: The Environmental Implications of Using One Kilowatt-hour of electricity

	2003	*2002*	*2001*	*2000*	*1999*	*1998*	*1992*
Water usage *litres*	1.29	1.27	1.26	1.21	1.25	1.23	1.45
Coal Usage, *kg*	0.50	0.49	0.50	0.49	0.49	0.48	0.48
Ash produced, *g*	142.01	132.62	139.78	129.95	133.65	134.90	-
Ash emitted, *g*	0.28	0.29	0.31	0.35	0.37	0.36	1.03
SO2 emissions, *g*	8.22	7.56	7.91	7.95	8.28	8.65	7.25
NO2 emissions, *g*	3.62	3.55	3.61	3.56	3.70	3.65	3.65
CO2 emissions, *kg*	0.90	0.89	0.89	0.85	0.88	0.89	0.90

Source: Eskom, 2004c:139.

Table 4 shows that there is no clear trend in local pollutants emitted for the period 1992 to 2003, except for ash emitted, which shows a steady decline for the mass emitted, from 1.03 g/kWh in 1992, to 0.36 g/kWh in 1998, and on to 0.28 g/kWh in 2003. This trend implies an improvement in the PM10 pollution situation with regard to Eskom power stations. According to the table, it would appear that it is difficult for Eskom to achieve any further cuts in local pollutants, apart, perhaps from ash emitted. Any further desired significant improvements in the environmental implications of generating and using electricity imply a shift to a different electricity generation technology.

3.3.6 Shortcomings in Indicator 2

The PM10 data as presented in the 'State of the Environment', report for Cape Town (City of Cape Town, 2003), is defined as a 24 running average. A shortcoming of presenting the data in this way is that it gives no information on the severity and frequency of the pollution peaks. For places such as Khayelitsha, the pollution when stoves and space heaters are being lit (early evening or early morning) is much worse than that in the middle of the day or the middle of the night, but the duration of the peaks is evidently such that some health damage is done. It should be noted that although the data used in this survey does not reflect severity and duration of pollution peaks, the source report itself (City of Cape Town, 2003) does discuss and illustrate the nature of the pollution peaks.

Another shortcoming of using PM10 is that there is widespread use of paraffin in lower-income households. Measuring PM10 concentration does not give much of an indication of the local pollution and thus the health effects of paraffin, which is a threat to at least the respiratory and eye health of users, not to mention the danger of fires. Paraffin is particularly widely used in cities and other places where firewood and coal are not easily accessible. One such place is Cape Town and other urban areas in the Western Cape Province. Cape Town is far from the coal mines and many parts of it do not have easily accessible firewood, so paraffin is the best heating and cooking fuel option for low-income households.

3.3.7 Developments related to Indicator 2

Possibly the largest emitter of local pollutants by organisation is Eskom. Eskom has been continuously monitoring the environmental impact of its power stations and reporting on progress annually. As can be seen in Table 4, from Eskom's data, shown above, the local environmental impact of using one kilowatt hour of electricity is not improving by much in recent years. However, the monitoring no doubt does help to limit the pollution. In 2003, the Air Quality Bill of 2003 was published. It will, if passed into law, increase activities in local pollution monitoring and thus air quality should improve. In January 2004, New air quality monitoring stations started to generate data in South Durban (Department of Environmental Affairs and Tourism, 2004). This was a step which was said, by the national Department of Environmental Affairs and Tourism (DEAT) to be the precursor to a national roll-out to various sites (initially cities) around the country (Department of Environmental Affairs and Tourism, 2004).

3.3.8 Future prospects

It is foreseeable that data on a national level, at least for the major cities, will, within a few years to come, become available as South Africa's Department of Environmental Affairs and Tourism rolls out air monitoring stations, such as that for Durban. There is an opportunity for a downward trend to be established in future as the Department of Environmental Affairs and Tourism's Air Quality Bill of 2003 states:

> "6. Ambient concentrations of particulate matter with a particle size of less than 10 microns (u) in size (PM10) may not exceed- (a) a twenty four hour average of 180 micrograms per cubic meter (ug/m3) and the 24-hour limit may not be exceeded more than three times in one year; or (b) an annual average of 60 micrograms per cubic meter (ug/m3);"
>
> (Department of Environmental Affairs and Tourism, 2003: *Schedule 1, p. 24)*

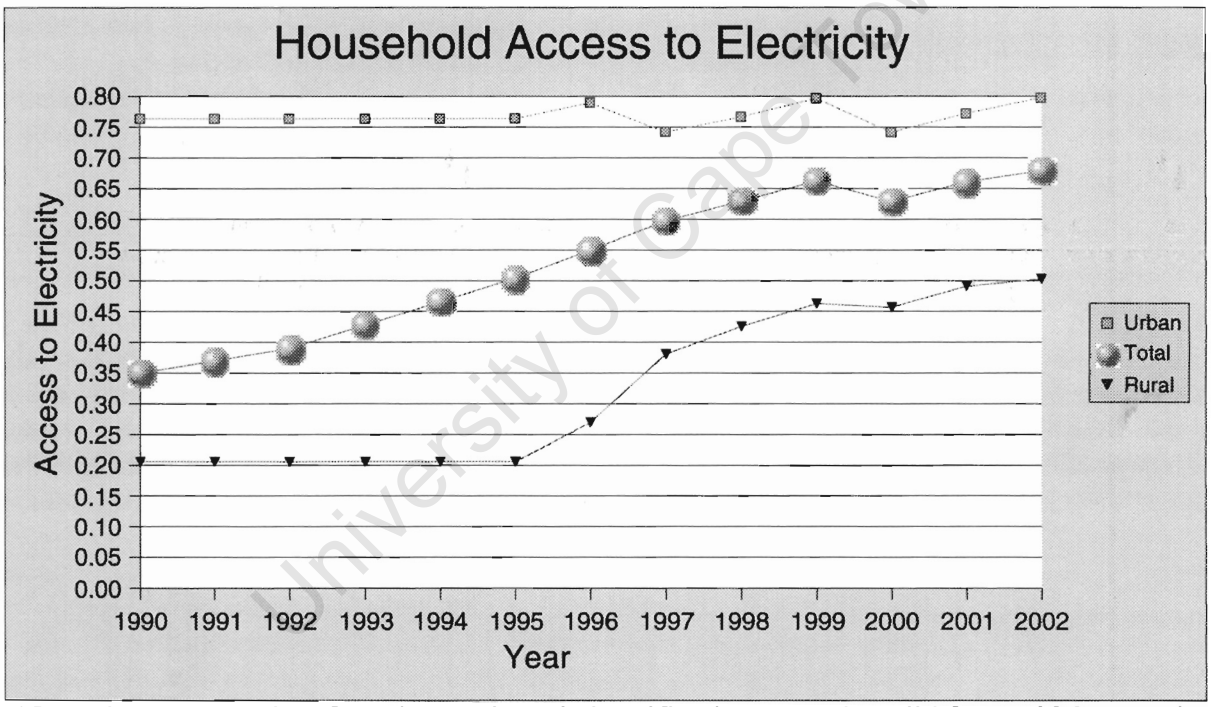
If enacted, the Bill will make a contribution to the improvement in air quality in South Africa. In addition to the Air Quality Bill, there is likely to be a positive effect from the roll out of the air quality monitoring stations. The existence of more monitoring sites will allow objective evaluation of the air pollution phenomenon in South Africa, and thus empower legislators to fine tune legislation against particulate pollution, as well as allow the judiciary to enforce these limits.

3.4 Indicator 3: Households with access to electricity

3.4.1 Results for Indicator 3

This indicator measures the number of households in South Africa that have access to electricity, as a percentage of the total number of households in South Africa. The sustainability target is, of course 100% of all households having access to electricity. The reference for unsustainability is 0% of households having access to electricity.

From 1990 to 2002, This indicator has improved from 0.65 to 0.32, showing a sustained move towards sustainability. The improvement in this indicator even in more recent times - 2001 to 2002 shows government's continued commitment to universal domestic electricity access. The percentage of households with access to electricity in this period increased from 66.1% to 67.9%, adjusting the vector for this indicator from 0.34 to 0.32. The plot for households access to electricity in South Africa is shown below.

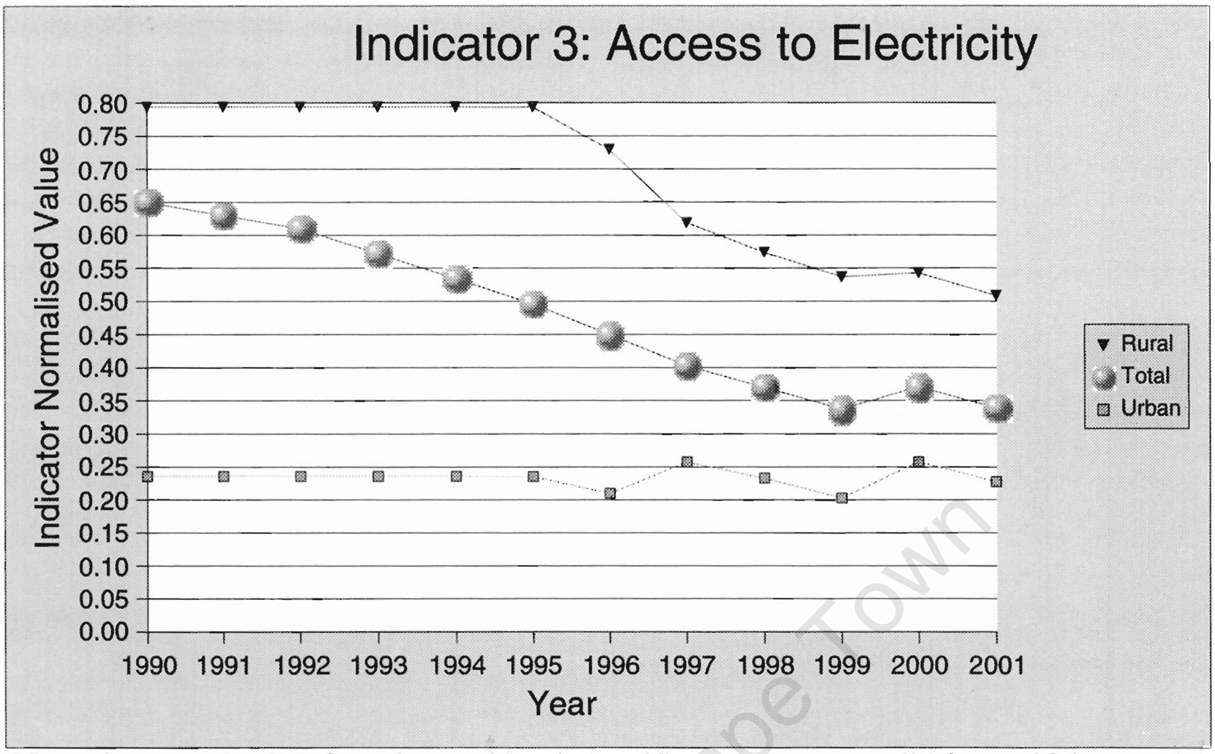


Note: the separate plots for urban and rural electrification are only valid from 1995 onwards.

Figure 4: Household Access to Electricity.

Source: Eberhard and Van Horen, 1995 and NER South Africa, 2003.

The plot for indicator 3, based on the values in Figure 4, is shown in Figure 5 below, but is like the inverse of Figure 4.



Note: the separate plots for urban and rural electrification are only valid from 1995 onwards.

Figure 5: Plot for indicator 3.

Source: Eberhard and Van Horen, 1995 and NER South Africa, 2003.

3.4.2 Developments related to Indicator 3

The discovery of coal fields, mainly in the Mphumalanga Province of South Africa gave South Africa access to an abundant and easily accessible source of fuel to use to generate electricity, which has contributed to low electricity generation costs. The South African economy was a government planned economy for much of the 20th century. Coal fired electricity generation was a significant part of this planned economy. In late 1990, as the political climate began to change from the apartheid state to negotiations on a new dispensation, mass electrification began as Eskom "(launched) its national electrification programme" (Van Horen C, 1996b). 1994 saw the advent of the new democratically elected government, which made domestic electrification a national priority, including it in its Reconstruction and Development Programme (RDP), and "One of the most prominent goals (being) that of electrifying 2.5 million additional homes by the year 2000." (Van Horen, C, 1996b). In 2002, South Africa government approved an allocation of 50kWh per month of electricity to households, targeted mainly at poor households, and paid for through the central government budget.

3.4.3 Future Prospects

National government continues to finance the electrification of households, and also funds an allocation of 50kWh per month to each household in South Africa. There is little doubt that the 50kWh per month allocated to each household will make a difference to the ability of poor households to access modern energy supplies. The value of the indicator is expected to continue to improve, but slower than before, as the (mainly rural) households that are being electrified at the later stages of the electrification programme are less accessible to the grid, and each one costs more to electrify. The planned introduction of Independent Power Producers - IPPs (Department of Minerals and Energy, 1998) should not affect the ongoing electrification, provided the supply remains comfortably in excess of demand.

3.5 Indicator 4: Investment in clean energy, as a proxy for job creation

3.5.1 Results for Indicator 4

This indicator measures investment in clean energy within both the public and private sectors in South Africa. Clean energy here includes renewable energy and end-use energy efficiency. Investment in these is taken as a percentage of total energy sector investments. Capital investments are included, but research and development is not. The reference for unsustainability is 0% investment and the reference for sustainability is 95% investment in clean energy.

Table 5 shows the trend in indicator 4.

Table 5: Indicator for investment in clean energy: 1998 – 2002

Year	*1998*	*1999*	*2000*	*2001*	*2002*
Indicator	0.99	0.99	0.99	1	1

Sources: Annual Financial reports on capital investments from Eskom (2000, 2001, 2003) and Mossgas (2001), SAPIA (2003), COM (2002a) and DBSA's 'SADC Renewable Energy market', southafrica.info (2004) and mbendi.co.za (2002).

The metric of this indicator for the year 2002 is 0.44%, compared to 0.36% for the year 2001 and the 0% estimate for the 1990 reference value. The latest value of this indicator – for the year 2002, is 0.995 or virtually 1, which is virtually unchanged on the assumed 1990 value, or the 1998 value, which can be seen in the table for the indicator above.
This indicator shows little change. The main reason for this is that the amount invested in clean energy remains substantially lower than the total energy sector investments.

Apart from the solar water heaters expenditure and the expenditure on windmill pumps, almost all of the rest of the clean energy investment is either part of a subsidised scheme or experimental.

3.5.2 Developments related to indicator 4

Policy documents that are likely to influence Indicator 4 include the promulgation of the White Paper on Renewable Energy in 2003 (Department of Minerals and Energy, 2003a), the Draft Energy Efficiency Strategy of the Republic of South Africa issued in April 2004 (Department of Minerals and Energy, 2004b). The implementation of the Kyoto Protocol, and specifically CDM, the Clean Development Mechanism, are likely to increase the number of investments in clean energy as, for example, there is much energy wasted in South Africa – requiring more investment in energy efficiency.

3.5.3 Prospects for the future

The following are interventions that may help to improve the investment in clean energy. The increased prevalence of extreme weather episodes which are seen to be the result of global climate change, as discussed earlier under 'future prospects' in the on indicator 1 (section 3.2.6) and later, in the section 'Interpretation of Results', should affect decision-making and accelerate the search for alternatives. As is the case for indicator 1, with the Kyoto Protocol as international law, CDM projects should multiply in South Africa, resulting in more investment in clean energy. More future possibilities affecting this and the other indicators are discussed in the section 'Interpretation of Results'.

3.6 Indicator 5: Resilience to external trade impacts

3.6.1 Introduction to Indicator 5

There are two sub-indicators which are part of Indicator 5. The first is 'Non-Renewable Energy Exports as a Share of Total Exports', and the second is 'Non-Renewable Imports as a Share of Non-Renewable TPES (Total Primary Energy Supply)'. South Africa scores relatively well in these sub-indicators compared with the other indicators.

3.6.2 Results: Non-Renewable Energy Exports as a Share of Total Exports

The first sub-indicator measures non-renewable energy exports as a share of total exports, measured by monetary value. In other words, it indicates how dependant South Africa's economy is on non-renewable energy exports for income. The value of the sub-indicator shows little change in the period 1994 to 2002 for which data exists, ranging from just below 0.08 to just below 0.11, a range of less than 0.03 as shown in Figure 6 below. The values measured show South Africa to be well below the non-sustainable reference value of 1. In Rand terms, non-renewable energy exports in 2002 totalled R30.96 billion, while the total exports for South Africa in the same year were R312.9 billion (TIPS, 2004). The dependence on non-renewable exports is clearly quite low. Figure 6 shows the trend in indicator 5a. It should be noted that while there might seem to be a trend with notable changes, the scale on the plot is only 10% or less of that for most of the other indicators, so the variations in this indicator are actually small.

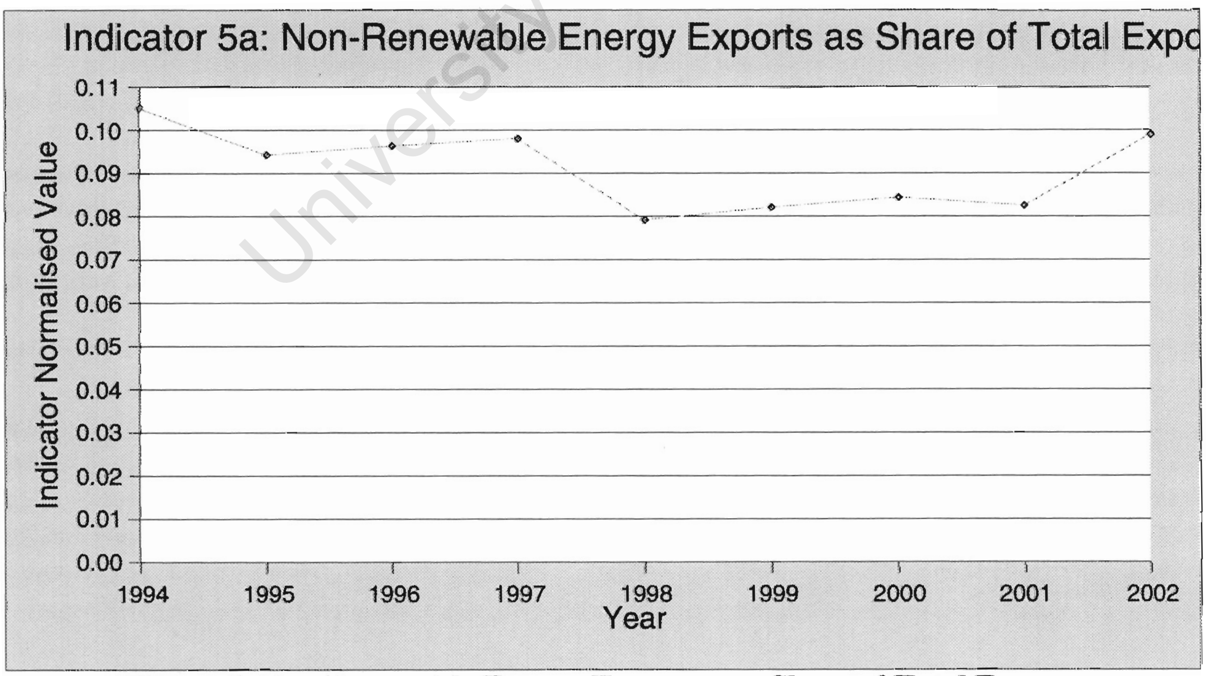


Figure 6: Non-Renewable Energy Exports as a Share of Total Exports

Source: TIPS, 2004.

3.6.3 Energy Exports and other Exports

Non-renewable energy exports in South Africa include coal, refined petroleum products and electricity generated using coal. The different exports making up South Africa's merchandise exports in 2000 are shown in Figure 7 below. Table 6 shows South Africa's mineral sales and exports in 2000. From the two illustrations it can be seen that coal made up around 14% of mineral exports and that primary and beneficiated mineral exports made up 60% of South Africa's merchandise exports in 2000. The fact that coal and the other non-renewable energy exports make a modest contribution to merchandise exports is certainly greatly influenced by the fact that South Africa has large reserves of minerals which it exploits to export.

Table 6: South African mineral sales and exports in 2000.

	Total sales R'mns	Exports R'mns	% exports to total sales
PGMs	27 095	24 646	91,0
Gold	25 272	25 055	99,1
Coal	19 691	10 914	55,4
Iron ore	3 065	2 469	80,6
Nickel	2 051	862	42,1
Copper I	578	603	38,2
Manganese ore	1 232	864	70,1
Chrome ore	1 076	361	33,5
Limestone & lime	792	14	1,7
Silver	170	156	91,5
Fluorspar	114	100	88,2
Lead	109	89	81,8
Asbestos	34	31	91,2
Miscellaneous	16 093	10 142	63,0
TOTALS	98 371	76 304	77,6

Source: Minerals Bureau/South African Reserve Bank, quoted in COM (2002a:7).

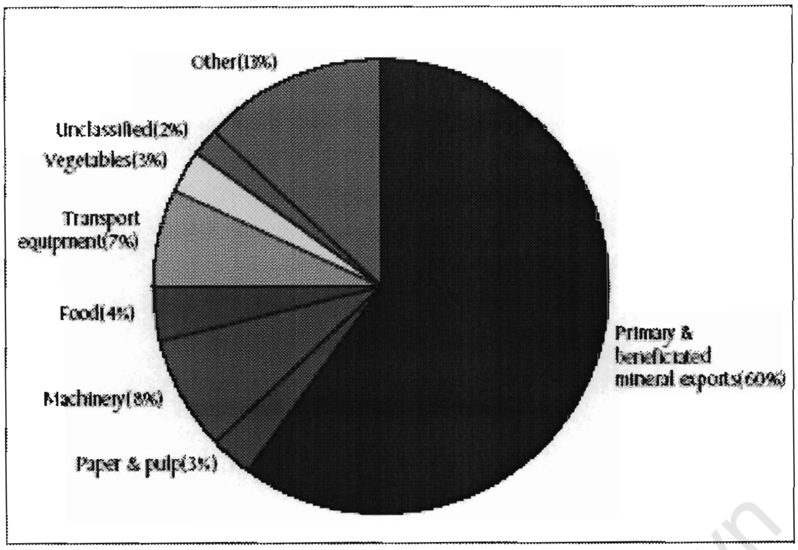


Figure 7: The contribution of primary and beneficiated exports to total merchandise exports from South Africa, 2000 (R208,5 billion). Note: primary & beneficiated minerals are the big, dark sector to the right and bottom of the chart.
Source: (COM, 2002a:24).

