



Sustainable Energy Watch  
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## Energy and Sustainable Development in the Republic of South Africa



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### **Summary of Report**

South Africa's energy sector is not sustainable as preliminary data would indicate. Prospects for progress are limited given the present global socio-political climate where global laws and standards are generally not enforced. South Africa's greater emphasis on economic development as compared to environmental and social sustainability further hinders any meaningful advancement.

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## Preface

This report covers the region South Africa, which lies on the southern tip of Africa. The South African mainland is between 22 and 35 degrees south of the equator, and between 17 and 32 degrees east of the Greenwich Meridian.

The data for this report has been sourced mainly from various statistics and reports related to the indicators in this report. The information has been sourced from South African entities as well as international sources.

The main difficulty encountered was in finding updated data, especially in relation to indicator 2 (local pollutant) as there has not been an organisation consistently monitoring and recording air pollution throughout South Africa. For this indicator, the city of Cape Town's data is used as a proxy for the national picture.

Summary details of the calculations deriving the indicators are in the appendix at the end, while further details are in the separate spreadsheet file used to make calculations for this report.

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## Executive Summary

South Africa's energy sector is on the whole not sustainable as the results in Table 2 show. The areas in which South Africa shows sustainability is in household access to electricity (indicator 3), energy vulnerability (indicator 5), and public burden of non-renewable energy investments (indicator 6). For these three indicators South Africa scores significantly less than 1. The results for the indicators concerning local pollutants (indicator 2), investment in clean energy (indicator 4), and renewable energy deployment (indicator 8), show marginal non-sustainability. These three indicators score around 1. The indicators show a rather serious non-sustainability in the areas of carbon emissions (indicator 2) and energy intensity (indicator 7). These indicators score at close to, or greater than 2.

Prospects for improvement in the indicators for South Africa exist. In terms of indicators 6, 7 and 8, better scores can be achieved through interventions, including policy to: make the transport and telecommunications sectors more efficient.

Indicators 1, 2, 4, 6, 7 and 8 would be improved by more focused and augmented measures to increase clean energy investment, including renewable energy deployment and energy efficiency measures. Among the measures that could help achieve the increase are an attractive guaranteed feed-in tariff for particularly private generators of renewable energy, and the adoption of a challenging, binding national renewable energy deployment target. These measures could be supported through subsidies, finance schemes, awareness programmes.

Prospects for further progress are to an extent limited given the present global socio-political climate, where global laws and standards are generally not enforced, and with it South Africa's greater emphasis on economic development as compared to environmental and social sustainability. It is suggested that a global legislative framework on sustainable energy practices, and practices to protect the environment in general, would make it easier for individual countries to pursue a sustainable path.

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## General Discussion of South Africa

South Africa covers a land area of 1,219,090 square kilometres (Statssa, 1999). Only 12% of this land area is classified as arable (CIA, 2005).

The population of South Africa stands at almost 47 million according to the mid-2005 estimate (Statssa, 2005) and has an annual population growth rate of 0.9% per year (Statssa, 2005). As of mid-2005, the population concentration was estimated to be at approximately 38 people per square kilometre (Statssa, 2005) and (Statssa, 1999). This, as is the case with most African countries, is relatively low by world standards.

The gini coefficient for South Africa is among the highest (therefore among the worst) in the world. The 2003 Human Development report for South Africa reports that gini coefficient for South Africa for 2001 was 0.635 (on 0 to 1) having increased from 0.596 in 1995 (UNDP, 2004).

Industry, transport and telecommunications infrastructure, as well as energy supply infrastructure, are well established in South Africa. South African oil refineries refine approximately 500,000 of crude per day and previously state-owned SASOL operates plants which achieve coal-to-liquids and a gas-to-liquids conversion. There are 10 large base-load coal fired power stations, and a 1.8 GW nuclear power station in operation, and some peaking power stations, all meeting a peak load demand in the order of 36 GW in 2005. Three additional power stations that were decommissioned due to excess supply in the past are undergoing re-commissioning.

Among the effects of globalisation on South Africa has been the loss of jobs in the textile industry, which continued to shed jobs in 2005 (DTI, 2005). However, the car industry, with government's help through the Motor Industry Development Programme (MIDP) has continued to do well domestically and internationally, mining of platinum has been growing, and refined aluminium and coal exports are strong. State-owned petroleum enterprise Petrosa, and the private entities SASOL and Energy Africa, have done well internationally. South African mobile (cellular phone) network operators have benefited from opportunities in various countries in the rest of Africa, where they have significant shareholding in many of the mobile phone operators.