Along with coal, the highest export earners among South Africa's mineral endowments are the platinum group metals, gold and iron ore. The dependence on mineral exports is strongly illustrated by the fact that South Africa is ranked first in the world in tonnage production of alumino silicates, chrome, gold, manganese, platinum group metals, vanadium and vermiculite (Appendix 3.3). South Africa ranks 5^{th} in coal reserves worldwide, and it ranks 6^{th} in coal production worldwide. Clearly, without this dominance in the other mineral resources, coal would make up a large part of South Africa's merchandise exports, rendering it more vulnerable to international shocks, such as the implementation of the Kyoto Protocol in February 2005. Notably, over the past several decades, however, the South African economy has been diversifying away from mineral extraction and processing.

3.6.4 Developments and factors affecting Non-Renewable Energy Exports as a share of Total Exports

South Africa has an abundance of coal reserves and has developed a fairly good coal extraction and transportation infrastructure through state planning and heavy investment in (rail) transport infrastructure by the Apartheid government. It is thus able to export excess coal production. The weakness of the Rand is another factor. The South African currency unit is (from 20 year trends, for example) historically relatively weaker than the world's major currencies, inspite of its recent improvements since early 2002. As of early November 2004, it remained at levels weaker than the pre-1999 levels when compared to the US dollar, the dominant commodity currency. The relative weakness of the Rand means that it is easier for South African coal producers to negotiate attractive coal supply contracts with its customers. It would seem that the entrance of the Kyoto Protocol into law on 16^{th} February 2005 will start to slow down enthusiasm for coal and other greenhouse gas intensive fuels. This is also looked at briefly in the next paragraph.

3.6.5 Future Prospects for the Energy Exports sub-Indicator

Future trends in this indicator depend on a number of factors. Firstly, it seems that coal use will in the short to medium term continue, in the absence of a (financially) cheap alternative. Secondly, in the present climate of world economic stagnation, exports of non-renewable energy from South Africa in general are not likely to grow in leaps and bounds. These two considerations would indicate very little change in this indicator. Another aspect of exports is that South Africa's total exports are, as already explained earlier, heavily dominated by primary and beneficiated minerals. If the era of speculative currencies (currencies without gold to back them) comes to an end, or the US dollar collapses under the weight of the present trade and fiscal deficits in the USA, then precious metals may appreciate in value, and with them, South Africa's export revenues. Non-renewable energy exports may then decrease as a share of total exports, decreasing the indicator further. In the event that climate change-induced weather changes become overwhelming within a few years, then the world's attachment to low (financial) cost energy and thus extensive fossil fuel use, may come to an end. The provisions of the Kyoto Protocol may be tightened, making the use of fossil fuels unfavourable and generally cutting non-renewable energy revenues of exporters of these fuels and related technologies, including South Africa. The indicator would therefore drop further, reflecting more sustainability. If the indicator drops quickly due to rapid forced cuts in exports – foreign customers switching to cleaner energy from elsewhere, then the transition will be a hard one for South Africa. The indicator is meant to give an indication of the ease with which South Africa will be able to adapt to such a transition.

3.6.6 Non-Renewable Energy Imports as Share of Non-Renewable TPES

The second sub-indicator measures non-renewable imports as a share of non-renewable TPES. It gives an indication of South Africa's economic dependency on non-renewable energy imports. Non-renewable energy imports (in Tera Joules) as a share of total non-renewable energy supply, in the year 2001 shows a very slight change for worse on the previous year's value of 21% to 23%. This is shown in Figure 8. As in the case for Figure 6, the total range of the scale for this figure is about 10% or less of that for most of the other indicators, so the changes in this indicator are exaggerated by the scale.

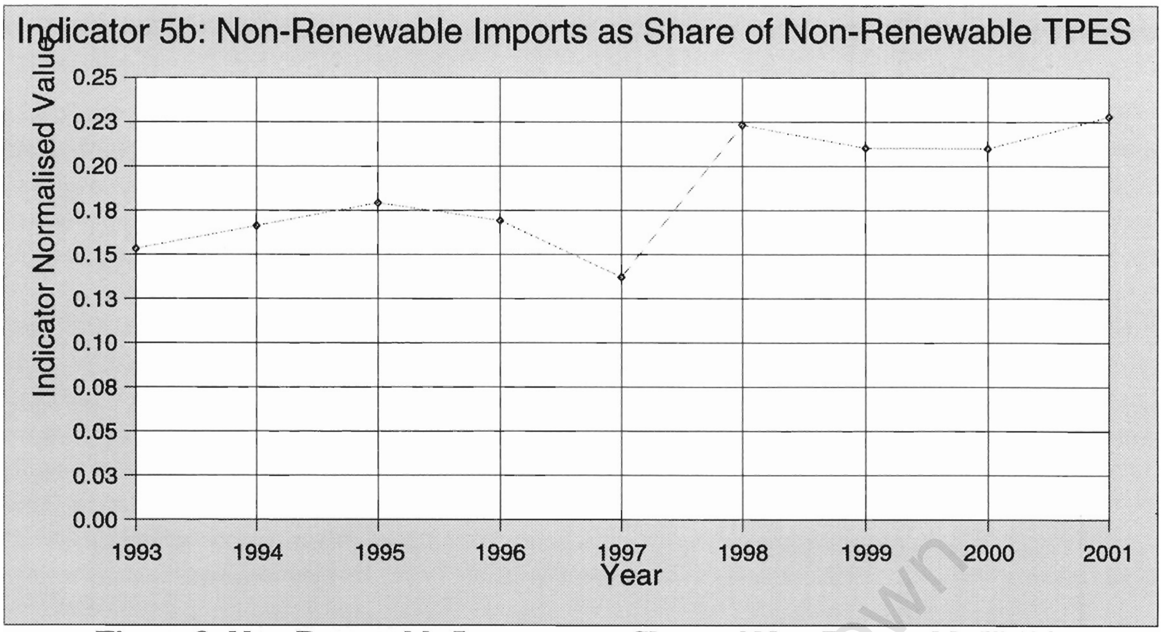


Figure 8: Non-Renewable Imports as a Share of Non-Renewable TPES.
Source: Department of Minerals and Energy (2000, 2002a, 2003b).

1993 is the year when the first data is available for this sub-indicator (imports) – due to the secrecy surrounding energy data during the time of the pre-democratic government. As compared to 1993, the value of the metric for the indicator has worsened from 15% to 23%, or by 53%, corresponding to a change in the vector value from 0.15 to 0.23, also a change for the worse of 53%. In Tera Joules (TJ), South Africa in 2001 imported 942,495 TJ out of a total 4,132,674 TJ of non-renewable TPES. The imports remain relatively low.

The main reasons for the increase and thus slight worsening of this indicator, or the increase in non-renewable energy imports as a share of non-renewable TPES is illustrated and analysed later in the chapter 'Transport Energy Analysis'.

3.6.7 Developments related to Energy Imports sub- Indicator

The shift from rail transportation of freight to road transportation is discussed in chapter 4 on transport energy. This shift has contributed to a variety of problems including higher costs for road maintenance and the increased demand for petroleum fuels in South Africa. As South Africa produces very little crude oil (it produced 4.2% of its required crude in 2002), the import of non-renewable energy has increased accordingly, as discussed in section 4.3.

3.6.8 Future Prospects for Energy Imports sub-Indicator

There seems little scope for improvement of this indicator, given that it is not easy to replace petroleum products, which make up a major part of the energy imports. Possibilities that exist to improve this indicator include the improvement of the transportation system in the country to allow more mass transportation of goods and people (especially rail for goods), as well as the facilitation of human powered transportation, which is viable to an extent in various urban and rural contexts in South Africa. Another possibility, which is being explored by a private initiative, is biofuels, namely biodiesel. Bio-ethanol is also being explored. These alternatives will require a commitment to thorough planning, coordination, and a policy framework in order to be implemented to a meaningful extent. They will face opposition as they will be in conflict with the interests of the petroleum sector in South Africa. There is a discussion of alternative fuels in the section on Indicator 8 below.

3.7 Indicator 6: Burden of energy investments on the public sector

3.7.1 Results for Public Sector Burden of Non-Renewable Energy Investments

This indicator, which looks at the burden of energy investments on the public sector, is defined as public investment in the non-renewable energy (NRE) sector as share of GDP. This report looked mainly at investments by state-owned enterprises Eskom and Mossgas (now part of PetroSA). The sustainability reference is 10% investment in non-renewable energy as a share of GDP, while the unsustainability reference is 0% investment in non-renewable energy as a share of GDP.

Figure 9 is a plot of trends in this indicator in recent years. It is worth noting that, as was the case for the indicators for energy trade, the scale for this indicator is much less than that of most of the other ones, so the change apparent from the plot is in reality much more muted.

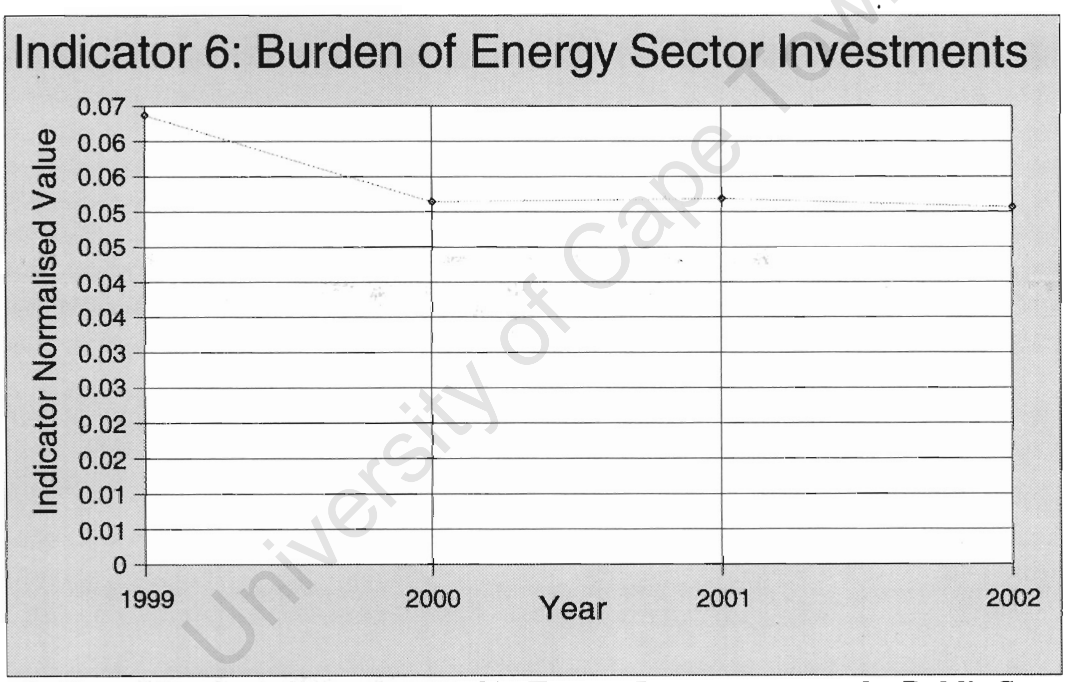


Figure 9: Plot of Burden of Non-Renewable Energy Investments on the Public Sector as a share of GDP.

Source: Annual Financial reports on capital investments from Eskom (2000, 2001, 2003) and Mossgas (2001), SAPIA (2003), COM (2002a) and DBSA's 'SADC Renewable Energy market', southafrica.info (2004), mbendi.co.za (2002) and South African Reserve Bank (2003).

The value of the metric for this indicator for the latest data (2002) is 0.51%, a slight but insignificant decline from the 2001 value of 0.52%. The vector for the indicator remains at 0.05. The metric for the earliest available data (1999) is 0.64% and the indicator vector value is 0.06.

The capital expenditures that contributed to the figures used to quantify the indicator include Eskom and Mossgas (reference part of Table 4.1).

There is little change in the value of this indicator in the period from 1999, when the first reliable data is obtained. Historically, there was a time when the indicator would seemingly have certainly been significantly higher than it is now. This is mainly the 1980s when the coal fired power stations were constructed, as stated in the following paragraph.

3.7.2 Developments affecting Public Sector Burden of Non-Renewable Energy Investments

The period of construction of the great coal-fired power stations, located mainly in Mphumalanga Province, in the 1980s, was a period of great financial drain on state funds. However, the present period is reaping the benefits of this excessive expenditure, in the form of low electricity prices, which are said to be among the cheapest in the world (Eskom, 2004a).

3.7.3 Future prospects

In the way it is presently determined, this indicator is already reflecting much sustainability, and will continue to do so. If, however, the issue of how this indicator is determined is changed in order to take into consideration more of the true burdens of non-renewable energy on the public sector, then there would be much room for improvement in the indicator for South Africa. It is also imminent that the indicator will get slightly worse as Eskom spends more in the years to come on additional electricity generation capacity, which will, for the most part, be non-renewable. The 'Simunye' project to bring back on-line some coal-fired power stations that had been decommissioned due to excess supply (see section 3.9.2), is an example. South Africa is in the process of building a prototype Pebble Bed Modular Reactor, a nuclear technology, and therefore non-renewable. Should the technology be a success, spending on fully operational units would result, and this would also contribute to an increase (worsening) in this indicator.

3.8 Indicator 7: Energy intensity

3.8.1 Results on Energy Intensity

This indicator looks at South Africa's energy intensity in megajoules of total primary energy supply per 1990 US dollar of GDP (MJ/US$ 1990 GDP).

There was an improvement in this indicator from the 1999 value to the 2001 value. At exchange rates, the value of the metric decreased from 35.9 to 32.3 (MJ TPES/US$1990 GDP), decreasing the indicator vector value from 3.64 to 3.26. At purchasing price parity (PPP), the value of the metric decreased from 22.1 to 19.8 (MJ TPES/US$1990 GDP), decreasing the vector value from 2.19 to 1.95. There is, however, no consistent trend in this indicator in the 11 year period from 1990 to 2001 as evident in the plot of the indicator shown in figure 10 below. This figure plots the trend in the vector of the indicator using PPP. Notably, there is a sudden increase in the vector value of the indicator in 1997-1998.

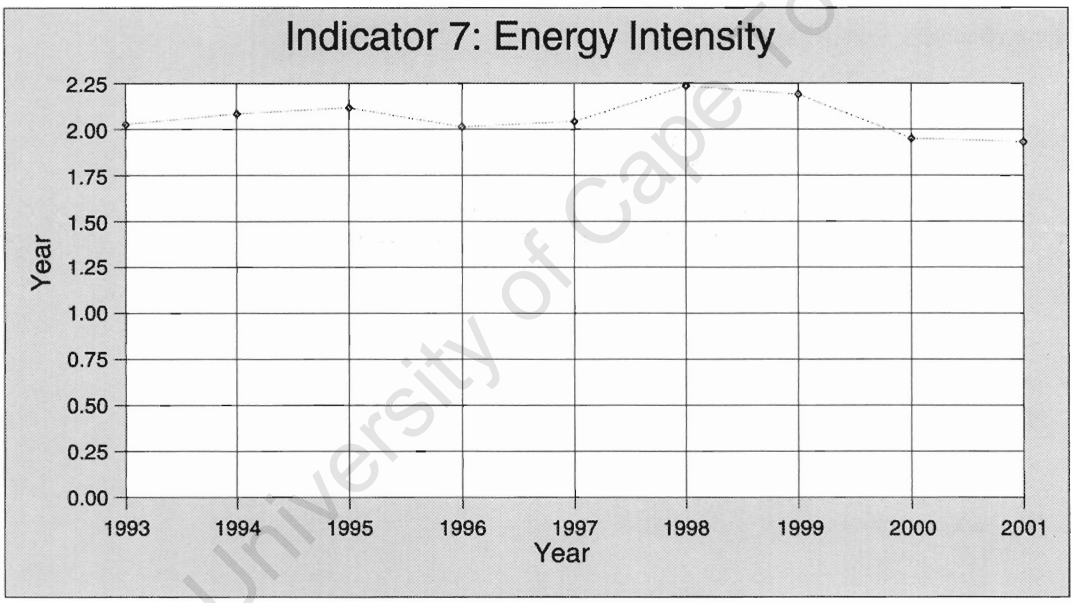


Figure 10: Plot for indicator 7.

Source: Department of Minerals and Energy (2000, 2002a, 2003b) and South African Reserve Bank (2003).

From the latest data for this indicator, it can be seen that South Africa has an energy intensity, using PPP, of about 19.6 (MJ TPES/US$1990 GDP), which is almost twice the world 1990 average of 10.64 (MJ TPES/US$1990 GDP). Higher energy intensity as measured here is generally typical of developing countries, while the economically developed countries such as Japan and the countries of the Western Europe have the lowest energy intensities.

3.8.2 Energy Intensive Investments

Concerning energy prices, South Africa's industry depends almost entirely on coal and electricity. Almost all the electricity (94% according to 2001 DME energy balance) is generated using coal. Coal is abundant in South Africa, and therefore the price is among the lowest in the world (Eskom, 2004a). South Africa sees the low prices as an economic advantage and tends to encourage energy-intensive industry such as aluminium smelting and steel production. Once established, these energy-intensive industries must, for financial reasons, be maintained for many decades, thus keeping the country on an energy-intensive path during their economic lifetime. The pursuit of low energy prices and the use thereof to establish energy intensive industries contributes to a higher (less sustainable) value of this indicator.

3.8.3 Coal and Energy Intensity

Coal-based energy has externalities related to health – as noted in the section on indicator 2. It also has other local and regional environmental effects such as acid rain, and it has the global effects which are the focus of indicator 1. Capturing the externalities of coal-based energy production would raise the price of coal-based electricity, and perhaps reduce the energy intensiveness of South African industry, but this may not be favourable to the South African government, which has prioritised economic development and universal access to modern domestic energy. Lower energy prices seem to favour the attainment of these goals but do not favour energy efficiency in the absence of other interventions. Interventions to encourage energy efficiency while allowing development could include:

- Stepped tariffs: these are widely used within various municipalities in South Africa for domestic customers. The typical stepped tariff begins with 50kWhs of free electricity, followed by a range where the unit charge is about 40 South African cents per kilowatt hour (in 2004). Beyond the 50kWh usage step, there seems no incentive in the domestic electricity market for consumers to become more efficient, as the electricity does not, at some usage amount, become more expensive per unit. If a further high domestic use step, which increases the unit cost after a certain number of units have been used in a particular month, is built into the tariff, it should encourage energy efficiency. Such a tariff regime would, of course have to be flexible in terms of allowing exceptions, for example, for home-based industries. The use of appropriate price signals as well as the accommodation of multi-step, as well as time-of-use tariffs, is set down by the National Electricity Regulator in its National Retail Tariff Guideline (NER, 2004).
- Time-of-use tariffs: these are tariffs which reward behaviour such as off-peak power usage. This incentive may be in use with some large industrial customers, but is not applied to domestic sector at present. If appropriately applied to domestic consumers, it could make a significant difference to both energy efficiency and the peak loading on the South African power network. It is worth noting that domestic consumption is responsible for only 17% of total electricity energy consumption (see figure 9.1 in the section 'Transport Energy Analysis'), but accounts for about 30% of the peak loading (Eskom, 2004b). Time-of-use tariffs could also cause a surge in clean energy technology such as solar water heaters, efficient lighting, skylights, insulation and so on.

3.8.4 Developments related to Indicator 7

In 1923, Eskom, virtually the country's only electricity producer was established. The South African government established Iscor in 1928, to produce steel products from iron ore. It contributed to development, but also contributed to setting South Africa on an energy-intensive development path. In 1944, the Monetary and Financial Conference was hosted by the United Nations. The Bretton Woods Conference, as it is also known ended with a flawed compromise on how to stabilise world trade. The World Bank and IMF are created to perform the task. The stage was set for an increase in the gap between wealthy and poorer countries, as the two institutions are controlled mostly by the USA, and a few other rich countries. Energy intensity is just one area where this gap is visible. The energy intensity of the marginalised poorer countries is generally higher than that of the richer countries, while the per capita energy consumption of the wealthier 'developed' countries is multiples of the energy consumption of the poorer 'developing' countries. In the 1950s, the government again intervened in setting up industry: Sasol was formed to produce petroleum products from coal, an energy intensive process. In the 1990s, there has been continued investment in energy intensive economic activities in the form of aluminium smelters (Bayside Aluminium Smelter in Richards Bay), and an expansion of stainless steel production (R3.3 billion expansion of Columbus Stainless in Middelburg, Mphumalanga, in 1995, as well as the construction of Saldanha steel in the Western Cape Province), and the expansion of platinum mining in the Northwestern and Northern Provinces. The Air Quality Bill of 2003, already mentioned in the section on indicator 2, will, if passed and enforced adequately, increase pressure on polluters to become more energy efficient, in their pursuit of lower local pollutant emissions.

3.8.5 Prospects for the future

The following is a discussion of the future possibilities for the improvement of energy efficiency in South Africa in the next two or so decades.

Direct energy efficiency measures included in the South African Department of Minerals and Energy's Integrated Energy Plan, including energy management systems, audits, awareness practices and time-of-use tariffs (Bennet K, 2004) are bound to make a contribution. One of the initiatives being pursued to achieve the saving is the promotion of the move to efficient lightbulbs, known as CFLs (compact fluorescent lightbulbs).

The positive results of effective environmental controls such as emissions controls should have an effect. For example, laws to control sulphur emissions or particulate emissions would encourage the transition to better energy efficiency since efficiency would result in burning less fuel.

Targeting the many opportunities in the domestic sector could improve energy efficiency. Although technically many technologies are already practical (for example solar water heaters, and energy efficient building design including skylights, insulation, window sizing and orientation, overhang and the direction in which the house is facing), they do, however require government intervention to create a framework (legislation, incentives etc.) to promote them by, for example discouraging the pursuit of short-term savings in favour of better long-term energy efficiency. Another initiative which holds promise in improving energy efficiency is the energy-efficiency labelling of products (Bennet K, 2004).

If energy production is decentralised, then there are prospects for better energy efficiency resulting from decentralised energy management (See note 2.7.1 in Appendix 2). Decentralised energy generation systems also offer the obvious energy saving due to the fact that there is generally less transmission loss, except perhaps in the case where there is large-volume long distance 'wheeling' through the grid (transmission into the grid when a local generating community has excess supply, and at another time, drawing from the grid by the same community when demand exceeds supply).

Transport energy is an obvious opportunity for South Africa to improve its energy efficiency. South Africa's public transport system by no means meets world best practice standards in terms of use of public transport relative to private car use. In addition, the mini bus taxis, which account for 65% of all passenger trips (Department of Transport, 2004a), are a relatively inefficient form of public transport as they carry only about 12 passengers.

Similar to Indicators 1 and 4, this indicator should benefit from Kyoto becoming international law, as this should mean more energy efficiency projects through the CDM mechanism.

The high number of power cuts in the area managed by the corporatised utility City Power in Johannesburg will encourage the implementation of alternatives, such as onsite emergency power supply alternatives, including the use of solar photovoltaic panels and diesel power generators. The increased use of onsite emergency power supply systems should in turn favour better energy efficiency measures to avoid high expenditure on fuels such as diesel, which may be used during power outages. Such measures would include more energy-efficient buildings incorporating, for example, better insulation, installation of solar water heaters, and the use of sky lights.

3.9 Indicator 8: Deployment of renewable energy

3.9.1 Results for Deployment of Renewable Energy

This indicator measures the deployment of renewable energy in South Africa.

The deployment of renewable energy as a percentage of TPES increased from 4.3% to 4.6% in the period 1999 to 2001. The change was not significant enough to change the value of the indicator, which remains at 1.05. The percentage rise is not a significant rise and it cannot be seen to be part of a sustainable trend into the future. Indeed, over the period for which data has been obtained for this report, namely the period 1993 to 2001, the indicator vector has changed by less than .01, or about 1% of the total change required to reach the sustainability goal of 0, which represents 100% renewable energy deployment.

Figure 11 shows a plot of the vector value of this indicator over the period under consideration, clearly illustrating the lack of change in this indicator, and thus a lack of movement in the proportion of renewable energy used as a fraction of total energy consumption.

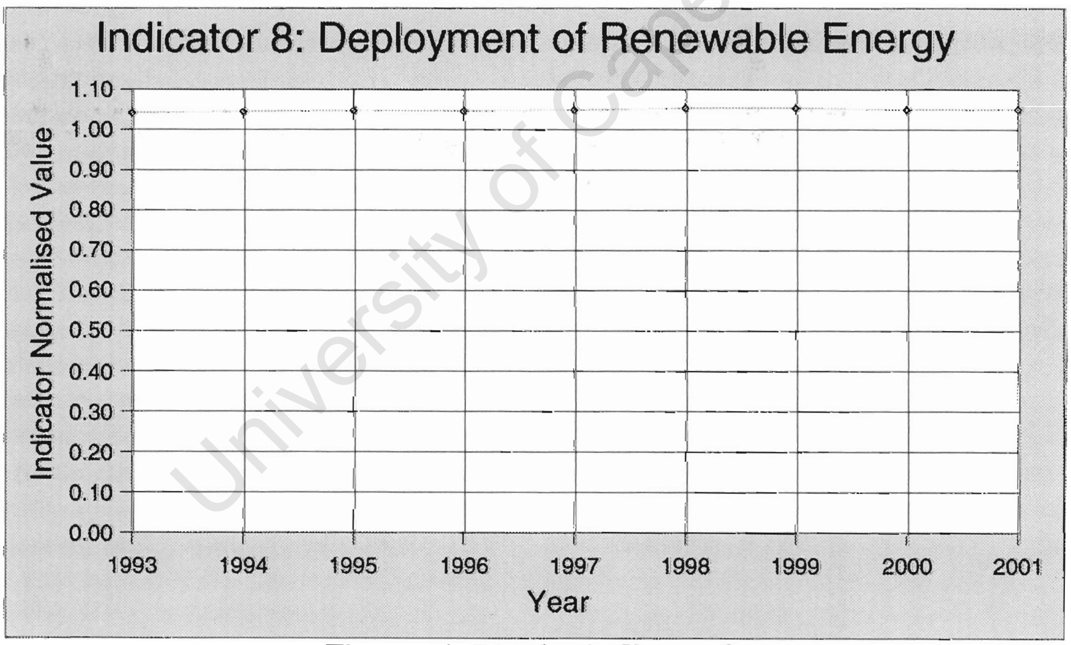


Figure 11: Plot for indicator 8.
Source: Department of Minerals and Energy (2000, 2002a, 2003b).

3.9.2 Developments related to Indicator 8

The contribution of renewable energy to total world primary energy supply is less than 14%, a majority (9.3 out of the 14%) of which is traditional biomass (UNDP 2004b:28). Globally, the fastest growing renewable energies by percentage growth per year for the period 1997 to 2001 were wind (for electricity) and solar photovoltaic at 30% per year, followed by low temperature solar heat and geothermal heat at 10% per year (UNDP 2004b:50).

The advent, on a global level, of 'jobless growth' (see interpretation of results on indicator 7 - energy intensity, in section 6.5.1.2) and the WTO and IMF campaign to liberalise markets without focusing on fairness in the markets (see the section 7.5 on the economic framework within chapter 7 – 'Some imperatives to Improving the Indicators' later in the report), has put pressure on governments, especially those in the developing world to pursue less-than-ideal development paths with respect to sustainability, supposedly in favour of economic growth.

The main form of renewable energy consumption in South Africa remains biomass in the form of domestic woodfuel and other fuels, sugar cane bagasse, and wood chip waste. There are some large hydro generators inside and outside South Africa which contribute to the electricity supply, but there is very little energy generation from renewable (small) hydro supply.

In the period 1999 to 2001 (between the data of the last report and of this one), little has happened to change the deployment of renewable energy percentage. Additional renewable energy deployment included solar home systems in rural areas in (Eastern Cape and the Northern Province) and preparations for the commissioning of the Eskom demonstration wind power station at Klipheuwel in the Western Cape. Both of these made very little difference to the national picture. In the period immediately leading up to the writing of this report - 2001 to 2003, for which there is not yet enough data to update the indicator, this indicator should again show little change as there were no significant developments that would affect the deployment of renewable energy percentage. The contribution of the new wind farm at Klipheuwel, as well as that of the solar home systems, will not be a significant percentage. The Klipheuwel Wind farm produced 3.4 Gwh of electricity in 2003 compared to Eskom's total output of 196,980 Gwh in the same year (Eskom, 2004c: 70,136). This represents a little less than 0.002% contribution. The Eskom/DBSA demonstration solar Stirling dish in Midrand, Gauteng generated a thousand times less energy than the Klipheuwel wind farm in 2003 (Eskom, 2004c: 70).
In the period from 2004 on, this indicator will most likely get worse (increase) for two reasons: firstly, the existing coal-fired power plants will have to produce more energy to meet rising demand, and secondly, ESKOM, in the face of the forecast national electric power deficit due around the year 2007, is bringing some 'mothballed' coal fired power plants back into operation. These are referred to as the Simunye Power Stations (Eskom, 2004c). There will not be a corresponding increase in energy obtained from renewable sources.

The White Paper on Renewable Energy (2003) sets a target for renewable energy deployment for the 10 year period 2004-2013:

> "In order to meet the long-term goal of a sustainable renewable energy industry, Government has set the following 10-year target for renewable energy:
>
> *"10 000 GWh (0.8 Mtoe) renewable energy contribution to final energy consumption by 2013, to be produced mainly from biomass, wind, solar and small-scale hydro. The renewable energy is to be utilised for power generation and non-electric technologies such as solar water heating and bio-fuels. This is approximately 4% (1667 MW) of the estimated electricity demand (41539 MW) by 2013.*
>
> *"This is equivalent to replacing two (2x 660 MW) units of Eskom's combined coal fired power stations."*

The pursuit of this goal is a positive undertaking. It will hopefully strengthen the seemingly inevitable move towards a more thorough deployment of renewable energy technology, in pursuit of possible future goals such as "...immediate reduction in its emissions of 50%-70% and further reduction thereafter..." expressed by Winkler et al, (2002), quoted in the section the section on Indicator 1. The concern would be that, in order to unlock job creation potential in South Africa as stated by AGAMA (2003) quoted in the section on indicator 4, a more aggressive renewable energy target would need to be pursued, with more likelihood of giving the benefit of economies of scale to establish strong local industries.

For developments related to this indicator, see the section 'developments related to indicator 1' in section 3.2.5. Many of those developments also relate to this indicator.

3.9.3 Future Prospects

Future prospects for the improvement of this indicator are further lessened by the plans to use large hydro-electric capacity in Central Africa to supply electricity to Southern Africa, since large hydro-electric generation is not considered to be renewable energy. A World Commission on Dams report in the year 2000 listed a number of the negative impacts of dams. The negative ecological effects of dams included loss of wildlife habitat and thus spieces in and around the flooded zone, loss of aquatic biodiversity, cumulative effects (of multiple dams on the same river) on water quality, natural flooding and species composition (World Commission on Dams, 2000:15). The report also notes an ecological effect most relevant to power generation, which was that depending on its location, a dam can emit more greenhouse gases than its thermal (fossil fuel) alternative, although it could also emit much less. Mitigation of the ecological effects, the report further notes, has met with limited success. In terms of the social effects of dams: mass displacement people (40-80 million people so far), loss of livelihoods downstream (also millions of people so far), and the difficulty in repairing the social damage wrought by dams – even when efforts are made (World Commission on Dams, 2000:16).

However, there are Southern African large hydro power projects under consideration which would have a positive impact on both indicators 8 and 1 for South Africa, due to the fact that the dams have already been constructed and the electricity from the dams would feed into the Southern African Power Pool. These include Itezhi-tezhi and Kafue dams in Zambia (Koritarov et al, 1997).

The implementation of the Pebble Bed Modular Reactor would also not help in the improvement of this indicator as nuclear energy is not considered to be renewable energy. However, it is very low in carbon emissions, and it would contribute to easing climate change pressure.

The following are being investigated by South Africa's Department of Minerals and Energy as renewable energy sources able to contribute to South Africa's future energy mix. More specifically, they are seen as able to contribute towards the achievement of the goal of 10,000 GWh of renewable energy contribution to final energy consumption by 2013. They are: biomass - bagasse in the sugar industry; biomass - paper and pulp industry; landfill gas utilisation to produce electricity; small scale hydro; solar water heating in residential houses with water and electricity; solar water heating in commercial buildings; wind energy (CaBEERE, 2004).

The total renewable energy potential of South Africa is shown in table 8 below:

Table 7: South Africa's Renewable Energy Potential

RE Technology Power generation from :	Potential GWh Contribution	Percentage
Biomass pulp and paper	110	0.1%
Power Generation from Sugar bagasse	5,848	6.9
Landfill Gas	598	0.7%
Hydro	9, 245	10.3%
Solar Water Heating: commercial	2,026	2.0%
Solar water heating: residential	4,914	6%
Wind	64,102	74%
TOTAL	86,843	100%

Source: (CaBEERE, 2004).

The following are some of the possible ways in which the deployment of renewable energy in South Africa's energy mix may be increased.

The increased use of biomass. This source of renewable energy is already being exploited in South Africa's sugar mills and timber saw mills, as well as for domestic use. It is estimated that South Africa has a biomass-supplied energy potential of 5,958 GWh per year, as noted in Table 7 above.

Energy from sunshine in South Africa is abundant by world standards:

> "South Africa experiences some of the highest levels of solar radiation in the World. The average daily solar radiation in South Africa varies between 4.5 and 6.5 kWh/m^2 (16 and 23 MJ/m^2) (Stassen, 1996), compared to about 3.6 kWh/m^2 for parts of the United States and about 2.5 kWh/m^2 for Europe and the United Kingdom." (Department of Minerals and Energy, 1998: 20).

This fact, coupled with the fairly mature nature of solar water heater technology has made solar water heaters practical and financially practical in today's South Africa. However, the initial capital cost, together with the lack of a financing mechanism, make them unattractive to consumers at present, unless included in the initial cost of a building. They are also cheaper if included as part of a new building at construction, rather than retrofitted. A focussed, government-led programme to facilitate greater use of solar water heaters seems achievable within the present policy framework. Solar water heaters have the potential to supply 6,940 GWh of energy per year as can be derived by adding domestic and commercial potential in Table 7 above.

Persistently high crude oil prices would stimulate the deployment of alternatives to crude. These include ethanol from sugar cane. This has been proven to be practical, except for the cost, which has remained high in comparison to crude products, until recent years, when the price of crude has risen, and remained high. Even though ethanol may be economically viable however, it does have environmental externalities in the form biodiversity concerns, for example as other vegetation is replaced in the large areas needed for viable ethanol-from-sugar cane production. Food security also becomes a concern when a single crop takes up a large percentage of arable land.

Other possibilities include biofuels, such as biodiesel made from the seed of the 'Physic Nut' tree, or 'Jatropha'. A number of organisations are promoting the use of this plant, whose oil is useful for a number of purposes. There are programmes already in existence in places such as India and Zimbabwe. There is much information available on the cultivation, technical issues and economics from organisations such as India's Centre for Jatropha Promotion (www.jatrophaworld.com). Other promising biofuels are methanol and soya based biofuel.

Electric vehicles research, as is being promoted by Eskom (Eskom, 2004a), should intensify. Toyota is already a leader in this field, with the electric-petrol hybrid car, the Prius already paving a possible pathway to the future (Toyota, 2004). More details at the end of the section 'General Comments on the Updated Indicators for South Africa' below. If electricity is generated by renewable means, then this indicator could improve if electric vehicles are deployed on a more extensive scale.

Increased use of public transport systems, depending on quality of services, could lessen the demand for crude per capita, as people move towards less expensive public transport. This could improve the indicator for renewable energy, provided the renewable energy contribution to the energy supply, in terms of energy units, does not decrease.

3.10 Conclusion to Chapter 3

Chapter 3 has presented the latest results of the indicator surveys for South Africa. In this chapter, the developments associated with each indicator, as well as future prospects for each indicator, were presented. Each indicator has been plotted to show the trends over time. In chapter 5, there is a deeper look at the trends in the different indicators, as well as an attempt to ascertain the existence of interrelations between the trends in the different indicators. Meanwhile, chapter 4, which follows, is an in-depth look at transport energy in South Africa. Transport energy is important in its relationship to indicator 1 (carbon emissions), indicator 2 (local pollutant), non-renewable energy imports as a share of total primary energy supply (indicator 5b) as well as the indicator on energy intensity (indicator 7).

4. Transport Energy Analysis

4.1 Introduction

This section looks more deeply at the transport energy subsector in South Africa in order to attempt to give a deeper insight into the foundation underlying, and the dynamics affecting the sustainability indicators. Among other things, it compares growth in transport energy use in relation to population growth and economic growth. The indicators most connected with transport energy are carbon emissions per capita (indicator 1), local pollutant (indicator 2), non-renewable energy imports as a share of total primary energy supply (indicator 5b) as well as the indicator on energy intensity (indicator 7).

Transport accounts for approximately 27% of the final energy consumption in South Africa. This figure is illustrated in the following chart:

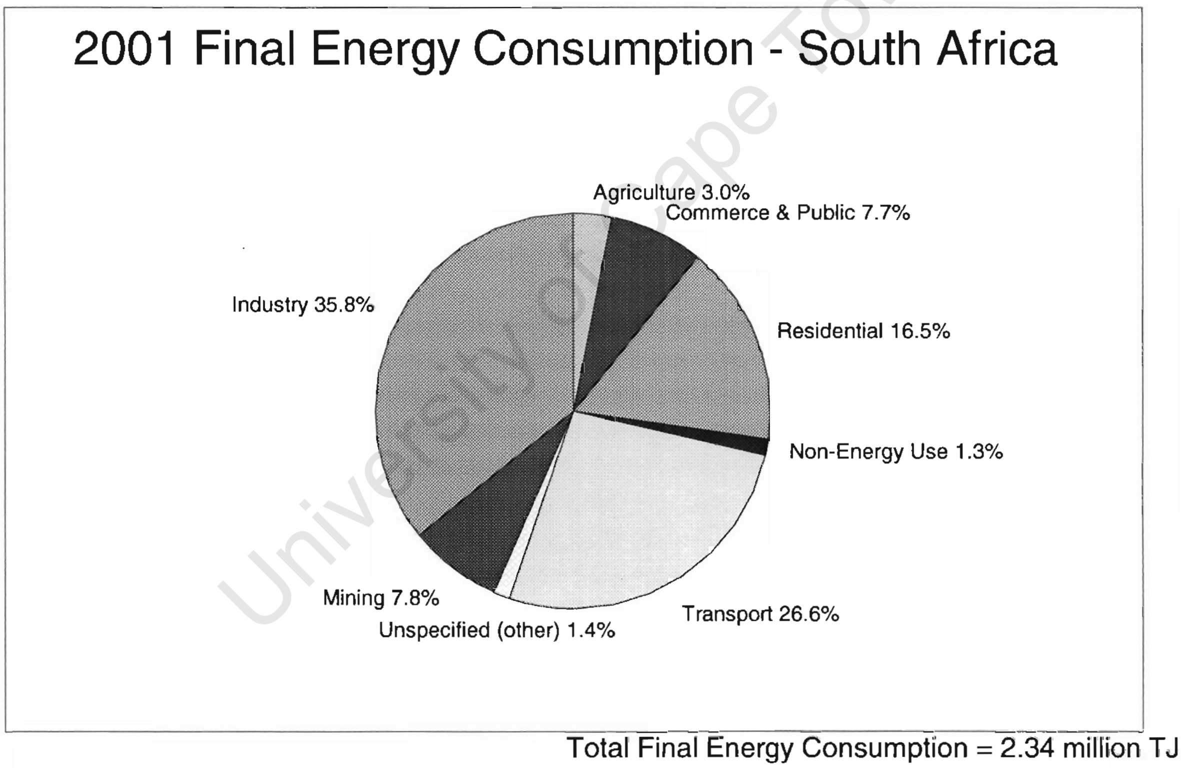


Figure 12: 2001 Final Energy Consumption – South Africa.

Source: Energy Balance 2001 from (South African) Department of Minerals and Energy (2003b).

South Africa's transport sector is diverse, and includes practically all the modes possible in this sector. The most prominent modes are road, rail and air, with each mode moving both passengers and freight.

- As already mentioned in the section on indicator 7, the mini bus taxis account for 65% of all passenger trips (Department of Transport, 1998a), but are a relatively inefficient form of public transport as they carry only about 12 passengers. They are also generally not very safe, with the operators not making the required expenditure and investment on the vehicles to ensure safe operation (see figure 9b below). The estimated backlog in minibus taxi maintenance is R20 billion (NNP, 2003).

- Figure 13, also shows the general under-investment in the transport sector, including buses (some of which are state owned through municipalities) and commuter rail, hints at the problem that South Africa is not able to keep up with its roads maintenance. The backlog in roads maintenance has been estimated at R65 billion (NNP, 2003). This has resulted in the setting up of many toll roads in a various parts of the country. See the section 'Full Cost of Road Freight' (section 4.2) below.
- Shipping is mainly for purposes of international trade. While it is possible to send goods by ship between a number of South Africa's cities, there are reasons other than cost which make this unattractive. Notably, delays at South Africa's ports are notorious. According to the Department of Transport:

  "The average port delay in 1997 was almost 20 hours, and over 61% of vessels calling at South African ports were delayed for some period of time."

  (Department of Transport, 1998b)

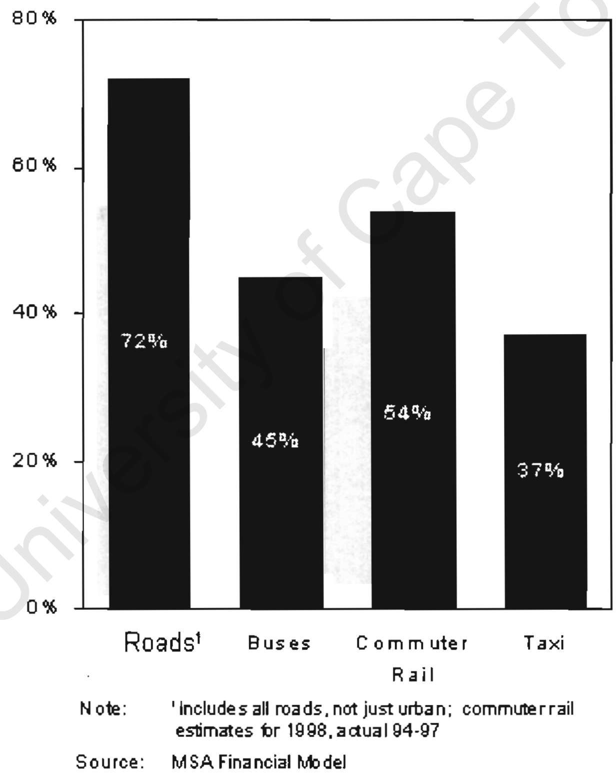


Figure 13: Current Capital Spending as a Percentage of Long-term Capital Requirements

Source: (Department of Transport, 1998a).

The analysis of Indicator 7 in the section on South Africa's score on the indicators shows that South Africa's energy intensity in MJ TPES/US$1990 GDP, using PPP (purchasing price parity), is about 19.6, which is almost twice the world 1990 average of 10.64 MJ TPES/US$1990 GDP. It is therefore to be expected that transport energy intensity, also measured in MJ TPES/US$1990 GDP, would be higher than the world average.

South Africa's rail network is fairly good. As of the year 2000, Spoornet, South Africa's rail parastatal, had 20,041 km of railway lines by route distance, of which 8,202 km were electrified (Department of Transport, 2001:4.2). The non-electrified lines are serviced by adequate diesel-electric locomotives. In addition to these railway lines, there are private and SARCC (South African Rail Commuter Corporation) railway lines (Department of Transport, 2001:4.2). SARCC (which is state-owned) has the main function of owning and managing rail commuter assets. Unfortunately, the backlog in the maintenance of the railway system is estimated at R22 billion (NNP, 2003). Notwithstanding this statistic, which has at least some truth in it, the railway system is presently able to achieve more to alleviate transport problems through passenger and rail transport (Railroad Association of South Africa, 2005). South Africa has a high vehicle and private car population compared to the world's countries as can be seen in appendix 3.1. The number of vehicles per capita and private cars per capita is also high, at 137 and 96 respectively, when compared to developing countries such as India (5 and 3 respectively), Egypt (28 and 21 respectively) and Indonesia (20 and 10 respectively), but are somewhat modest next to developed countries such as Japan (538 and 360 respectively) and Denmark (387 and 332 respectively), and is slightly higher than that of Romania, a transitional economy with 114 vehicles per capita and 97 private vehicles per capita respectively (Metropolitan Transportation Commission, 2004 - details in appendix 3.1).

4.2 Full Cost of Road Freight

Not only is road freight in South Africa not as efficient as rail, in terms of energy use per ton km, but has very costly externalities – air pollution and costly damage to roads. The cost of road damage by vehicles in South Africa is recovered mainly through fuel taxes and through toll roads. There are also fines for overloaded trucks, which are not strictly enforced and can be bypassed on many routes (CSIR, 2004), and the gross amount collected from annual vehicle registration licence fee is relatively small - less than R150 for small motor vehicles, and of the same order of magnitude for trucks.