**Table 1: Profile of South Africa**

Indicator	Value
Human Development Index (and ranking)	0.658, rank 120 (2003)
Human Poverty Index (and ranking)	30.9%, rank 56 (2003)
Environmental Sustainability Index (and ranking)	Score 46.2, rank 93
GHG Emissions	CO2 Emissions of 318 Mt (2003)
GDP and GDP per capita	GDP (yr2000US\$ PPP) = \$ 447.91 billion (2003); GDP/capita (yr2000US\$ PPP) 9,773 US\$(2000)PPP/capita (2003).
Gini coefficient	0.635 (2001)

Sources: HDI Rank (UNDP, 2005), Human Poverty Index (UNDP, 2005), Environmental Sustainability Index (Yale University, 2005), GHG Emissions (IEA, 2005), GDP and GDP per capita (IEA, 2005a), Gini coefficient (UNDP, 2004).

## Overview of National Sustainable Development (SD) Strategy

The South African government has not enunciated a clear, unified sustainable development strategy. There is a strong emphasis on economic development projects and achieving economic growth, which is manifested, for example, in institutional realities. The Department of Environmental Affairs and Tourism (DEAT) has undertaken a few projects to promote sustainable development, including environmental management and monitoring. However, the DEAT budget is significantly lower than that of the Department of Trade and Industry (DTI). The resource imbalance has implications on the ability to pursue, for example, environmental protection. One case that illustrates this negative outcome for sustainable development is the South African government's intervention to promote motor vehicle manufacture in South Africa through the Motor Industry Development Programme (MIDP). There has not been an equally successful programme to make public transport more attractive to the average South African.

Another example in South Africa is the favourable electricity supply contracts given to an aluminium smelter in South Africa, which the state-owned electricity utility is facing difficulty in renegotiating as electricity prices head upwards in order to fund new generation capacity. Effects of having established the aluminium smelter through a favourable electricity tariff include the possibility that other customers will have to subsidise the aluminium producer, as well as the difficulty South Africa will have in trying to move away from (financially) cheap coal-based electricity.

In the energy sector, the Department of Minerals and Energy (DME) has produced two significant policy papers that outline South Africa's sustainable development approach. They are the Energy White Paper (Department of Minerals and Energy, 1998) and the White Paper on Renewable Energy (Department of Minerals and Energy, 2003). Within

these documents, it clear that the DME prioritises energy security, but sees fossil fuel (coal) as important in contributing to this security. The low (financial) cost of power from coal is also seen as important. The DME has also begun to engage in integrate energy planning, publishing documents which reflect this pursuit.

DEAT has also established a policy foundation for its work in managing and monitoring the environment, including the Air Quality Bill (DEAT, 2004).

The Department of Water Affairs and Tourism (DWAF) is responsible for securing and protecting the country's water resources, which are very important to South Africa's sustainability. This department has established a policy framework with documents such as the National Water Resource Strategy (DWAF, 2005).

## Other Energy-Related Developments

It is foreseen that South Africa's electricity demand will surpass supply, at the estimated date of 2007, if more generating capacity is not added. Eskom, the state-owned utility is therefore investing in the re-commissioning of power stations that had previously been taken offline due to excess generating capacity. The expenditure associated with this re-commissioning will raise the cost of electrical power in South Africa, thus raising the value of indicator 6 (the burden of non-renewable public energy investments). The planned expenditure by Eskom to increase capacity is R110 billion over 5 years starting in 2005 (National Treasury, 2005).

South Africa is involved in developing Pebble Bed Modular Reactor (PBMR) technology, a nuclear technology and therefore promising lower carbon emissions. PBMR also promises a nuclear weapons proliferation-free technology. However, the problem of nuclear waste that must be stored for a very long time remains.

The natural gas pipeline from Mozambique, feeding South African gas-to-liquids industry as well as various industries and domestic use sectors, is now online and will contribute to a lowering of the emissions intensity figure for South Africa. There have been other natural gas finds on the west coast of South Africa and Namibia, which have not yet been exploited.

The ratification of the Kyoto protocol by Russia in late 2004 has paved the way for a possible stricter enforcement of that treaty. South Africa's high greenhouse emissions per capita (about twice the global average), make South Africa economically vulnerable if emissions controls are enforced on developing economies in the second commitment period.

Parts of South Africa such as the Western Cape region are predicted to be highly vulnerable to climate change. Climate swings, such as the drought

of 2004 could, if severe enough, start to influence the choice of energy source away from fossil fuels.

Southern African countries are working together to harness the large hydro-electricity resources in the western Democratic Republic of Congo (DRC). A power line system will be built from the DRC through Angola to supply countries including Angola, Namibia, Botswana and South Africa. To achieve this end, the power utilities of these countries have established a joint venture company called WESTCOR (Western Corridor) (BPC, 2005). Initially, 3500 MW will be transmitted southwards along the power corridor, while the total potential of Inga falls is estimated total of at least 40 GW, and could thus contribute greatly to electricity power supply in Africa.

## Results for South Africa

The results of the indicator survey are summarised in the table below.