While toll roads have the virtue of making people pay for what they use, vehicles using them do not pay according to the damage that they cause to the roads. Trucks typically pay no more than 5 times the amount paid by small motor vehicles (Wheels24, 2004). The damage caused to the roads by trucks however, is clearly not a multiple of 5 compared to the damage done by cars, as can be deduced from AASHO road tests in the US (Railroad Association of South Africa, 2004). The Railroad Association of South Africa states: "Tests first conducted in the US (the AASHO Road tests) between 1956 and 1960 revealed that axleload damage to pavements is exponential", with the exponent averaging 4. So, for example, a truck that is overloaded by 20% over the set limit will damage the road by a factor of 1.2 to the exponent 4, which is over 2 times as much as one whose weight equals the set limit. This load versus damage relationship applies between normally loaded trucks and private passenger vehicles. There are many claims of the damage caused by trucks as compared to private cars on roads, with figures between 6000 and 9000 times the damage often quoted, many of them among activist and research groups in the USA. The Cascade Policy Institute of Oregon claims: "A single large truck can cause as much damage as thousands of automobiles" (Cascade Policy Institute, 1995). Further, a CSIR (South Africa) article states:

> "Overloaded heavy vehicles cause about 60% of the damage to roads in South Africa representing some R600 to R700 million a year, according to the CSIR's 1997 South African Heavy Vehicle Weighing Statistics Annual Report."
>
> (CSIR 1999).

Fuel taxes are paid on the basis of volume of fuel purchased. For a given distance, a large truck may use perhaps 5 times as much fuel as a small one (40 litres per 100km compared to 8 litres per 100km).

It can be seen here that trucks cause much more damage than they pay for, whether on the toll roads, annual licence fees, or in the fuel taxes paid. This issue of full costs would have implications on the indicators if indicator 6 (Burden of Non-Renewable Energy Investments on the Public Sector) were re-defined.

4.3 Consumption of Petroleum Products

The following chart shows the trend in the consumption of a number of petroleum products in South Africa in the period 1988 to 2003.

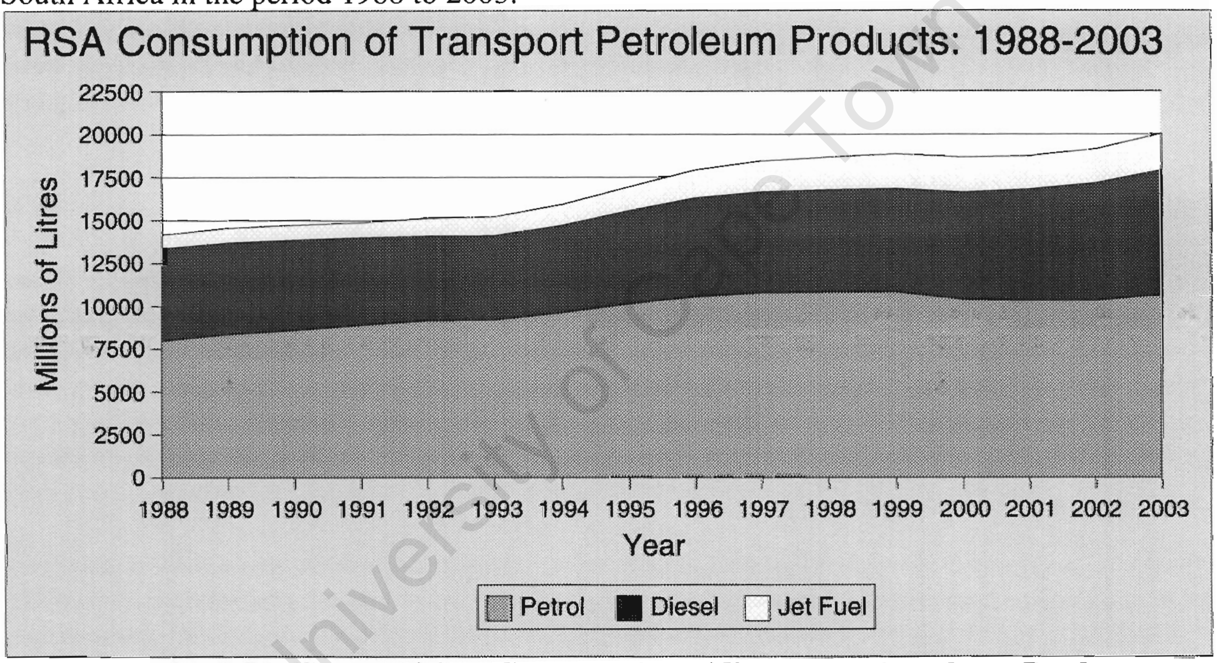


Figure 14: RSA (South Africa) Consumption of Transport Petroleum Products.
Source: SAPIA, 2004: Appendix 7.

There was a marked increase in the volume of transport petroleum products sold in the years 1990 to 2002. The volumes of petrol and diesel combined increased by 24% from 13,885 million litres to 17,166 million litres. Real GDP growth over the same period was 26% (SARB, 2004), while population growth was 27% (Statistics South Africa, 2003a). Appendix 2.3 shows a trend of GDP and population relations in the period 1990 to 2002. Diesel is the fuel of commercial road transportation (goods and passenger road transportation via buses and trucks). The increase in the consumption of diesel fuel alone was 30% (SAPIA, 2004), thus outstripping real GDP growth by 4% for the period. When we compound by multiplication, the increased volumes of diesel and the increase in the price of diesel in the same period, which was 241% (SAPIA, 2004), we see that gross spend on diesel increased by 343%, exceeding real GDP growth by 317%. These figures imply a strong growth in road transport, inspite of the cost increases. Major causes of this increase are discussed in the following paragraph.

Before discussing the cause of the strong growth in road transportation, we look briefly at the nature of the growth in crude oil and petroleum products usage. From 1995 to 2002, which makes up a little more than the latter half of the period just discussed, the use of crude oil by the South African petroleum industry grew by 15% compared to a 12.9% growth in the use of petroleum products - petrol, diesel and jet fuel (SAPIA, 2004: Appendices 5,7). SAPIA (2004: Appendix 5) seems to indicate that the percentage contribution to total liquid fuels requirement, of the SASOL liquid-fuels-from-coal production, has decreased during this time.

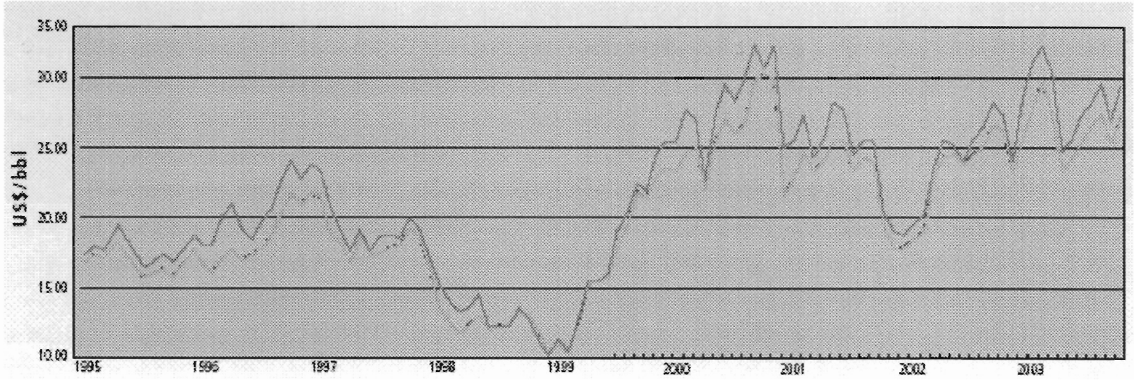
In the period under discussion in the previous paragraph, South Africa's state-owned rail operator, Spoornet, which is a division of state-owned transport giant Transnet, has lost market share in freight transport to road transportation. There was a decrease in the use of railway transport and correspondingly, an increase in the use of road transportation which has greatly contributed to the rapid increase in the use of diesel fuel. The goal of winning back market share from road transport has remained elusive for Spoornet. The problems involved are highlighted in an article in South Africa's Engineering News (May 28 – June 3, 2004):

> "Rail utility Spoornet has announced a far-reaching restructuring plan, designed to improve customer service and win back some of the market share it has lost to road hauliers over the last decade. However, it still has not been able to secure the funding package necessary for capital investments that would bring about improvements so desperately demanded by its long-suffering customer base."
> (Engineering News, May 28-June 3, 2004, p. 19).

Another contributing factor to the increase in diesel (and petrol) usage is that passengers have been abandoning the commuter rail services mainly for mini buses. The decline in rail commuter passengers between the annual period beginning March 1981 and that ending March 2000 is shown in Appendix 3.2 (from Department of Transport 2001:3.3a), which shows a decline in numbers of passenger journeys in the rail commuter category (operated by Metro Rail, a subsidiary of state-owned transport utility Transnet). The drop is a remarkable 31%, from 707,536,460 to 491,048,967 passenger journeys, inspite of population growth and increasing urbanisation. To look at a period almost identical to that for which we have looked at the fuel demand increase, we look at the annual periods beginning March 1990 to end March 2000, and see a clear decrease of 6%, from 524,217,535 to 491,048,967, again going against the onward march of urbanisation and population growth. This drop can be compared to the 10.4% population increase in South Africa during the 5 year period from 1996 to 2001, when the urban population grew by more than 10.4% due to urbanisation (Statistics South Africa, 2003b).

The excessive growth in the use of petroleum products has contributed to the increase in the value of indicator 5b (Non- Renewable Energy Imports as a share of total Non-Renewable TPES).

4.4 Vulnerability to International Shocks



Note: The higher value plotted is the price of Brent, and the other is Dubai. Note: x-axis text elements are years 1995 to 2003.

Figure 15: Crude Oil Price Movements: January 1996 to October 2003.

Source:SAPIA Annual Report 2003, (Appendices) p60.

The volatility in international fuel prices is evident from figure 15. It can be seen from the plot that the maximum variation from the approximate median of US$20 per bbl (barrel), is approximately US$10, or 50%, both above and below the median. However, what is of importance is the impact that it has on sustainability in South Africa. As of July 2003, when the crude cost represented 35% of the retail price, the fluctuation was (using the 50% fluctuation) equivalent to about 17% of the retail price. The plot above shows that this fluctuation can happen within a year. Fluctuating crude oil prices, which in turn mean fluctuating fuel prices in South Africa's domestic economy, creates uncertainty in investment decision making, as transport is a part of just about every enterprise. International shocks are one objective for the two sub-indicators 5a and 5b.

4.5 Prospects for the future

South Africa is faced with vulnerability to crude oil supply shortages and its vulnerability to climate change related international carbon emissions controls is outlined in section 6.4.2. When looking into the future, the problems plaguing South Africa's transport sector, impacting on South Africa's energy sustainability, are certainly not insurmountable in technical terms. The following are some considerations in support of this view.

Railway transport, both of goods and passengers, is under-utilised, but the basic infrastructure is in place, namely the railway network. The rolling stock, which although presently requiring capital injection, is, however, able to deliver a fairly reliable, comfortable service.

Better service is required for South Africa's commuters where railways are not practical, for example in towns with low populations, or parts of larger cities that are far from rail access. The mini bus taxi industry in South Africa in particular is clearly inefficient and unsafe and in need of an overhaul. Since the late 1990s, the South African government has been attempting to persuade the owners of the mini-bus taxis to switch to larger vehicles, with government funding, but there has been no agreement on a way forward. There are precedents worldwide where efficient bus services have been instituted. One notable example is the Bus Rapid Transit (BRT) system, which originated in South America, and is being introduced into a number of cities worldwide, although known by a number of names such as 'High Capacity Bus System', 'Metro Bus', 'Express Bus System', 'Busway System', 'Bus Corridor System', or

'Surface Metro' (This Day online, 2004). These bus systems are considerably cheaper to implement than surface rail systems, and very much cheaper to implement than underground rail systems (ITDP, 2002). Examples of Latin American cities using this system are Bogota in Colombia and the city of Curitiba in Brazil, known for its exemplary urban planning (DFID, 2004).

More efficient motor cars are a reality. South Africa could encourage the deployment of these cars, such as the Toyota Prius, quoted in the section on indicator 8. Tax reductions, government seeking positive influence in the pricing of each car, government facilitation of local manufacture of such energy efficient cars, and other incentives could help to make such cars a common sight, contributing to energy sustainability in South Africa. Biofuels are another option and are explored in section 3.9.3.

The improvement in the energy efficiency and the energy sustainability of the transport sector would have a positive effect on the indicators mentioned associated with transport energy, mentioned in the introduction to this chapter.

The following chapter (chapter 5) is a discussion of the results based on a look at the trends in the indicators.

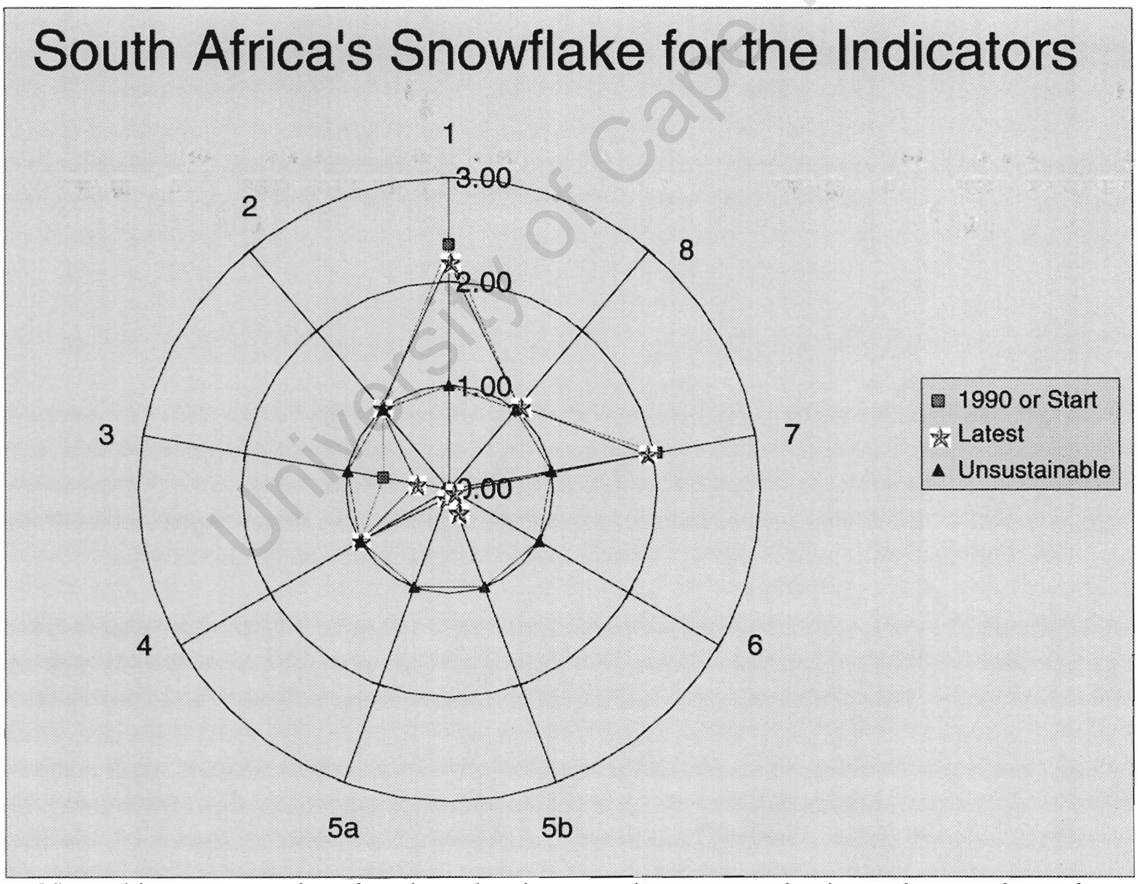
5. Discussion of Results

5.1 Introduction

This chapter looks into the patterns emerging from the survey of the indicators for South Africa. The different indicators show a variety of trends. The discussion will firstly take an overall look at the results, and then look at the trends in specific indicators within the different sustainability dimensions, namely environmental, social, economic and technological. Unless otherwise indicated, the sources of the data are the same as those quoted in chapter 3. The purpose of this chapter is to discuss the trends in the indicators. An interpretation of the trends is carried out in chapter 6, which follows this chapter.

5.2 Overall perspective

The values of all the indicators for South Africa are shown in the 'Snowflake' diagram for South Africa below.



Note: Lines connecting the plotted points are there to emphasize values and trends.

Figure 16: Snowflake of South Africa's Indicators.

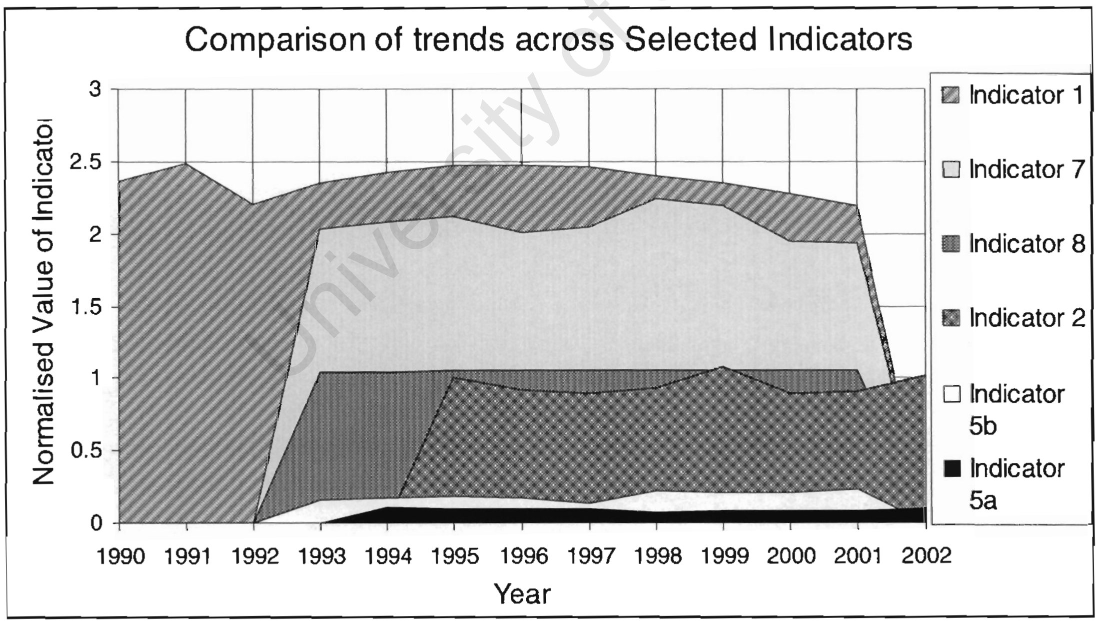
Source: All combined sources for the plots and tables evaluating the indicators in chapter 3.

In the plot above, the circle of radius 1 indicates the unsustainability reference labelled 'Unsustainable' in the legend. The centre of the plot marks the sustainability reference for each indicator, with a value of 0. The value of the indicator in 1990, or its value when the first usable data was available after 1990, is plotted with the squares, labelled '1990 or start' in the legend while the latest indicator values are plotted with stars.

It can be seen from the plot that two of the indicators – indicator 1 (carbon emissions per capita) and indicator 7 (energy intensity), are grossly unsustainable, with values of twice the unsustainablity reference. Three of the indicators are at the same value as the sustainability reference. These are indicator 2 (local pollutant), indicator 4 (investment in clean energy), and indicator 8 (renewable energy deployment). The other four indicators, including the two sub-indicators that make up indicator 5, show good sustainability. These are indicator 3 (household access to electricity), indicator 5a (non-renewable energy exports), indicator 5b (non-renewable energy imports) and indicator 6 (burden of non-renewable energy sector investments).

The plot also shows that that most of the indicators are in fact not far off from their '1990 or start' values. Indeed the only indicator which has shown a significant move from it '1990 or start' value (in the case of this indicator, the 1990 value) is the indicator for household access to electricity, which has shown a noticeable improvement.

Figure 17 below shows the trend in a number of the indicators, chosen mostly for dynamic nature, to allow an analysis of relationships in trends between the indicators over time.



Note: Except for indicator 1 (topmost plot), all the indicators plotted do not have data for all the years shown. A sharp rise from 0 or a sharp drop in the plot to 0 indicates the start or end of available data respectively.

Figure 17: Trends over time in South Africa's Indicators.
Source: same as for the individual indicator plots in chapter 3.

5.3 Environmental indicators

5.3.1 Discussion of carbon emissions per capita

In trying to understand trends in indicator 1 (Energy sector carbon emissions per capita), the plot for indicator 1 can be divided into three periods, namely: the period leading up to 1992, the period 1992 until 1997, and the period from 1997 until 2001. The period from 1990 until 1992 shows no real trend, except that there is volatility and a decrease in the indicator from 1990 to 1992, indicating a decrease in energy sector emissions per capita. Following this period, there is a worsening (increase) in the indicator during the period 1992 until 1995. The third period is the period from 1995 until 2001, during which the indicator improves (decreases), showing a decrease in energy sector carbon emissions per capita. The trend in carbon emissions intensity is analysed in section 6.2.1 of the following chapter.

5.3.2 Discussion of Local Pollutant

There is no clear trend in the indicator for local pollutant. The indictor plot (**Figure 2**) shows an oscillation between values 0.9 to 1.1, which starts with a decline (improvement) in the indicator from 1995, the year of the first available data, to 1995, when the decline rate slows but continues until 1997. Following 1997, the indicator value rises (worsens) until it reaches a peak in 1999. From 1999 to 2000 is another decline, followed by a two-year rise to 2002. The trends, over the years, for indicator 2 have some correlation with those for indicator 7 (**Figure 10**). This correlation is analysed in chapter 6.

5.4 Social indicators

5.4.1 Household Access to Electricity

This indicator has shown very rapid improvement, the best of all the indicators considered in this report, over the period under consideration from 1990 till 2002, with household access to electricity improving from 35% to 68%. The urban electrification in the period 1992 till 2002 increased from 61% to 80%, while rural electrification increased from 6% to 50%. In comparison: according to AFREPREN, the electrification rate for urban households in Africa is generally below 30% (Karekezi and Majoro, 2005).

5.4.2 Investment in Clean Energy

The indicator for investment in clean energy shows virtually no change between 1998 (the year of first available use-able data) and 2002. The overall change for the period is 0.01, from 0.99 to 1.00, the range of values for the period is also within 0.01. The unsustainability reference is the assumed 1990 level of clean energy investment of 0% of total energy sector investments.

5.5 Economic indicators

5.5.1 Overall Consideration of Economic Indicators

South Africa scores well in the indicators for energy imports and exports as well as in the indicator for burden of non-renewable energy investments on the public sector. The score for all three of these indicators is below 0,25.

5.5.2 Non-Renewable Energy Exports as a share of Total Exports

The maximum range of the values in this indicator from 1994 and 2002, is less than 0.03. There is an improvement in the indicator from 1994 to 1995, followed by a very slight increase in the indicator value from 1995 to 1997. From 1997 to 1998, there is a relatively sharp decrease in the value of the indicator. The period 1998 to 2001 is one of stagnation, showing very little change. From 2001 to 2002, the indicator increases relatively sharply from about 0.08 to 0.1.

5.5.3 Non-Renewable Energy Imports as a share of Non-Renewable TPES

This indicator, which scores very well, shows little sustained overall change in the period 1993 to 2001. The changes are as follows: there is an increase (worsening of the indicator from 1993 to 1995, followed by an improvement (reduction) from 1995 to 1997. From the year 1997 to 1998, there was a relatively sharp increase in the indicator, from 0.14 to 0.22. Following 1998, the indicator remains mostly unchanged, with maximum and minimum for the period being within 0.03 of each other. The trends in this indicator are to a large part driven by the crude oil contribution to South Africa's total primary energy supply (TPES). The relatively sharp increase between 1997 and 1998 is echoed by a similar increase in indicator 7 (energy intensity). In the same transition (1997-1998), there is a sudden (though small) decrease in the value of indicator 5a (non-renewable energy exports). A deeper analysis of these seemingly minor changes in this indicator is carried out in section 6.4.2.

5.5.4 Burden of Non-Renewable Energy Sector Investments as a Share of GDP

This indicator only has useful data, and thus indicator values, for the years 1999 to 2002. The indicator value drops from 1999 to 2000. In the period thereafter, the indicator remains stagnant at just above 0.05.

5.6 Technological indicators

5.6.1 Energy Intensity

This indicator (indicator 7 – energy intensity), which has data available from 1993 to 2001, shows a number of distinct changes during this period namely: a rise from 1993 to 1995,

followed by a drop until 1996. After 1996 there is a slight rise until 1997, followed by a sharper rise until 1998. Three years of decline then follow: a slight decline from 1998 to 1999, followed by a sharper decline from 1999 to 2000, and then a slight decline from 2000 to 2001. There is some correlation between the plot for this indicator and the plot for indicator 2 (local pollutant) in the period 1995 to 2000, although the difference is that the plot for indicator 2 peaks in 1999, one year after the peak for indicator 7.
The table below shows the trend in the total primary energy supply (TPES) as well as the trend in the crude oil contribution to TPES. Column 6 in the table shows the crude oil contribution to TPES while column 7 shows the absolute amount of the crude component (in TJ) relative to the absolute amount of the crude component in TJ in 1995.

Table 8: Trends in Total Primary Energy Supply and the crude contribution 1995 to 2001

	TPES	TPES	Crude Contribution to TPES			Crude Amount
Year	Total TJ	Rel. 1995	Crude Trade Net	Renewables	Less Ren	Relative to 1995
1995	**4,299,195**	100.0%	10.7%	10%	11.8%	100.0%
1996	**4,269,622**	99.3%	8.8%	10%	9.7%	81.8%
1997	**4,423,365**	102.9%	10.2%	9%	11.2%	97.7%
1998	**4,639,614**	107.8%	20.1%	5%	21.2%	193.6%
1999	**4,636,914**	107.7%	16.5%	5.1%	17.4%	158.4%
2000	**4,298,220**	100.4%	9.8%	5.5%	10.4%	87.6%
2001	**4,370,645**	102.1%	11.1%	5.4%	11.8%	101.4%

Source: Department of Minerals and Energy (2000, 2002a, 2003b)

The very high crude oil contribution to TPES in 1998 and 1999 (the 1998 amount is almost double the usual amount), coincides with a peak in energy intensity during these two years. The high crude oil contribution to TPES in these two years is not a result of lower TPES, as illustrate by column 7 of table 8, which shows that the absolute amounts of crude oil used also followed the trend in the percentage crude oil contribution to TPES.

5.6.2 Deployment of renewable energy

The plot for the indicator on renewable energy deployment (indicator 8) shows that this indicator does not change much during the years 1993 to 2001, during which time the indicator vector changes by noticeably less than 0.1, remaining at a value of approximately 1.

The following chapter (chapter 6) is an interpretation of the results, analysing the factors behind the trends identified in chapter 5.

6. Interpretation of Results

6.1 Introduction

This section relates the patterns observed in the previous chapter to relevant trends in factors related to energy sustainability in South Africa and the world. The interpretation of each indicator begins with a consideration of the accuracy of the data used.

6.2 Environmental Indicators

6.2.1 Carbon Emissions Intensity

6.2.1.1 Interpretation of Declining Carbon Emissions Intensity

Factors that contribute to the ability to have fairly reliable data for this indicator include: the existence of a well-resourced statistics agency in South Africa (Statistics South Africa, 1998, 1999, 2003a), the fact that within South Africa, much of the coal is used by SASOL - for liquids and chemicals and power production, and Eskom - for electricity generation, both of which keep track of vital statistics, the existence of a number of associations that make the relevant data more accessible, such as SAPIA - South African Petroleum Industry Association, Chamber of Mines, as well as the initiatives of the department of minerals and energy. Data from all of these associations no doubt contributed to the IEA data on carbon emissions (IEA, 2003). While the data is assumed to be fairly accurate for the sake of this analysis, factors that would contribute to inaccuracies in the data include the difficulty in obtaining comprehensive data on domestic biomass use.

In the previous chapter (section 5.3.1), we looked at the trend in the value of this indicator during the period 1990 to 2001. Some of the parameters that are important to the trend in this indicator are GDP trend, technological deployment in the energy sector, population growth, and a shift between energy carriers of different emissions intensity among others, as already mentioned in section 3.2.3. The discussion here is an analysis of the features of the trend in carbon emissions intensity shown in figure 1a, mainly through looking at GDP trends, trends in TPES and energy carrier changes, as well as population growth in the period under survey.

South Africa predominantly uses coal and petroleum in its economic activity, both of which are carbon emissions intensive. In the period 1990 to 1992, South Africa's GDP was showing the effects, or the remnant effects of the economic sanctions imposed in the previous decade because of its policy of Apartheid.
Figure 11a below is a plot of South Africa's GDP for the period 1990 until 2002:

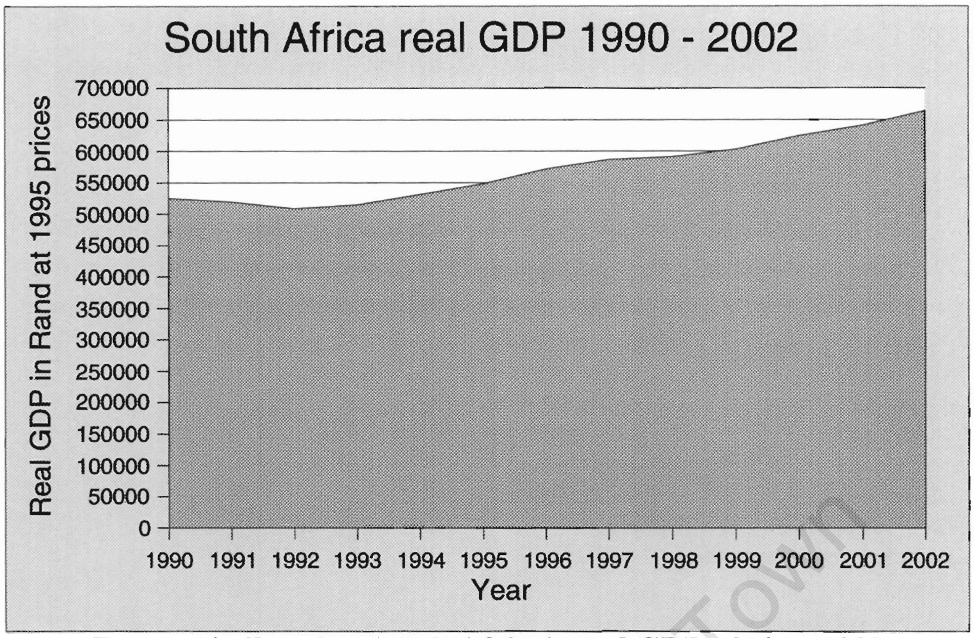
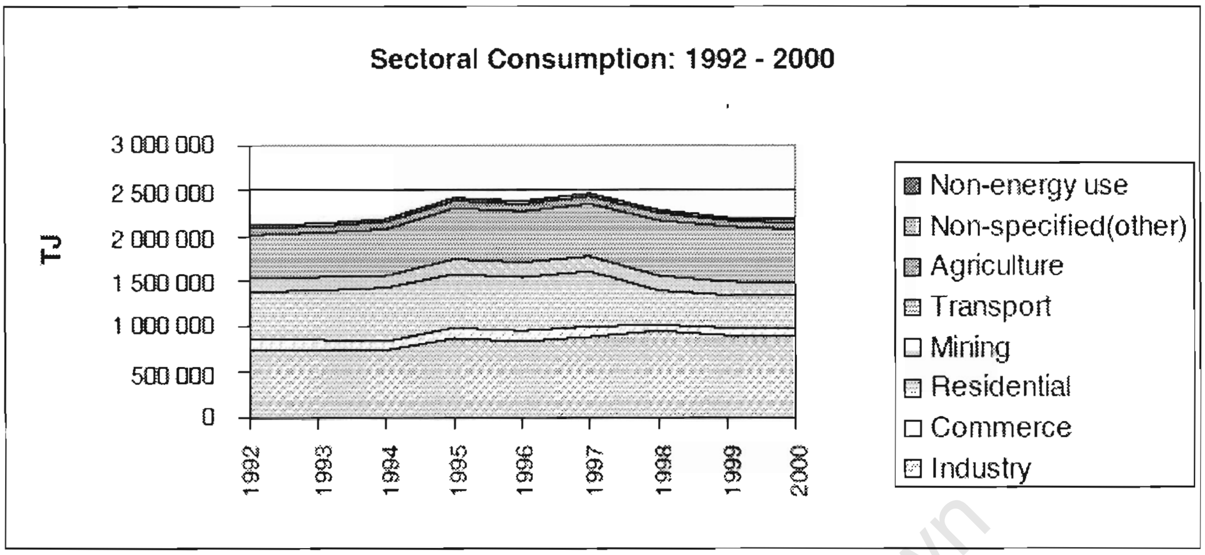


Figure 18: Trend in South Africa's real GDP 1990 to 2002
Source: South African Reserve Bank, 2003

As is clear from the plot, South Africa's real GDP was on a downward trend in the period 1990 until 1992. The decline in the energy sector carbon emissions intensity in this period is due mainly to the decrease in production, while the population did not follow a similar decline but increased from 36 to 37 million people (Statistics South Africa, 1998). The following period, 1992 until 1995 shows an increase in the carbon emissions intensity. During this period, South Africa's GDP was growing steadily, as can be seen in **Figure 18**. The emissions intensity also grew steadily as is evident in **Figure 1**, showing a continued link between GDP growth and carbon emissions intensity growth. A look at the total primary energy supply for this period, shows an increase of 9.7% from 3.92 million TJ to 4.3 million TJ (Department of Minerals and Energy, 2002a)

During the third period, from 1995 until 2002, the emissions intensity first levels off between 1995 and 1997. After 1997, it starts to decline steadily until the year with the last data available, 2001. The decline in the indicator means that the county's population grew faster than the rate at which carbon emissions grew. From 1996 to 2001, South Africa's population grew a total 10.4% or at an average rate of 2% per annum (Statistics South Africa, 2003b). Carbon emissions basically remained the same at 340 megatons of CO_2, for the period 1997 to 2001, the variation being less than 1.5% of the 1997 value. Real GDP, however, continued at to grow during this period, at an average rate of 2.6% per year. To explore the TPES trend and the effect of a shift in energy carriers, we can look at Table 8 in the previous chapter. According to the table, the total primary energy supply (TPES) remains constant in the period 1995 to 2001, with just a 2.1% overall rise (column 3). The fairly constant total primary energy supply is consistent with the similar stagnation in carbon emissions. A shift in energy carriers is looked at in the second paragraph from the next one.

Another development related to the carbon emissions intensity is now explored. The trend in sectoral consumption of energy 1992 to 2000 is shown in figure 19 below.



Note: Mining is part of the third layer from the bottom in the actual plot

Figure 19: Sectoral Consumption of Energy 1992 – 2000

Source: Department of Minerals and Energy, 2002a

The reason for the virtually constant annual carbon emissions, while GDP was growing, seems, at least in part due to the decline in energy consumption in the mining sector after 1997, which can be seen in figure 19 above.

It has been established here that the trend in annual energy sector carbon emissions for South Africa in the period 1990 to 1995 was consistent with the trends in GDP, in the absence of other, more pertinent trends. The period 1995 onwards, and in particular 1997 onwards, seems to go against the GDP trend, and even the total primary energy supply trend. **Table 8** in the previous chapter shows that in 1998 and 1999, the crude oil contribution to total primary energy supply was on average virtually double the crude oil contribution in the other years for the period 1995 to 2001. Coal, which accounts for most of South Africa's total primary energy supply, has higher carbon emissions per unit of energy input into TPES than crude, by 27% (see Appendix 2.2). The increase in the crude contribution to the total primary energy supply, which was at the expense of the relative contribution of coal, would go some way to explaining the reduction in the carbon emissions in 1998 and 1999, while the total primary energy supply was constant. A shortcoming in this explanation is that the crude oil consumption rises again after 1999, while the carbon emissions continue to decline.

The decreased energy consumption in mining after 1997, seen in figure 19, is another way to explain the decline in carbon emissions after 1997. Unlike the crude contribution case above, the reduction in mining energy consumption is sustained through until at least the year 2000. The stagnation from 1995 to 1997, a period in which the carbon emissions stagnated, but mining energy consumption remained high, and the crude oil contribution to total primary energy supply remained low, is not easily explained with the available data.

The decline in the energy consumption in the mining sector while GDP continued to grow may show the action of some or all of the following factors: an increase in energy efficiency in mining, a decline in mining activity, a shift in GDP contribution, so that less energy intensive sectors contribute more to the GDP. Improvements in energy conversion technology, particularly industrial processes as well as automotive technology, are possibly factors in the declining annual carbon emissions for South Africa, but the extent of the contribution would require a detailed study to quantify.

6.2.1.2 South Africa and Climate change: Impact on the Indicators

Concerning the (widely accepted as real) climate change caused by greenhouse gas emissions, South Africa has clearly adopted an attitude which, as shown by the excerpts from the Energy Policy White Paper 1998, which have been quoted in the section on indicator 1, can be summarised as: wait-and-see how the global greenhouse gas negotiations progress, to embark on a 'no-regrets' path to spending on greenhouse gas mitigation, as well as clearly specifying coal as destined to be a major part of the energy mix for many years to come. While it is clearly meant to buy time to allow South Africa to continue to pursue affordable development, this approach has a number of shortcomings.

On a social-ethical level, it is somewhat opportunistic, as the stance takes advantage of the lack of a strong international framework for dealing with the climate change problem. The approach is, however, somewhat pardonable when we consider that South Africa economy is closely linked with the global economy, so that the cost of energy becomes a consideration in economic competitiveness.

While on the economic considerations, it can also be said that South Africa's approach is not very strategic because the climate change problem will, sooner or later, affect all countries in the world. As the Kyoto Protocol becomes international law, the rate at which there will be a movement towards obliging developing countries to adopt targets will depend, no doubt on factors such as advancements in global governance and heavily on future climatic events and perception of their causes. An example of present evidence of climate change has already been presented in the 'Larson B episodes' of 1998 and 2002 in Antarctica (section 3.2.5), in the section on Indicator 1. When the response to climate change comes, there will most certainly be a technological shift from fossil-fuel based technology to alternatives. If South Africa has not developed the technologies and markets of the alternatives, then it will trail behind the countries that have already exerted efforts in their attempt to move away from fossil fuels. A case in point is the fledgling industry for small electricity wind turbines in South Africa, which would benefit if government set a significant target for deployment of this technology.

6.2.2 Local Pollution trend Interpretation

The data used in this survey is taken using a fairly accurate system – air sampling stations. The values for local pollutant (City of Cape Town, 2003) are therefore fairly representative of the PM10 air quality situation in Cape Town area. However, factors such as the weather and grass fires do affect the ability of the PM10 readings to reflect trends over only a few years, such as the eight annual averages used in this survey. From year to year, winds, rain and grass fires cause variations which are not the result of energy sector particulate pollution changes.

Section 5.6.1 has already outlined from the plots, the correlation between the plot for indicator 2 and the plot for indicator 7. The reason for this correlation may be a real one or it may be coincidental. If the relationship is a real one, then it could be said that the changes in the level of local pollutant in the Cape Town area in the period followed, to a reasonable extent the increases and decreases in the energy intensity in South Africa, which in turn showed a correlation with the crude contribution to total primary energy supply (TPES). In particular, the peak in energy intensity 1998/1999 coincides with the 1999 peak in the crude contribution to TPES. This peak in crude contribution in turn coincides with a minimum, of just above US$10, in the nominal crude oil price for at least the period since the beginning of 1995 until the end of 2003 as shown in **Figure 15** in section 4.4. Cape Town's particulate pollution is due in a large part to petroleum products in the form of transport fuels and paraffin for domestic use. The particulate pollution resulting from industry is less in Cape Town than in certain parts of the country such as south Durban, Secunda and Vereeneging, which have more polluting industry in an around them.

It should be noted that the value of the metric for Khayelitsha in 2002 was 50 micrograms per cubic metre (as mentioned in section 3.3.3), which is equal to the United Kingdom air quality requirement limit. Further, the PM10 level in Khayelitsha exceeded 40 micrograms per cubic metre for six of the eight years from 1995 to 2002 inclusive. Therefore, the outside air PM10 level in Khayelitsha is already at a critical level. The implication for poor (especially urban) communities around South Africa is bleak: of the large metropolitan areas, Cape Town is one of the farthest from abundant coal and firewood resources, and much of the cooking and heating in poor households in done using paraffin (kerosene). The particulate emissions of paraffin are lower than those of firewood and coal as noted by South Africa's Department of Environmental Affairs and Tourism:

> "the worst exposures to total suspended particulates occur in coal-burning households in unelectrified and partly electrified urban areas, and wood-burning households in rural areas."
>
> (Department of Environmental Affairs and Tourism, 1999)

The particulate emissions from household fuels in poor households in most of the rest of South Africa are therefore worse than in Cape Town.

6.3 Social Indicators

6.3.1 Household Access to Electricity (Indicator 3) and sustainability

This indicator has possibly the most accurate data among the indicators surveyed in this report. The existence of a capable statistics gathering infrastructure in South Africa, including the government's Statistics South Africa (e.g. Statistics South Africa, 2003a), which conducts regular census exercises, the capacity of the National Electricity Regulator (NER South Africa, 2003), and the records of Eskom and municipalities which distribute electricity all contribute to the good data. For periods before the political transition in 1994, research by other institutions has been helpful (Eberhard and Van Horen, 1995). Shortcomings in the data would be the result of factors such as the remoteness of some communities in South Africa.

This indicator, which shows the most rapid improvement among all of the indicators considered in this report, shows the results of an unambiguous will to pursue a particular goal, in this case, the South African government's intention to increase the household access to electricity. It is also noteworthy that the mass electrification did begin before the change in government of 1994. Eskom, the state-owned electricity utility, had already begun activities in this regard before the change in guard, as mentioned in section 3.4.2. This action by a parastatal shows at least some benefit of state ownership. Eskom electrified poor households without much certainty of adequate financial returns, no doubt uplifting the lives of millions of South Africans, and therefore obtaining a tangible social return for the society at large. While there is still room for more improvement, the value of this indicator for South Africa is very good for a developing country.

The re-organisation of the electricity distribution sector in South Africa is posing a challenge as the powers and nature of shareholding of the six new 'Regional Electricity Distributors' (REDs) is not clear. Any future instability, such as disruption of cash flows to Eskom in the new structure, could have a serious effect on the strength of South Africa's electricity supply industry. In particular, it could affect its ability to deliver electrification for the poor, as well as the monthly 50kWh of free electricity (GCIS, 2005).

There is a limitation in the ability of this indicator to reflect sustainability in the case of South Africa. The limitation has to do with the urban pull caused by mass urban electrification, while other development aspects of people's lives perhaps get worse. Electrification in the urban areas is more thorough than in the rural areas. This has made the urban areas even more attractive to rural dwellers. At the same time, there is no employment forthcoming for a large number of those who are housed in the low income housing areas within the cities and towns. In 2002, 58 per cent of South Africa's population was urbanised (UNICEF, 2004), compared to the African average of 37 per cent, reported in 2004 (Tibaijuka, A 2004). Relevant to the problems of urbanisation, Tibaijuka, who is the executive director of UN-HABITAT also states:

> "Today, Africa has the world's fastest annual rate of urbanisation. The annual average urban growth rate is 4 per cent, twice as high as Latin America and Asia. Already, 37 percent of Africans live in cities, and by the year 2030 this rate is expected to rise to 53 per cent. In a process known as the urbanisation of poverty, more and more people are seeking a better life in towns and cities but in Africa urbanisation has occurred in an environment of consistent economic decline over the past 30 years."
>
> (Tibaijuka, A 2004)

In the same communication, the executive director of UN-HABITAT notes sub Saharan Africa as having the world's highest proportion of slum dwellers among urban residents, and that:

> "These slums are home to 72 per cent of urban Africa's citizens. That percentage represents a total of 187 million people."
>
> (Tibaijuka, A 2004)

Within this setting, the government of South Africa is paying for the electrification of informal dwellings in the urban areas. It seems wise to ask whether this is a sustainable policy: is there really much hope that the lives of these millions of households will improve beyond that of slum dwellers, if these dwellers remain in the urban areas? The slum dwellers have hope of getting access to the ongoing government housing subsidy programme, which has a backlog of 2.4 million households as of 2004 according to the Housing Minister (Engineering News, July 9-15, 2004).

If the housing subsidy is received, will there be any hope of these households becoming viable in today's climate of globalised *laissez-faire* capitalism, without a global governance framework to deal with the welfare tragedy? In other words, are employment opportunities likely outcome in a world where corporations are downsizing and unemployment is a global phenomenon? Economist Legum quotes an estimate that there is a global (industrial) overcapacity of 15-40% at present (Legum, M, 2002: 14). In addition to considering the economic sustainability, the ever-looming issue of the environmental impact of the growing cities on the ecology and on those who live within them cannot be ignored.

A second issue with regards to sustainability and electrification is affordability of the electricity once a household has been connected to the grid. The income of the poorer households in South Africa is such that they are generally not able to use electricity for anything more than lighting and operating radios. A 2003 study by EDRC (now ERC) students at UCT into energy use in poor households in Masiphumelele Township brought forth some aspects of this phenomenon (EDRC Masters Students, 2003). Among the factors which make electricity for cooking unaffordable for poor households are:

- the higher consumption of electric cooking appliances, as compared to light bulbs and radios - about 40 cents (South African) per hour per hotplate (as each cooker hotplate is rated at about 1kW). Some households may not be able to afford the higher cost of electricity. In some cases, the inability to control electricity usage once a certain amount has been purchased, makes paraffin cooking more attractive. Also, electricity has to be bought in the daytime when the vendors are open. Paraffin can be bought even at odd times, and there are more sales outlets for it. This is crucial in cases where people are not able to plan in terms of weeks but are only able to think a day or two ahead due to low, inconsistent income.
- While cooking with electric hotplates is cheaper than paraffin in the mid to long run (Cowan B, 2003:55), the up-front electrical appliance cost is prohibitive for the poorer households, who generally are not able to financially plan their lives ahead by more than a couple of days. If the electric stove was purchased, it would pay for itself within five months, using the 2002 prices quoted by Cowan, and using the Cape Town 2003 prices for the paraffin and electric double hotplate stoves (Cowan B, 2003: 55). If the electricity subsidy of 50kWh free per month is factored in, the electric option pays for itself within three months. After break even period is reached, the burden of the paraffin option relative to the electric one escalates, as the paraffin stoves last three months at the most, whilst the electric double hotplates usually last for at least two years.

6.3.2 Clean Energy Investments

6.3.2.1 Clean Energy Investments Trends and Job creation

Data for this indicator is not very comprehensive, partly because the activity in clean energy investment is low. While the investment in non-renewable energy is generally continuous and therefore well-reported, the investment in clean energy is not generally continuous and is often isolated and sporadic in nature. Sources of data for this indicator are shown in table 4.1 in section 3.5.1.

For the period for which there is data (1998-2002) there is very little investment in clean energy in South Africa. The focus remains energy for development, which, in the case of electricity, remains synonymous with (financially) cheap coal-derived. The attitude of the government of South Africa in this regard is enunciated in section 6.5.1.3, on Energy Efficiency, which looks at the Energy Policy White Paper of 1998. The environmental cost is not yet high on the national agenda. The job creation potential of clean energy is not widely considered or seen as important at this stage. This can be seen in the small amount spent on renewable energy and energy efficiency, relative to total energy sector investments. However, as noted in a study (AGAMA, 2003):

- there is significant potential for job creation through investment in renewable energy. AGAMA (2003) estimates that the job creation potential for renewable energy deployment by 2020 is approximately 1.2 million.
- About 30% of these jobs would be created in the solar water heating sub-sector, while another 58% of these jobs would be created in the biofuels sub-sector.
- the job creation can be achieved, provided the South African government commits to a target of 15% renewable energy deployment in the South African total electricity mix, as well as (in the transport sector) "the development of a biodiesel and bioethanol program that replaces 15% of current (petrol and diesel consumption)".
- furthermore, AGAMA states the importance of a renewable energy goal that is significant enough to enable a significant amount of local manufacturing, and thus improve job creation benefit of renewable energy deployment. (AGAMA, 2003).

Clean energy investment can therefore yield positive overall benefits. Apart from the job creation potential (with its effect of social stabilisation), investment in clean energy in the form of better energy efficiency lowers the need for additional power plants. This can contribute to an easing of the South African government's pre-occupation with cheap coal-based energy.

There are a number of initiatives aimed at promoting clean energy. One of these is REEEP, the Renewable Energy and Energy Efficiency Partnership', which is global with involvement in South Africa. REEEP, which is an outcome of the World Summit on Sustainable Development, is "an active global partnership that structures policy initiatives for clean energy markets and facilitates financing for energy projects" (REEEP, 2005). Other initiatives include Eskom's SABRE-Gen programme to research and develop renewable bulk energy in South Africa, as well as BONESA, which promotes efficient lighting such as CFLs (Compact Fluorescent Lightbulbs), which have in recent years become a common sight in South African retail stores.

6.3.2.2 Privatisation and Clean Energy

The following is a brief analysis of possible effects of privatisation on clean energy investment. The planned privatisation of 30% of Eskom (the government-owned national electricity utility) generation is seen as a 'black empowerment' opportunity, with 10% of Eskom generation earmarked for BEE entities (Cliffe Dekker, 2004). It is also an effort to demonstrate liberalisation of the South African economy. However, it could result in job losses and problems in the quality of supply, as private concerns will do the utmost to reduce costs, often at the expense of service quality, as is the case in the United States, where electricity utilities have been privatised. In the USA, transmission powerlines generally have little reserve capacity. In addition, the generation, transmission and distribution of electricity are all fragmented among a number of utilities. The arrangement is presently resulting in a high frequency of power cuts – one every 13 days for the North American transmission grid (Carreras B. A. et al, 2003). In comparison, South Africa's transmission system has such a healthy reserve capacity, resulting in good performance as shown, for example, by the awards given by customers Sasol and Iscor (Eskom, 2004c:143). Another way in which the contrast between the US electrical power supply situation and the South African one is evident, is in the difference in the volume of the number of studies on actual blackouts and 'brownouts' in the US as compared to South Africa, where there is virtually no activity in this area, notwithstanding the fact that there would generally be more research on any topical issue in the USA. As of November 2004, the latest major US blackout was the major blackout of 2003 in the north-eastern United States (IEEE-USA, 2003) which cut power to 50 million people and was preceded by another major one in the western United States in August of 1996 (O'Donnel J, 2003). Given this record of under-performance in terms of quality of supply by private ownership in a highly industrialised economy, forced privatisation and fragmentation in South Africa is reason for concern. Looking at the North American grid: the under-performance by the North American power grid has been linked to the lack of investment to maintain the grid in a good condition. According to O'Donnel (2003): “Former DOE secretary Bill Richardson claims the United States is a first-world power with a third-world electric grid”. The record of private utilities in the USA highlights reason for concern about what the effect of privatisation would be in South Africa. In an environment of private utilities, it may indeed be very difficult for the government to ensure adequate investment in infrastructure, and along with it investments such as connecting low income customers to the grid, all of which are not lucrative in the short term. If private utilities yield such an environment, then ensuring meaningful clean energy investment by them would border on impossible. Winkler and Mavhungu (2002) outline the possible effects of energy sector restructuring on renewable energy and energy efficiency in South Africa, as well as propose solutions in the form of policy recommendations. On renewable energy, they outline the challenge of the low financial cost of South African electricity generated by Eskom. This low cost makes renewable energy not financially viable without government intervention. Also mentioned in the above reference is the lack of non-discriminatory third party access to the national electricity grid. Energy efficiency, on the other hand will, according to Winkler and Mavhungu (2002), face the challenge of private utilities not investing in demand side management that will reduce demand at all times, i.e. energy efficiency, as this would lower revenues for the utilities. The utilities would foreseeably invest in the types of demand side management that benefit the utility, such as interruptibility (or the ability to shed loads such as hot water heaters, remotely at peak times), load shifting (moving some demand to off-peak times) and strategic growth (growing off-peak demand).

It is foreseeable that investment in clean energy would be pursued by private concerns if sizeable subsidies or incentives were paid by the government, or if clean power produced had a guaranteed market at high enough guaranteed prices. This would, of course, defeat a significant part of the reason for allowing private participation in the first place: lowering of prices through competition. It is also significant that Eskom would seemingly have no difficulty in delivering under the subsidy and guarantee conditions mentioned, with the benefit that any dividends paid by Eskom would become part of the fiscus. This is in addition to other benefits of Eskom being state owned, such as its pursuit of electrification of poor, non-commercially lucrative households (section 6.3.1). While there are no significant clean energy projects in the country yet, Eskom has set up modern clean energy test sites in South Africa including a wind farm (Klipheuwel, Western Cape), and a solar dish (Midrand, Gauteng). If prices of electricity rise with the new investments in generating capacity within Eskom (see section 6.4.3.1), then, as Winkler and Mavhungu (2002) suggest, costing in environmental externalities as well as ensuring non-discriminatory third party access to the national electricity grid could increase renewable energy deployment. Energy efficiency is easier to implement with Eskom, the state owned utility than it would be with private power utilities.

Privatisation, it seems cannot be considered the natural route to the future. Former World Bank chief economist Joseph Stiglitz has commented on the role played by governments in East Asia over many decades while that region was economically the fastest growing in the world. He notes:
"While the Washington Consensus policies emphasized privatization, government at the national and local levels helped create efficient enterprises that played a key role in the success of several of the countries." (Stiglitz J, 2002: 92).

6.4 Economic Indicators

6.4.1 Non-Renewable Energy Exports

Problems in this data are evident in that, for example, the coal export revenues noted by the Chamber of Mines (COM, 2002a, 2003) differ slightly from those from TIPS (*TIPS, 2004*) used in this survey. This accuracy of this data is partly limited by accounting realities, in other words, by the fact that volume movements of energy exports such as coal (as with many bulk commodities in international trade) do not relate simply to payments for these exports. Long-term contracts affect pricing, and repatriation of foreign currency revenues is not done at similar intervals from the time of sale, making it hard to determine the exact rand value of the sales in an environment of fluctuating exchange rates. The data is dependant on the exporters' declarations, surveys based on volumes, and information from the South African Reserve Bank, which handles currency flows for the purpose of foreign trade.

According to the data for this indicator, for most of the period under survey (1994 to 2001), there is a steady increase in the Rand value of non-renewable energy exports for South Africa. In the same period, the indicator value generally decreases, pointing to the fact that South Africa's total exports increased faster than the non-renewable energy exports. The change in trend is from 2001 to 2002, when there is an increase in non-renewable energy exports as a share of total exports. The reason for this sharp increase is the decline in the value of the Rand relative to the US dollar in that period. As a result, in coal trade:

> "Export volumes in 2002 remained almost identical to those in 2001 at 69.2 million tons, but the value of the exports increased by 14.2 per cent to R19.4 billion."
> (COM, 2003:9)

Compounded with this increased value was the increase in the value of exports of liquid petroleum products (refined crude products), bringing the overall increase in the value of non-renewable energy exports to 50%, while in the same interval, the value of total exports from South Africa increased by only 24% (TIPS, 2004).

6.4.2 Non-Renewable Energy Imports

The data for non-renewable energy imports are fairly accurate because of the nature of crude oil, then main non-renewable energy import. It is a liquid that is metered and/or weighed at various points in the supply chain. SAPIA (the South African Petroleum Industry Association) is the source of much of this data (SAPIA, 2003, 2004). One shortcoming in the transparency of this data is that SAPIA has not, in its annual reports, noted the volume of (refined) petroleum products exported out of South Africa.

The values for this indicator over the surveyed period for this indicator propose that South Africa is not very dependant on non-renewable energy imports. The imports of non-renewable energy as a share of non-renewable (total primary energy supply) TPES are low. The use of crude oil products has been increasing in South Africa, as noted in chapter 4. A sharp increase in the contribution of crude oil products to non-renewable TPES occurred between 1997 and 1998, and since South Africa imports more than 95% of its required crude as of 2002 (SAPIA, 2004: Appendix 5), a sharp (percentage) increase occurred in non-renewable energy imports as a share of non-renewable TPES. Table 10.1 in chapter 5 shows the contribution by crude oil to non-renewable TPES, which increased from 11.2% to 21.2% between 1997 and 1998.

Although South Africa is, according to the indicator not very dependant on non-renewable energy imports, such a conclusion no doubt underscores the true gravity of the situation. It is not easy to replace crude with present technologies, It would take years to set up infrastructure to manufacture significant amounts of alternatives to liquid petroleum (such as ethanol), or to shift to another transportation technology. Meanwhile, global oil demand is rising fast, presently driven by China, and the oil price is following suit. It is estimated that China's oil demand will double between 2004 and 2020 to 11 million barrels a day (Business Week, 2004). The rising demand for the limited resources of crude oil, as well as the seemingly imminent imposition of carbon emissions limits with a global enforcement system, as a result of escalating symptoms of climate change, mean that all countries should seek to develop alternatives to crude oil. For South Africa, this possibly means exploring biofuels (as discussed in section 3.9.3), as well as promoting more efficient use of transport energy fuels by means discussed in section 4.5.

6.4.3 Public Sector Burden of Non-Renewable Energy Investments

6.4.3.1 Trends in Public Sector Burden of Non-Renewable Energy Investments

Data for this indicator is fairly accessible, as the non-renewable energy investments by state-owned entities has to be transparent, and is reflected in the relevant financial reports. One reason why some of the data is difficult to obtain is the transition that has occurred in transferring the government owned crude oil and gas producing assets from the Central Energy Fund and Mossgas (Mossgas, 2001) to the new state-owned corporation PetroSA (PetroSA, 2003), which was launched during 2002. The data from 2003 onwards should be more reliable and comprehensive.

The indicator shows a very low burden attributable to non-renewable energy investments on the public sector. For the year 2002, the indicator value of 0.05 is close to the sustainability value of 0. The period surveyed for this indicator in this report begins as the expenditure on large coal-fired power stations was coming to an end for the expenditure approved in the 1980s. A new round of expenditure is soon to begin as South Africa's peak electricity power demand reaches the supply amount. Public Enterprises Minister Alec Erwin noted the following in a February 2005 parliamentary media briefing:

> "Current estimates suggest that R107 billion will be needed between 2005 and 2009 to meet the country's growing energy needs. Eskom will invest R84 billion over the next five years. The balance of R23 billion is reserved for independent power producers (IPP) entrants".

(South African Government Information, 2005)

6.4.3.2 Perspectives: Public Sector Burden of Non-Renewable Energy Investments

This indicator requires careful reflection on what can be termed 'burden on the public sector'. Capital investment by Eskom or other state-owned enterprise cannot automatically be considered to be a burden on the public sector. While state owned, these entities (namely Eskom, PetroSA and the CEF (Central Energy Fund) are corporatised. Capital investment is inevitable, regardless of ownership.

Furthermore, public expenditure in the non-renewable energy sector, goes beyond the straightforward investments in energy, but also includes investments that facilitate the use of such energy. Among these investments is the building of roads, airports and sea ports. If the cost of such projects is not fully recovered through direct levies such as fuel tax, toll roads and airport taxes, then a subsidy is forthcoming from the fiscus. This consideration is particularly relevant in view of the fact that the construction of convenient roadways for non-motorised transport (which of course does not use non-renewable energy), for example walking and cycling, is not the norm in South Africa, whereas motorised transport is always provided for.
There is also the environmental burden of non-renewable energy which at present requires comprehensive evaluation. Such burden includes the effects of local and regional air pollution, water usage and the effects of coal mining. These are a burden on the public sector manifest through health care expenditure for example – as already mentioned in the discussion on indoor air pollution in the section on indicator 2 (section 3.3.3).
The use of road freight (trucking) over medium to long distances, as opposed to the more energy and economically efficient rail freight, is favoured through the under-recovery of expenditure on roads by the state (moving this cost on to operators of private vehicles) to facilitate trucking. Some of the details of this problem in South Africa can be found in the section 'Transport Energy Analysis' (section 4.2).

6.5 Technological Indicators

6.5.1 Energy Intensity

6.5.1.1 Energy Intensity Indicator Trends in Context

Data for this indicator is sourced from the Department of Minerals and Energy (2000, 2002a, 2003b), supported by the energy utilities, associations and associations mentioned in the interpretation of the indicator on carbon emissions intensity in section 6.2.1, as well as the South African Reserve Bank (2003) all of which are adequately resourced for the purposes of the required data, so the data is fairly accurate.

Section 5.6.1 showed the relationship between energy intensity and the crude contribution to total energy supply. The reasons for an empirical correlation would possibly imply that the increase in the crude contribution leads to an increase in energy intensity. In other words, the amount of energy needed per unit of GDP increases with more crude contribution to TPES (at least at the levels of crude use evident in the case of South Africa for the years included in this survey). Chapter 4 looks into the sizeable growth in petroleum product (and thus crude oil) use from about 1993 onwards, and looks into the reasons of this growth. The interesting correlation between a trough in the plot for the nominal world crude oil price and a sharp rise in the consumption of fuel products of crude oil in South Africa has been noted in section 6.2.2 (Local Pollution trend Interpretation). The growth in petroleum product use, which, as outlined in chapter 4, is greatly in excess of both economic growth and population growth, does possibly introduce an inefficiency in the economy. The greater spend on petroleum products, as well as the associated costs of using road transportation, as opposed to mass freight and passenger transport on the railway system, is in itself a transition to a more inefficient economy in that it increases the spend on what is essentially not a productive sector in the economy, but an enabler for other, more productive sectors such as mining, manufacturing and some services.

The main factors affecting the trend in this vector are energy pricing, government policy on energy efficiency, national economic productivity, fuel mix, and the structure of the economy in terms of the relative sizes of the primary, secondary and tertiary sectors of the economy, also often referred to as the extractive, processing/manufacturing and service sectors respectively. Fuel mix is a factor because some fuels are converted more efficiently than others e.g. electric cars are more energy efficient than petrol ones, if one starts with the respective fuels mentioned. Energy intensity generally decreases from primary to secondary to tertiary industry. South Africa, in line with the norm for developing countries, has a relatively dominant primary sector, as intimated in the section on indicator 5 earlier, when considering the share or exports attributable to the primary sector. Developed economies overwhelmingly reflect a leaning towards tertiary industries. This is phenomenon is illustrated in a survey by the United Nations Economic Commission for Europe (UNECE), the results of which are shown in Appendix 3.4, which show, firstly the maintenance of a large services/tertiary industry sector among developed countries, and secondly show the increase in the size of the tertiary industry sector among countries as they develop or become economically more productive. In this case, the countries that are increasing their economic productivity are central and eastern European countries as well as countries of the Commonwealth of Independent States, all of which are states from within the former Soviet bloc, which had initially experienced an economic collapse at the start of the 1990s, with the disintegration of Union of Soviet Socialist Republics. The overwhelming majority of these countries show an increasing share of GDP (at producer prices), by the tertiary sector (UNECE, 2003).

It appears that South Africa could reduce its energy intensity by growing the share of GDP of its tertiary sector. Transport, telecommunications and food sectors in the South African economy are not well developed. Transport inadequacies are outlined in the section 'Transport Energy Analysis'. The telecommunications sector is also suffering from the domination of fixed line telecommunications (as opposed to mobile telecommunications), by one corporation – Telkom (Pty) Ltd whose prices are often prohibitive. The government has been trying to introduce a competitor for a number of years now in its attempt to lower telecommunications prices. As of late 2004, this had not been achieved yet. What has been achieved though, is the legalising of voice-over-internet protocol, as of 1st February 2005, which, it is hoped, will bring down the cost of telecommunications in South Africa. The impact of the initiative will depend in a large part on the bandwidth (traffic carrying capacity) of internet infrastructure in South Africa, as well as its connections to other countries. It is unlikely to make calls much cheaper within South Africa, as Telkom still controls the infrastructure, and can thus control prices. The food sector suffers from low participation, from basic production to distribution and marketing. Out of a population of 44.81 million in 2001, only 960,000 South Africans were primarily engaged in agriculture, hunting, forestry and fishing (Statistics South Africa, 2004c). Further, the ownership of the agricultural assets rested within a population of only 85,000, within the sector group just mentioned (Statistics South Africa, 2004c). Only 60,000 commercial farming units have among them 80% of the agricultural land (Statistics South Africa, 2004c). Beyond production, distribution and retail of food is dominated by a few corporations and franchises. A relatively small number of producers and marketers results in a market that favours suppliers and not consumers, and one of the instruments used to effect this outcome is price control. There is therefore clearly much room for improvement in South Africa's tertiary industry sector. Government effort in the telecommunications sphere is already trying to address this. Much seems to be at stake in trying to invigorate the tertiary industry sector.

6.5.1.2 GDP, Energy Intensity and Sustainability

National economic productivity, usually measured in terms of GDP, is a function of the various forces within the market environment, including competitiveness, level of investment and other factors. Legum states that there is a global phenomenon of jobless growth whereby real production and employment are not rising in line with GDP growth (Legum, 2002). Reasons stated by Legum for this phenomenon are that technology has in many cases replaced labour, and that there is a wealth distribution trend whereby most of the world's wealth is being concentrated in the hands of fewer and fewer people. This concentration of wealth has caused lower aggregate demand among the poorer people in society (Legum, 2002). Under such a global economic regime, energy intensity tends to improve, while the creation of unemployment through technology and wealth concentration (a higher gini coefficient), both of which are effectng a lower energy usage per unit of GDP but are bad for sustainability, get worse.

6.5.1.3 Energy Efficiency

Energy Efficiency is directly related to indicator 7. It also features to a significant extent in indicator 1 (carbon emissions per capita). Developments in South Africa's policy-making domain show an intention to increase energy efficiency. According to the DME in its Energy Policy White Paper of 1998:

"Significant potential exists for energy efficiency improvements in South Africa."

More specifically, the White Paper goes on to mention future efforts in support of energy efficiency:

> "Government will establish energy efficiency norms and standards for commercial buildings and industrial equipment, and voluntary guidelines for the thermal performance of housing. A domestic appliance-labelling programme may also be introduced. Publicity campaigns will be undertaken to ensure that appliance purchasers are aware of the purpose of appliance labels."
>
> (DME, Energy Policy White Paper, 1998)

In April 2004, the Draft Energy Efficiency Strategy of the Republic of South Africa was issued. This document shows some commitment to energy efficiency and sets a target of "A Final Energy Demand Reduction of 12% by 2014". The reduction is projected by starting with a 'business-as-usual' baseline, which is projected demand in 2014, incorporating economic and population growth. The target is to achieve 12% below such a baseline. The Draft Energy

Efficiency Strategy (Department of Minerals and Energy, 2004b) which is also mentioned after the budget vote quote below notes a number of 'implementing instruments' that should help achieve energy efficiency, including: support mechanisms (efficiency standards, appliance labelling, certification and accreditation and so on); policy, mandate and governance; finance instruments; and coordination of stakeholders.

The capacity of the energy sector in South Africa is enhanced by the Energy Management programme of the Department of Minerals and Energy, which, as expressed in the 2004 budget vote:

> "Energy Management develops energy resources and promotes their optimal use. Programme activities are organised into four sub-programmes, whose main functions are: promoting integrated energy planning through policy development, in support of environmental objectives and renewable energy technology; managing, developing and implementing the National Electrification Programme and Fund, restructuring the electricity industry, and overseeing the National Electricity Regulator; the governance of the nuclear sector in the areas of safety, nonproliferation and nuclear technology; and developing policy and regulatory functions for coal, crude oil, petroleum and natural gas."
>
> (Department of Minerals and Energy, 2004)

With such outputs as the South African Energy Balance (Department of Minerals and Energy, 2000, 2002a, 2003b), the Integrated Energy Plan (2003c), the Draft Energy Efficiency Strategy (Department of Minerals and Energy, 2004b) and the Energy Outlook (Department of Minerals and Energy, 2002b), the activities of the Energy Management Programme are a positive contribution to sound decision-making in energy issues in South Africa. Eskom has a DSM - (Demand Side Management) programme (Eskom, 2005) which has different methods of reshaping demand, including energy efficiency, load shifting, strategic growth, and interruptibility. DSM is within the National Electricity Regulator's Integrated Resource Plan, which focuses on electricity.

A number of technologies promise to improve supply side energy efficiency and thus improve energy intensity. These include: Supercritical Coal Power Station, Integrated Gasification Combined Cycle (also coal-based), Fluidised Bed Coal Power Station, and combined cycle gas turbines (CCGT) which increases the efficiency of gas-based generation systems.

6.5.2 Renewable Energy Deployment

Data for this indicator is also fairly representative of the real situation in terms of the ability to compare one year to another. The data used is as compiled by the Department of Minerals and Energy (2000, 2002a, 2003b) Apart from domestic biomass use, there is very little renewable energy deployment in South Africa, and the change is very slow. However, the absolute accuracy of the data is limited by the inability to measure accurately the consumption of biomass for domestic use, which is mostly in rural areas. Biomass is the largest single type of renewable energy use in South Africa.

The lack of improvement in this indicator is a reflection of the lack of a concerted effort thus far in South Africa, to increase the deployment of renewable energy as a share of total primary energy supply (TPES). The increased demand for commercial energy is likely, in the years to come, to decrease the renewable energy share of TPES, as the demand is earmarked to be met by the re-commissioning of coal-fired power stations (see section 3.9.2). Consistent with the arguments put forward in section 3.2.6, an interest in renewable energy is likely to become the norm in South Africa and the world as a result of climate change and the perceptions around it.

6.5.3 Technological Prospects for Improving all of the Indicators

6.5.3.1 Introduction

Indicators 7 and 8 are, as defined, to a large extent dependant on the way energy technologies unfold in future in terms of viability, especially renewable and clean energy technologies, although it is also very true that there must be a willingness to implement more sustainable forms of energy. This section explores some of the pivotal technological and their associated natural resource issues.

6.5.3.2 Crude oil and its products

Possible effects of a sustained high oil price: The sudden oil price hike and oil shortages of the 1973 oil crisis resulted in a range of measures to get through the crisis, some of which were beneficial in terms of energy efficiency. These included, for example, the lowering of the speed limit in the United States to 55 miles/hour (90 km/hour) and the rise in popularity of bicycles in Europe (IMF, 2004).

On the future of oil, the pessimist are said to believe that the oil (production) peak could be upon us as early as 2010 (National Geographic, June 2004). The same National Geographic article goes on to say that the optimists, including the United States Geological Survey (USGS) and many economists say that there's at least 50 percent more oil than the pessimists believe, and much of it in the Middle East, and further states:

> "New Technologies will wring additional supplies from existing fields, the USGS predicts, and vast new reserves remain to be found.... many discoveries have fallen off simply because countries awash in oil like Iraq, Iran, and Saudi Arabia have had no incentive to drill for more. "If I'm an OPEC producer with lots of spare capacity, why would I waste money looking for more reserves?" asks Kaufman".
>
> (National Geographic Magazine, 2004)

It is disturbing that the whole article, entitled "The End of Cheap Oil" is silent on the threat that fossil fuel emissions pose to the global environment. This article is not unique in the context of current discourse on energy issues. There is a widespread preoccupation with energy security regardless of environmental impacts. Unfortunately, this disregard, or at least lack of a sense of urgency, seems to be widespread among ordinary citizens and policy makers in countries throughout the world, including South Africa. It is clear from the outcomes of the work of the UNFCCC and the Intergovernmental Panel on Climate Change (IPCC) supporting it, as well as other scientific research, quoted by Winkler et al (2002) in section 3.2.1, that drastic action needs to be taken to reduce anthropogenic greenhouse gas emissions.

6.5.3.3 The future of other fossil fuels

Coal poses a formidable challenge to the global energy sector. As is the case in many other countries of the world, South Africa has abundant coal supplies – a 200 year supply at present production, according to Eskom (Eskom, 2003a). This well-established source of fuel, with a low internal cost is readily favoured, especially in countries where there are few investment options. The global climate effect is either not considered or is seen as unavoidable.

Natural gas can help in the reduction of greenhouse emissions. According to EIA statistics from 1998, quoted at www.naturalgas.org, natural gas has 56% of the CO_2 emissions of coal, and 71% of the CO_2 emissions of petroleum when burnt (naturalgas.org, 2004). According to the same source, it is also cleaner on nitrous oxides, sulphur dioxide and particulates see Appendix 2.2. However, it is not abundant in Southern Africa, nor is it easy to transport. The natural gas finds in Mozambique, in the offshore areas off Western Namibia and South Africa, and the gas that is co-produced with crude petroleum off the Angolan coastline, are all together not large enough to significantly change the energy mix in South Africa. In any case, natural gas is no long term solution by itself, due to the fact that its CO_2 emissions are well above the average required to halt global climate change, as expressed earlier (by Winkler et al, 2002) in the section on indicator 1 (section 3.2.1).

6.5.3.4 The future of alternative fuels – Hydrogen

Hydrogen holds much promise as a convenient energy carrier, but not as a source in itself. The much talked about 'hydrogen economy' does not seem a near reality. As noted in The Engineer article (21 February-6 March 2003),

> "There is simply not enough financial or governmental backing behind hydrogen – and the indications are that in the coming decades the technology to harness its use will be dropped by the automotive, oil and gas industries.
> "Lack of renewable energy to produce sufficient amounts of hydrogen and the expense of installing a viable infrastructure to distribute it suggests that hydrogen will only ever be used in fleet or specialist automotive applications."
> (Article: 'The Hydrogen Hoax' The Engineer, 21 February-6 March 2003).

If the hydrogen economy can be a reality, then this will not be realised through half measures and spending merely to dampen criticism. The effort has to be a sincere one. The same can be said of other alternative fuels and energy systems.

While the 'grand solution' to the energy crisis (perhaps nuclear fusion – briefly discussed under section 6.5.3.6) remains elusive, there is progress in various technical areas towards a more efficient and more convenient energy conversion. In this category are advancements in fuel cell energy conversion (from chemical to electric), which is quiet and very efficient. Fuel cells are, for example being applied to areas where dry cell technology previously dominated (New Scientist 2004). One example is the use of fuel cells to power portable computers (laptops), where a small (25 ml) bottle of methanol will be able to give at least the same power supply time as a new battery in the current technology (4 hours). It is foreseen that this will improve to 20 hours and more later (New Scientist, 2004). Fuel cells are also set to take over remote power supplies, distributed generation and power back-up systems, as well as many other applications (Smithsonian, 2001 and KTKM, 2004). If a way is found to source the fuel for fuel cells (which could be hydrogen, methane, ethanol etc) economically, then power systems – from rural power supplies to vehicle power systems, will experience a revolution as fuel cells with a bigger power output will come into common use.

6.5.3.5 Efficiency Improvements

Building energy efficiency technology that is already well established includes passive heating and cooling design, including geothermal energy in the form of ground source heat pumps.

Another example of advancement in energy conversion, which is more important in terms of its implications for greenhouse gas mitigation, is the advent of petrol-electric hybrid power systems that are capable of much higher fuel efficiencies. One of two production models, and the more efficient one, is the Toyota Prius, which, on an urban cycle consumption of 26 km per litre, (3.8 litres per 100 km) has almost 2 times the fuel efficiency of a typical South African market small car with a petrol efficiency of 7 litres per 100km, and is almost 3 times as efficient as a typical South African market medium sized family sedan rated at 9 litres per 100km (Toyota, 2004).

6.5.3.6 Nuclear Energy

Nuclear options for the future remain open with the continued construction of nuclear reactors worldwide. According to Engineering News: "the entire nuclear power chain, from mining uranium, through construction of the reactor and power facilities, to disposal of the waste, emits only 2 g/kWh to 6 g/kWh (of Carbon), which is about the same as for wind and solar power and two orders of magnitude below coal, oil and even natural gas", and 27 nuclear power plants were under construction as of the middle 2004 (Engineering News 2004:19). There is continued opposition to nuclear energy on the basis of safety concerns, and perhaps also because nuclear reactors are operated by government agencies and corporations, both of which are often not very transparent in safety and other operational issues involving nuclear assets. Renewable energy technologies, in contrast promise more participation by ordinary people, by virtue of the fact that renewable energy is dispersed.
Nuclear weapons proliferation, while topical at the beginning of the 21st Century, is in itself not an intractable problem, but will remain so while global institutions for security remain prone with inequities. The present constitution of the UN Security Council, with veto powers and permanent seats, does not foster confidence in global security issues. Instead many countries take any opportunity to acquire nuclear weapons, or are seen to do so. Present calls for the reform of the United Nations Security Council (BBC, 2004d and Chinadaily, 2004) are an attempt to address this. Meanwhile, nuclear energy deployment is seemingly not hampered much by proliferation issues, to a large part because the International Atomic Energy Agency (IAEA) has, as part of its mission, the role of helping countries that want to develop nuclear power for peaceful purposes (IAEA, 2004). Ironically this assistance brings countries closer to being able to manufacture nuclear weapons by, for example, secretly reprocessing spent nuclear fuel.

South Africa's efforts to establish the Pebble Bed Modular Reactor (PBMR) are seen by the relevant energy decision makers in that country as timely, given the global concern with greenhouse gasses, South Africa's high greenhouse gas emissions, the short lead times in setting up one of these reactors, and the fact that the PBMR's relatively small power unit size will make it economic to implement the PBMR in scenarios where electrical power consumption is growing slowly (Daily News, 2004 and PMG, 2004).

The energy conversion technology which is most favoured to solve global energy problems - nuclear fusion, promises a practically endless, non-polluting supply of energy, and is being pursued earnestly. At the end of 2004, the partners in the project were trying to agree over the location of the reactor for next phase of the project. Known as International Thermonuclear Experimental Reactor (ITER), its goal is to establish commercially viable fusion technology, over a 35 year period (BBC, 2004c). This is fairly long term, but if the project shows further promise, then it will start to affect the planning (especially with respect to timing) of capital expenditure on energy generation assets in the coming couple of decades.

7. Some Imperatives to Improving the Indicators

7.1 Introduction

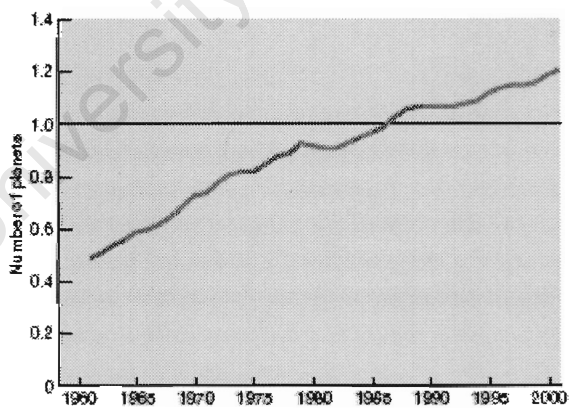
The following three factors are already raised in the commentary on, and analysis of the indicators. If addressed, these factors would evidently make it much easier for South Africa to pursue a sustainable energy path and improve the indicators. They include: the respect for environmental limits, improvement of South Africa's gini coefficient (inequality measure), and the establishment of an adequate global government system.

7.2 Environmental Limits

This issue is directly relevant to indicators 1 (carbon emissions) and 2 (local pollution), and should strongly influence indicator 8 (renewable energy deployment). Section 3.2.5 on the polar ice recession or the 'Larson B episodes' possible shows the danger in ignoring environmental limits.

Energy sustainability issues are closely interrelated with the wider environmental sustainability problem in the world today. If not already apparent to many, it is a fact that the global environment clearly has limits that must be respected. It can supply a certain amount of resources, and it can absorb a certain amount of waste. This point is made elegantly by WWF (previously the World Wide Fund for Nature), which has developed a measure for humanity's ecological footprint. Figure 20 below illustrates one outcome of the of the 'ecological footprint' approach to measuring sustainability.

Humanity's Ecological Footprint, 1961-2001



"Human Demand on biosphere increasing. The Ecological Footprint measures people's use of renewable natural resources. Humanity's Ecological Footprint is shown here in number of planets, where one planet equals the total biologically productive capacity of the Earth in any one year. In 2001, humanity's Ecological Footprint was 2.5 times larger than in 1961, and exceeded the Earth's biological capacity by about 20 per cent. This overshoot depletes the Earth's natural capital, and is therefore possible only for a limited period of time."

Figure 20: Humanity's Ecological Footprint, 1961-2001

Source: WWF (2004:1)

The idea that all socio-economic activity on planet earth is limited by the "total biologically productive capacity of the Earth" is presently not central in present rhetoric on enterprise, trade and development strategy or in the mass worldwide media. Instead, the pursuit of GDP growth, 'energy security' and other such concerns are considered more important. China's present rapid economic expansion powerfully illustrates the problem with this approach. The lament over China's global quest for oil and its geopolitical effects (Christian Science Monitor, 2005, and Business Week, 2004), is in truth a lament over the lack of a global regulatory regime (section 7.4) for the environment and to regulate the equitable use of the earth's limited resources. Respect for, and emphasis of the environmental reality is necessary if sustainability is to be achieved. A statement by the Baha'i International Community, a religion-based agency with consultative status at the United Nations, first issued at the (1995) United Nations World Summit on Social Development in Copenhagen, Denmark notes:

> "A challenge ...faces economic thinking as a result of the environmental crisis. The fallacies in theories based on the belief that there is no limit to nature's capacity to fulfil any demand made on it by human beings have now been coldly exposed. A culture which attaches absolute value to expansion, to acquisition, and to the satisfaction of people's wants is being compelled to recognize that such goals are not, by themselves, realistic guides to policy."
>
> (Baha'i International Community, 1995: V).

For the energy sustainability indicators to be visibly improved, there needs to be a contrast to the approach set forth in South Africa's energy white paper, noted in section 3.2.2, which highlights the importance of low cost (not including externalities), commits to coal use, makes South Africa's decision-making on climate change perhaps too dependant on 'international developments' and 'negotiations' (potentially the foundation for 'lowest common denominator behaviour'), and declares a 'no regrets' approach (which can be seen a euphemism for 'no commitment to principle'), to be the policy (Department of Minerals and Energy, 1998). It would be in South Africa's interest to consider deeper principles when approaching issues of energy and sustainability, rather than the approach set forth in the energy policy white paper. While a principled approach seems usually more expensive and often initially unpopular, it is more capable of gathering support as time passes because it has a more solid foundation than an approach based on convenience.

7.3 Gini Coefficient – extremes of wealth and poverty

Narrowing the gap between rich and poor would, as the following discussion suggests, go a long way towards ensuring energy sustainability in South Africa. Among the indicators surveyed in this report, extremes of wealth and poverty show the most direct effect on indicators 2 (local pollution) and 3 (access to electricity).

The behaviour which results from the desperation of poverty is generally not conducive to the pursuit of sustainability, as noted in the 2004 Living Planet Report of the WWF:

"...all 191 Member States of the United Nations have signed up to support the Millennium Development Goals, which not only address the root causes of environmental degradation – such as escalating poverty – but also include a specific goal on environmental sustainability."

(WWF, 2004:1).

The prevalence of relative poverty has been on the increase in South Africa. South Africa's national gini coefficient/gini index, which is the measure for income inequality in a country, is among the worst in the world, and it increased (worsened) from 0.596 in 1995 to 0.635 in 2001 (UNDP, 2003: 5). There are only a handful of countries in the world with gini index worse than South Africa's (UNDP, 2004a).

Proponents of the Washington Consensus (Appendix 4.1) as a solution to underdevelopment often imply that growth in GDP by itself will solve problems of poverty. The evidence is however that the state has to intervene with measures to avoid extremes of wealth and poverty (Stiglitz, 2002: 80). Hills (2004) notes from a survey the case of a country that is considered highly developed, but has noticeably more poverty than other countries that are considered developed: In the year 2000, the US was shown to have a 10.8% of its population living on less than 40% of the US median income, while (with statistics from either 2000 or the late 1990s) each of Belgium, Austria, France, Luxembourg, Finland, Norway and Sweden have less than 4% of the population living on less than 40% of each respective country's median income (Hills J, 2004: 57).

Local pollution (indicator 2), as discussed in section 3.3.3, is significantly contributed to by the poor using whatever fuel can be afforded (e.g. firewood, coal). In turn the local pollution, especially indoor smoke from cooking and space heating, affects the poor greatly. If the extreme poverty is removed, the choice of these fuels ceases to be an issue. Similarly for indicator 3 (household access to electricity), electrifying extremely poor households is usually a demanding proposition and often an unsustainable one. Ensuring adequate incomes is a more elegant solution to universal electrification of households.

The following two paragraphs look at the effectiveness of how South Africa seems to be dealing with extreme relative poverty.

Poverty has to some extent become socially acceptable, and the methods of dealing with it are often inadequate, seemingly because they do not question the basic acceptability of poverty – or at the least extreme relative poverty, but instead aim to lessen its effects. A comment by South Africa's Housing Minister possibly illustrates this point. In the article on South Africa's housing backlog, already quoted in the section on Indicator 3, the Housing Minister asserts:

> "The department is looking into creating communities with roads, creches, and schools, which is a human settlement rather than just a township.
> ""I aim to provide people with a home that they can be proud of, instead of just dumping them in a township with no amenities," Sisulu Explains."
> (Engineering News, July 9-15, 2004).

While better planned settlements for the poor offer some alleviation to poverty, a question is raised on what quality of "roads, creches and schools" can be built and maintained in poor communities. There are examples that show that infrastructure for communities without adequate income will do little by itself to uplift poor communities. Inner city housing blocks for the poor in the USA, known as 'the projects' have ironically given a negative meaning to the phrase 'the projects' as they symbolise poverty and crime in many cases. Does the question not arise as to whether the problem would not be tackled more directly by aiming for a situation whereby extremes of wealth and poverty were eliminated as much as is necessary and practical - without falling into the obvious trap of removing incentive for individual achievement? Evidence from countries with lower inequality, for example those listed above from Hills (2004), would tend to show that societies that do not allow great extremes of poverty and wealth, achieve a "social cohesion" (aimed for by European Union policy according to Hills) which eliminates, among other things, the effect of people without adequate income inhabiting marginal residential areas without "roads, creches, and schools" as listed by the South African Housing Minister. This social cohesion is also raised by Joseph Stiglitz (in 'Globalization and its Discontents') as seen by East Asian countries as important, in his discussion of the so-called 'Asian miracle' (Stiglitz, 2002: 92). The phenomenon of extremes of wealth and poverty between countries in the world today also has implications for sustainability. The measures proposed in the following section (section 7.4) would be able to contribute to the solution to this problem.

South Africa would seemingly achieve much from following the example of the European Union and certain other governments in actively working to eliminate extremes of wealth and poverty.

7.4 Global Government

This section looks at world governance and the opportunities for improving the indicators through it. The scramble for oil involving China, with its rapidly growing economy, has serious global security implications in terms of both energy and geopolitics. It is mentioned in section 6.4.2 (interpretation of the non-renewable energy imports indicator) as well as in section 7.2 (environmental limits). The issue of China and the present difficulty in improving indicator 1 (carbon emissions) around the world, both make a strong case for the resolution of the central issue discussed in this section.

On a global scale, it is clear that national governments alone are not adequate in an age of international and multinational corporations, criminals who are not constrained by national borders, as well as other challenges including environmental degradation. There needs to be a binding global legislative framework in order to secure a chance of effectively solving these problems. The quotes earlier by Galbraith in chapter 1 (Problem Statement) notes this requirement of our age – he notes the need for "international action to protect and coordinate the welfare measures of individual States", laments the inadequacies of the UN agencies and other international agencies, and firmly notes: "The United Nations agencies have discussion, but alas not power. This we must now correct."" (Galbraith, 1997).

Worldwide binding legislation on pollution, environmental degradation and human rights would improve global sustainability by, for example, removing the ability of countries to sacrifice environmental and social well-being for short-term economic gains. A case in point: South Africa encourages the construction of energy intensive aluminium smelters (Davidson and Winkler, 2003) which are powered by electricity from coal-fired power stations that are contributing to global climate change. These smelters could also mean that other electricity consumers in South Africa have to bear the cost of subsidising cheap long-term electricity supply contracts given to the smelter operators.

Sadly, the lack of a binding international legislative framework is not due purely to oversight, but also to active opposition to the achievement of this objective, as illustrated by the case of UNCTAD and WTO. Since its inception in the 1960s, UNCTAD's objectives and main activities have included what the WTO has been pursuing since its establishment in the 1990s, and more. The problems and inadequacies of WTO in terms of ensuring environmental protection and welfare are well documented and are re-emphasized time after time by protesters, activists, commentators and poor countries alike during periods surrounding WTO meetings (Africa Renewal, 2003). UNCTAD, a subsidiary organ to the United Nations

General Assembly, has a more sustainable approach to trade and development as evident in the way it publicises itself:
"During four decades, the organization has been the focal point within the United Nations for the integrated treatment of trade and development and related issues in the areas of investment, finance, technology, enterprise development and sustainable development."
(UNCTAD, 2004a).

Also in its publicity information, is an explicit respect for the environment:
"(UNCTAD) assesses the trade and development impact of environmental requirements and relevant multilateral agreements and provides capacity-building activities to help developing countries participate in and derive benefits from international negotiations on these matters."
(UNCTAD, 2004b).

There seems no reason why GATT and its consequences should not be part of the responsibilities of UNCTAD, an agency of the United Nations. A number of critics raise the issue of UNCTAD living in the shadow of a less legitimate WTO (Bello, 2005; Raghavan, 2000; Oxfam-Solidarity, 1999: 34). According to Bello, the sidelining of WTO has been deliberate:

> "The northern offensive escalated during UNCTAD VIII, held in Cartagena in 1992. At this watershed meeting, the North successfully opposed all linkages of UNCTAD discussions with the Uruguay Round negotiations of the GATT and managed to erode UNCTAD's negotiation functions, thus calling its existence into question."
>
> Bello (2005).

Among the indicators for South Africa, the first visible beneficiaries (improvements) in a global government system would be carbon emissions (indicator1) and local pollution (indicator 2), but others would follow closely.

A global legislative framework in turn has security implications, compelling the world to implement, in its pure form, the concept of collective security on which the United Nations was founded upon - Article I of United Nations Charter (United Nations, 1945). Collective security cannot operate, for example with veto powers present, nor with the victors of a previous war enjoying more privileges than other countries. A democratic vote in a democratically constituted UN institution is closer to implementation of collective security in accordance with justice. With globally binding laws and the necessary security arrangement, it will be a less daunting task to pursue sustainable development everywhere in the world. The achievement of such a global arrangement must be underpinned by the acceptance, throughout the planet, of a common humanity. The global implementation of the United Nations Universal Declaration of Human Rights of 1948 (United Nations, 1948) would be a powerful tool in this direction.

The discussion in this section has brought forth the importance of South Africa needing to address three issues as a strong basis for achieving sustainable energy policy and practice. These are: the need to acknowledge the apparent and definite sovereignty of nature relative to human beings (environmental limits); the need for South Africa to lower its gini coefficient (and thus decrease wealth inequalities) and the need to acknowledge and work for the all too-important goal of establishing an adequate global government system to ensure global governance for the benefit of all.

8. Conclusion

8.1 South Africa's Performance on the Indicators

The best performance for South Africa is in indicators 3 (access to electricity), 5a (non-renewable energy exports as a share of total exports), 5b (non-renewable energy imports as a share of non-renewable TPES) and 6 (burden of energy sector investments) for which South Africa scores fairly close to 0, the ideal.

The worst performance for South Africa is in indicators 1 (Carbon Emissions per capita) and 7 (Energy intensity), for each of which South Africa scores about 2 – off from the unsustainability level by a factor of approximately 2.

South Africa's energy sector is moving toward greater sustainability in the following areas: carbon emissions (indicator 1), access to electricity (indicator 3) and burden of energy sector investments (indicator 6).

Although presently very scoring well, South Africa appears to be presently moving away from greater sustainability according to the indicator for non-renewable energy imports as a share of non- renewable TPES.

In the following indicators, South Africa is showing no discernible trend towards or away from sustainability: level of most significant local pollutant (indicator 2), investment in clean energy (indicator 4), non-renewable energy exports as a share of total exports (indicator 5a), energy intensity (indicator 7), and deployment of renewable energy (indicator 8).

8.2 Developments that will Contribute to Progress

Recent legislation and proposed legislation in the energy sector and environmental sector, the volume of published statistics, and other energy management initiatives, and the beginning of the implementation of air pollution monitoring stations should help South Africa to make sound energy sector decisions in future.

8.3 Further Initiatives Required

Further interventions in the energy sector by the South African government that should improve the indicators include: addressing the issue of public transport on and off the rail network, as well as addressing the roads degradation and goods transport problems by implementing proper costing and facilitating the resurgence of the more efficient rail transportation of goods (which would improve energy intensity and lower energy imports, carbon emissions and local pollution), facilitating the deployment of the already economically viable renewable and clean energies such as solar water heaters and energy efficient building design, increasing the renewable energy target to ensure economies of scale that would support local manufacture (improving renewable energy deployment), facilitating lower energy intensity of the economy by facilitating an increase in the size of the tertiary sector of the economy through interventions to make telecommunications, transport and the food sectors more economically efficient.

8.4 Addressing some Fundamental Imperatives

In order to steer South Africa towards a development direction which would yield more sustainable energy practices, development planning in South Africa would, it seems, be more successful if it: pursues development aspirations with a clear respect for the prevailing environmental limits (which should greatly improve renewable carbon emissions per capita, local pollution and renewable energy deployment); aims to eliminate extremes of wealth and poverty, which will lessen the knock on effects of this phenomenon (improving local pollution and household access to electricity); promotes the establishment of an adequate global government system (which should improve all indicators, especially carbon emissions, local pollution) and meanwhile supports global institutions whose policies, at least through their objectives and their constitution, are realistically working towards a sustainable global economic dispensation. Such institutions include the UN agencies, particularly UNCTAD, whose mission is in line with making it easier for countries to pursue more sustainable development paths.

The events that marked the end of apartheid, and the peaceful advent of a democratic country in South Africa require reflection upon here. Those events showed the human ability to embrace principles and ignore the lower tendencies of emotive, violent reaction to human conflict. Such a human power should be evoked in a parallel manner against today's worldwide challenge of sustainability. Economic prosperity at all costs seems to be the opium of the global community. If South Africa or any other country is serious about achieving sustainability, then it should give up all notion of convenience and accept the trials, tribulations and joys of leading by example.

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APPENDICES

Appendix 1: Formulae for the calculation of energy sustainability indicators

Adapted from a document prepared by Ricardo Cunha da Costa, December 2001

The section presents the formula to calculate vector values for the eight sustainability indicators, and how that is adapted for each indicator. There are four main variables to calculate each indicator. The definitions of these variables remain the same for each indicator. The generic formula is written:

$$I = \frac{X-Y}{Z}$$

where:

I = the value of the vector (in relative terms);

X = the value (in absolute terms) of the environmental, economic or social parameter for this indicator;

Y = the sustainability goal (in absolute terms) which corresponds to value 0 of the vector; and

Z = the value of the segment (in absolute terms) which goes from 0 to 1 on the vector.

Where:

Z = W –Y

and:

W = the reference value for unsustainability (in absolute terms) which corresponds to value 1 of the vector.

The two above equations demonstrate the importance of carefully defining the values of Y (the sustainability objective) and W (the benchmark for unsustainability at the other extreme of the segment). As the difference between Y and W becomes greater, the impact of a variation of the variable in question becomes less significant. The values for the ends of the vectors are also presented in Table 2 of this report.

Let us proceed to the calculation of each indicator.

Environmental sustainability

Indicator 1: Energy sector carbon emissions per capita

X = emissions of the current year;

W = 1130kgC/capita (world average energy sector carbon emissions in 1990);

Y = 339kgC/capita (70% reduction from 1990 levels); and

Z = 791kgC/capita.

$$I = \frac{X - 339}{1130 - 339}$$

Indicator 2: Local impacts: level of most significant local energy pollutant

X = level of selected pollutant for the current year;

W = level of selected pollutant in 1990;

Y = 10% of the level of selected pollutant in 1990; and

Z = W –W/10 = 9W/10.

$$I = \frac{X-Y}{W-Y}$$

Social sustainability

Indicator 3: Households with access to electricity

X = percentage of the households which have access to electricity in the current year;
W = 0% of the households have access to electricity;
Y = 100% of the households have access to electricity; and
Z = -1.

$$I = \frac{X- 100\%}{0\% - 100\%}$$

Indicator 4: Investment in clean energy, as a proxy for job creation

X = investment in renewable energy and energy efficiency as a share of total investment in the energy sector in the *current* year;
W = the value of X in 1990;
Y = 95% of the investment of the energy sector going to renewable energy and energy efficiency; and
Z = W–95%.

$$I = \frac{X - 95\%}{W - 95\%}$$

Economic sustainability

Indicator 5: Resilience to external trade impacts

a) Countries that are net importers of energy:

X = imports of non-renewable energy as a share of non-renewable energy primary energy consumption;
W = 100%;
Y = 0%; and
Z = 1.
I = X

b) Countries that are net exporters of energy:

X = exports of non-renewable energy as share of the total *value* of all exports;
W = 100%;
Y = 0%; and
Z = 1.
I = X

Indicator 6: Burden of energy investments on the public sector

X = public investment in non-renewable energy as a share of GDP in the current year;
W = 10%;
Y = 0%; and
Z = 0.1.

$$I = \frac{X - 0}{0.1} = 10X$$

Technological sustainability

Indicator 7: Energy intensity

X = total primary energy consumption per unit of GDP in the current year;

W = 10.64 MJ/US$1990 which corresponds to the world average consumption of primary energy per unit of GDP in 1990;

Y = 1.06 MJ/US$1990 which corresponds to 10% of W

Z = 10.64 – 1.06 = 9.58.

$$I = \frac{X - 1.06}{9.58}$$

Indicator 8: Deployment of renewable energy

X = renewable energy supply as a share of total primary energy supply in current year;

W = 8.64% which corresponds to the share of world primary energy supply from renewable energy in 1990;

Y = 95%; and

Z = 8.64% – 95% = -0.8636.

$$I = \frac{X - 0.95}{-0.8636}$$

Appendix 2: Additional Notes and statistics

Appendix 2.1

Note 2.7.1: Decentralised energy production has the ability to improve energy efficiency as follows: when the generating plant is close to the consumers, for example where there is a local gas or petrol generator, any unnecessary system overloading or waste will cause local problems and most probably be quickly corrected. Another benefit of a local generator such the one just mentioned is that there may be times when the community shuts down the supply according to a schedule in order to conserve energy. The author observed this phenomenon in the Malaysian province of Sarawak (December 1998), where, in a remote village, the village petrol electricity generator was switched on in the early evening and turned off at about ten pm.

Appendix 2.2

Fossil Fuel Emission Levels
- Pounds per Billion Btu of Energy Input

Pollutant	Natural Gas	Oil	Coal
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016

Source: EIA - Natural Gas Issues and Trends 1998

Quoted in Naturalgas.org, 2004

South Africa: Year-by-year GDP changes 1990 – 2002 and Pop, GDP per Cap

Base year = 1990

Year	GDP ratio	Population ratio	Relative GDP/Capita	Raw Pop
1990	1	1	1	36
1991	0.99	1.01	0.98	36.2
1992	0.97	1.03	0.94	37
1993	0.98	1.05	0.93	37.8
1994	1.01	1.07	0.94	38.6
1995	1.04	1.1	0.95	39.5
1996	1.09	1.12	0.97	40.3
1997	1.12	1.14	0.98	41.2
1998	1.13	1.17	0.96	42.1
1999	1.15	1.2	0.96	43.05
2000	1.19	1.22	0.97	43.94
2001	1.22	1.25	0.98	44.82
2002	1.26	1.27	1	45.73

2002 population is an extrapolation

Appendix 2.3

Source: Statistics South Africa (2003) for population, South African Reserve Bank, 2004 for GDP figures.

Appendix 3: Additional Notes and statistics.

Appendix 3.1

International Auto and Vehicle Ownership Comparison - 1995

(Table on next page).

Country/Area	Passenger Cars	Total Vehicles	Total Population	Cars per 1000 Pop.	Vehicles per 1000 Pop.
United States	149,120,000	198,798,000	265,000,000	563	750
Japan	45,000,000	67,245,000	125,000,000	360	538
Germany	40,499,442	42,836,202	81,844,000	495	523
United Kingdom	20,780,000	23,077,000	56,800,000	366	406
California	*17,262,533*	*22,729,243*	*32,223,000*	*536*	*705*
Canada	14,280,000	18,175,600	30,600,000	467	594
Spain	14,212,259	17,196,399	40,460,000	351	425
Russia	13,550,000	23,410,000	149,000,000	91	157
Brazil *	13,030,000	14,870,000	156,000,000	84	95
Australia	8,370,000	11,010,300	18,000,000	465	612
Mexico	8,330,000	12,551,000	89,400,000	93	140
Poland	7,517,266	8,989,544	38,609,000	195	233
Korea	6,006,290	8,468,901	44,847,000	134	189
Ukraine	4,510,000	4,510,000	53,000,000	85	85
San Francisco Bay Area	*3,823,812*	*4,702,991*	*6,454,400*	*592*	*729*
South Africa	3,810,000	5,450,000	39,700,000	96	137
Sweden	3,630,760	3,953,046	8,837,000	411	447
Austria	3,593,588	3,893,630	8,039,000	447	484
China	3,490,000	9,190,000	1,200,000,000	3	8
Turkey	3,231,562	4,040,923	62,525,000	52	65
Switzerland	3,229,169	3,506,568	7,064,000	457	496
India	2,720,000	4,927,000	897,000,000	3	5
Malaysia	2,558,641	3,054,581	19,886,000	129	154
Greece	2,204,761	3,106,818	10,475,000	210	297
Romania	2,197,477	2,582,588	22,681,000	97	114
Indonesia	2,030,000	4,039,000	200,000,000	10	20
Finland	1,900,855	2,181,239	5,117,000	371	426
Denmark	1,729,405	2,017,869	5,216,000	332	387
Saudi Arabia	1,710,000	2,882,600	17,300,000	99	167
Norway	1,684,664	2,066,683	4,369,000	386	473
Bulgaria	1,647,571	1,891,847	8,385,000	196	226
New Zealand	1,640,000	2,008,200	3,540,000	463	567
Venezuela *	1,520,000	1,954,000	20,600,000	74	95

Egypt	1,280,000	1,703,000	60,000,000	21	28
Israel	1,121,730	1,394,323	5,609,000	200	249

Source: (Metropolitan Transportation Commission, 2004). Survey of Countries with Greater than 1.0 million Passenger Cars. For brevity, some countries are omitted here.

Appendix 3.2

Passenger Journeys: Metro Rail Services (March 1980 to March 2000).

Financial Year Ending 31 March	1st Class	3rd Class	Total
1980/81	124 277 492	556 791 429	681 068 921
1981/82	123 806 831	583 729 629	707 536 460
1982/83	112 315 338	569 938 195	682 253 533
1983/84	104 195 965	578 598 307	682 794 272
1984/85	96 503 514	565 656 341	662 159 855
1985/86	89 826 391	548 440 793	638 267 184
1986/87	75 918 186	522 686 438	598 604 624
1987/88	63 407 068	506 308 296	569 787 364
1988/89	63 437 928	510 637 789	574 075 717
1989/90	62 753 424	484 639 680	547 593 104
1990/91	64 875 001	459 342 534	524 217 535
1991/92	61 470 228	406 855 390	468 325 618
1992/93	49 824 660	348 594 783	398 419 443
1993/94	40 280 400	363 249 416	403 529 679
1994/95	35 542 544	377 972 135	413 514 679
1995/96	33 663 110	409 075 572	442 738 682
1996/97	29 546 586	428 489 774	458 036 360
1997/98	79 019 231	417 709 337	496 728 568
1998/99	23 901 592	461 455 987	485 357 579
1999/00	21 444 926	469 604 041	491 048 967

Source: SARCC Information Resource Centre, quoted Department of Transport (2001:3.3a).

Appendix 3.3

South Africa's ratio of world reserves and production for selected minerals, 2001

Commodity	Reserve Base (%) & world ranking	Production (%) and world ranking
Aluminium	Not available	2,7 (8)
Alumino-silicates	37,4 (1)	35,9 (1)
Antimony	7,8 (4)	4,3 (3)
Chrome	72,4 (1)	37,0 (1)
Coal	10,9 (5)	5,8 (6)
Copper	2,0 (13)	1,1 (12)
Fluorspar	18,2 (3)	6,3 (3)
Gold	45,7 (1)	15,2 (1)
Iron ore	0,9 (9)	3,5 (9)
Lead	2,3 (5)	2,7 (13)
Manganese	80,0 (1)	19,9 (1)
Nickel	8,1 (6)	2,9 (11)
PGMs	55,7 (1)	50,5 (1)
Phosphate rock	5,3 (4)	1,9 (9)
Titanium minerals	20,7 (2)	22,8 (2)
Uranium	9,1 (4)	2,5 (9)
Vanadium	44,4 (1)	57,9 (1)
Vermiculite	40,0 (2)	33,6 (1)
Zinc	3,5 (5)	0,7 (25)
Zirconium	21,1 (2)	28,1 (2)

Sources: ABARE, Business Day, Johannesburg Securities Exchange, SA Minerals Bureau, SA Reserve Bank, Statistics SA.

Source: COM (2002b).

Appendix 3.4

(following page – table fills whole page)

GDP by major economic sectors*, 1995 and 2001

% share of GDP at producer prices

	Notes	1995			2001		
		Agriculture	Industry	Services	Agriculture	Industry	Services
European Union:							
Austria		2.5	30.8	66.7	2.3	30.5	67.2
Denmark		3.6	24.9	71.5	2.7	25.3	72.0
France		3.2	26.3	70.5	2.8	24.8	72.4
Germany		1.3	32.1	66.6	1.2	29.1	69.7
Greece		9.9	22.4	67.7	7.0	21.4	71.6
Ireland	a	7.7	38.2	54.1	3.6	41.4	55.0
Luxembourg		1.0	21.2	77.8	0.6	17.9	81.5
Portugal		5.2	30.0	64.9	3.6	28.7	67.7
Spain		4.4	29.6	66.0	3.4	28.7	67.9
Sweden		2.7	30.1	67.2	1.9	28.1	70.1
United Kingdom		1.8	30.9	67.3	0.9	26.5	72.6
Other Western Europe:							
Iceland	b	11.8	27.0	61.2	10.4	28.1	61.5
Malta	b	2.9	33.7	63.4	2.8	25.5	71.7
Norway		3.0	34.1	62.9	1.8	39.3	58.8
Switzerland	a,c	1.6	27.0	71.5	1.2	25.6	73.2
Turkey	a	15.7	31.9	52.4	12.6	29.6	57.9
Central and Easten Europe:							
Albania	a	54.6	22.0	23.4	51.0	26.3	22.7
Bosnia and Herzegovina	a	25.0	27.4	47.6	13.2	29.0	57.8
Bulgaria		13.4	32.4	54.3	13.7	28.5	57.9
Croatia		10.4	33.4	56.3	8.5	29.3	62.2
Czech Republic		4.7	41.9	53.4	4.2	40.0	55.8
Estonia		8.7	31.0	60.3	5.8	28.7	65.5
Hungary		6.8	30.9	62.3	4.3	31.3	64.4
Latvia		9.9	33.5	56.6	4.8	24.9	70.3
Lithuania		11.7	33.2	55.0	7.2	31.5	61.3
Poland		6.9	7.3	33.3	3.8	31.4	64.8
Romania	a	20.9	40.3	38.8	14.8	34.0	51.2
Serbia and Montenegro	a,e	19.3	37.8	42.9	21.1	32.1	46.8
Slovakia		6.0	38.2	55.8	4.5	31.8	63.8
Slovenia		5.5	41.7	52.8	3.0	36.3	60.7
The former Yugoslav Republic of Macedonia	a	12.8	28.9	58.3	10.6	30.1	59.3
Commonwealth of Independent States:							
Armenia		40.8	30.9	28.3	25.2	34.8	40.0
Azerbaijan		26.7	32.9	40.4	16.8	45.0	38.2
Belarus		16.8	35.2	48.0	11.7	36.1	52.3
Georgia		44.4	12.4	43.2	21.9	21.7	56.4
Kazakhstan		12.8	31.2	56.0	9.3	38.4	52.3
Kyrgyzstan		43.1	19.2	37.7	37.0	28.1	34.9
Republic of Moldova		32.2	31.4	36.4	23.6	24.1	52.3
Russian Federation	a	7.2	37.5	55.3	7.0	36.9	56.1
Tajikistan	b,f	38.0	35.1	26.8	29.4	29.6	41.0
Turkmenistan	a	16.9	61.3	21.8	25.9	41.9	32.2
Ukraine	a	15.0	41.3	43.7	16.9	35.2	47.9
Uzbekistan	a	31.4	27.0	41.6	34.9	22.8	42.3
North America:							
Canada	d	2.9	30.7	66.4	2.6	30.1	67.3
United States	a	1.5	27.0	72.3	1.6	24.5	73.9

Source: UNECE Statistical Division

a/ Data for 2000 instead of 2001
b/ Data for 1999 instead of 2001
c/ Data for 1997 instead of 1995
d/ Data for 1998 instead of 2001
e/ Data for 1996 instead of 1995
f/ Gross Material Product

* Shares in value added at current prices
"Agriculture" covers agriculture, forestry and fishing;
"Industry" comprises the production industries (including electricity, gas, and water), mining and quarrying and construction;
"Services" comprise market services and non-market services.

Source (for table on previous page): UNECE (2003)

Appendix 3.5

Country of origin	Thousands of metric tons							
	1995	1996	1997	1998	1999	2000	2001	2002
Saudi Arabia	1 114	384	1 810	3 346	8 042	8 545	7 219	7 364
Iran	11 014	9 301	9 238	6 757	5 824	7 414	5 718	6 239
Nigeria	-	-	971	287	1286	842	1 246	3 615
South Africa	-	-	403	649	493	689	524	791
Kuwait	577	2 863	2 589	2 094	833	858	431	342
Russia	-	-	255	305	-	-	-	267
Angola	122	910	127	-	389	48	382	138
United Arab Emirates	520	765	387	897	300	758	734	70
Yemen	353	299	216	354	-	140	475	62
Oman	120	131	91	313	71	-	610	8
Egypt	1 024	1 046	343	-	-	292	-	-
Gabon	-	-	-	-	-	-	373	-
Iraq	-	-	943	413	137	-	343	-
Mexico	-	-	589	633	244	-	-	-
North Sea / U.K.	1 394	541	327	-	18	-	-	-
Qatar	-	-	137	345	-	76	130	-
Venezuela	-	-	127	787	-	-	-	-
Other	197	186	-	-	-	-	-	-
Total	**16 435**	**16 426**	**18 553**	**17 180**	**17 637**	**19 662**	**18 185**	**18 896**

Sources of Crude Oil for SAPIA members: 1995 – 2002.

Note: Only figures from 2000 onwards include SASOL's imports, as SASOL joined SAPIA during 2000. SAPIA accounts for virtually all crude oil imports into South Africa.

Source: SAPIA, 2003.

Appendix 4: Further Notes.

Appendix 4.1

The Washington Consensus

The original list of reforms, with commentary by John Williamson, who coined the phrase 'Washington Consensus.'.

1. **Fiscal Discipline**. This was in the context of a region where almost all countries had run large deficits that led to balance of payments crises and high inflation that hit mainly the poor because the rich could park their money abroad.
2. **Reordering Public Expenditure Priorities**. This suggested switching expenditure in a progrowth and propoor way, from things like nonmerit subsidies to basic health and education and infrastructure. It did *not* call for all the burden of achieving fiscal discipline to be placed on expenditure cuts; on the contrary, the

intention was to be strictly neutral about the desirable size of the public sector, an issue on which even a hopeless consensus-seeker like me did not imagine that the battle had been resolved with the end of history that was being promulgated at the time.
3. **Tax Reform**. The aim was a tax system that would combine a broad tax base with moderate marginal tax rates.
4. **Liberalizing Interest Rates**. In retrospect I wish I had formulated this in a broader way as financial liberalization, stressed that views differed on how fast it should be achieved, and—especially—recognized the importance of accompanying financial liberalization with prudential supervision.
5. **A Competitive Exchange Rate**[2]. I fear I indulged in wishful thinking in asserting that there was a consensus in favor of ensuring that the exchange rate would be competitive, which pretty much implies an intermediate regime; in fact Washington was already beginning to edge toward the two-corner doctrine which holds that a country must either fix firmly or else it must float "cleanly".
6. **Trade Liberalization**. I acknowledged that there was a difference of view about how fast trade should be liberalized, but everyone agreed that was the appropriate direction in which to move.
7. **Liberalization of Inward Foreign Direct Investment**. I specifically did not include comprehensive capital account liberalization, because I did not believe that did or should command a consensus in Washington.
8. **Privatization**. As noted already, this was the one area in which what originated as a neoliberal idea had won broad acceptance. We have since been made very conscious that it matters a lot how privatization is done: it can be a highly corrupt process that transfers assets to a privileged elite for a fraction of their true value, but the evidence is that it brings benefits (especially in terms of improved service coverage) when done properly, and the privatized enterprise either sells into a competitive market or is properly regulated.
9. **Deregulation**. This focused specifically on easing barriers to entry and exit, not on abolishing regulations designed for safety or environmental reasons, or to govern prices in a non-competitive industry.
10. **Property Rights**. This was primarily about providing the informal sector with the ability to gain property rights at acceptable cost (inspired by Hernando de Soto's analysis).

Source: From a paper commissioned by Fundación CIDOB for a conference "From the Washington Consensus towards a new Global Governance," Barcelona, September 24–25, 2004 (Williamson J, 2004).

Appendix 4.2

WHO Definition of DALY and YLD.

DALYs / YLDs definition

Definitions:

YLDs = Years Lived with Disability

DALYs = Disability Adjusted Life Years
The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability.

Source: (WHO, 2005)