**Table 2: South Africa's Indicator Results**

Indicator Description	Unit	Data Points		Parameters			Results	
		X(current)	X(1990)	W(reference)	Y(goal)	Z	I(current)	I(1990)
1) CO2 emissions	kgC/cap	1,893	2,205	1,130	339	791	1.964	2.359
2) Ambient pollutants	µgr/m3	34	33	33	3.3	29.7	1.034	1.000
3) Access to electricity	%	69.0	35.0	0.0	100.0	-100.0	0.310	0.650
4) Investments	%	0.85	0.53	0.53	95.00	-94.47	0.997	1.000
5) Vulnerability	%	7.33	10.49	100.0	0.0	100.0	0.073	0.105
6) Public sector investment	%	0.57	0.64	10.00	0.00	10.00	0.057	0.064
7) Energy productivity	MJ/\$	17.01	20.50	10.64	1.06	9.58	1.665	2.029
8) Renewables	%	11.10	5.38	8.64	95.00	-86.4	0.972	1.038

Sources : Indicator 1 ( IEA, 2005a), indicator 2 (City of Cape Town, 2003), indicator 3 (Eberhard and Van Horen, 1995 and NER, 2004), indicator 4 (financial reports from Eskom, SAPIA companies, CEF, SASOL, etc, see APPENDIX section III), indicator 5 (mainly DTI and SARB, see APPENDIX section III), indicator 6 (CEF, Eskom and SARB, see APPENDIX section III), indicator 7 (IEA, 2005a), indicator 8 (IEA, 2005c). All calculations are explained in section III of the appendix.

The latest data for evaluation for the indicators is from the years shown in the following table:

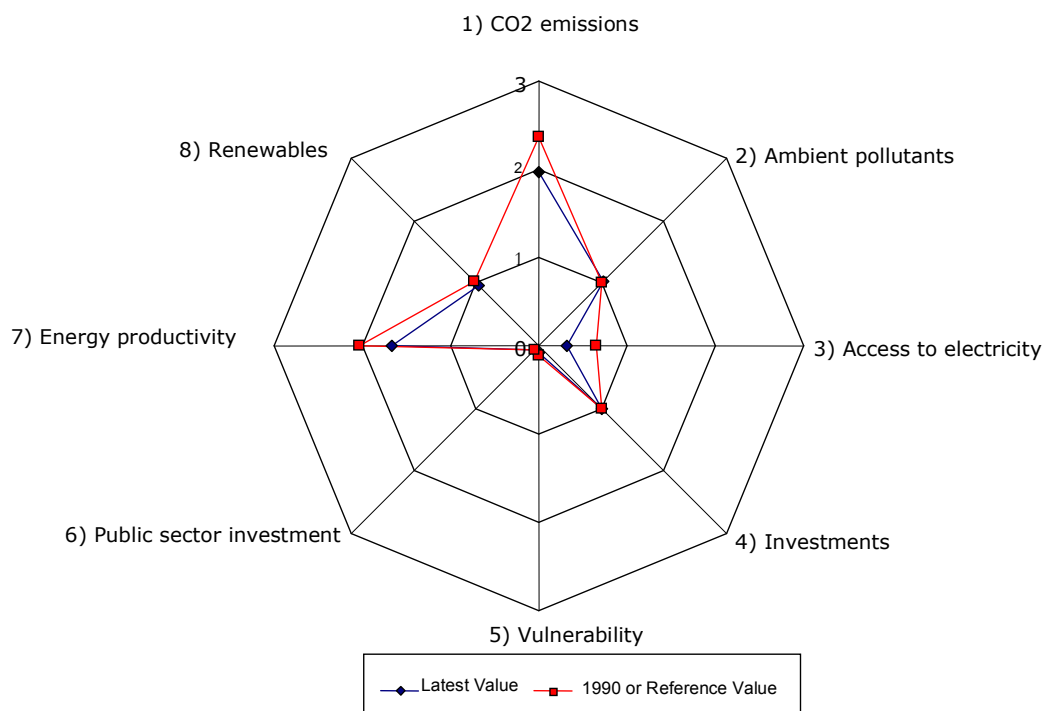
Indicator	Year of Evaluation
1. Carbon Emissions	2003
2. Ambient pollutants	2002
3. Access to Electricity	2003
4. Renewable energy investments	2004
5. Trade vulnerability	2004
6. Public sector investments	2004
7. Energy productivity/intensity	2003
8. Renewable energy deployment	2003

The results of the survey of the indicators shows that South Africa’s energy sector is mostly not sustainable. Indicator 1 is the least sustainable, with a latest indicator value of about 2. Indicator 7 is also quite unsustainable, with latest indicator values at about 1.4. Indicators 2, 4 and 8 reflect average unsustainability, with values close to 1, while indicators 3, 5 and 6 show good sustainability.

Indicator 3 is fairly close to sustainability at 0.31 and has shown a great improvement since 1990. This improvement can be seen in the star plot for South Africa's indicator's below. Indicator 4 has shown little improvement since 1990 as there has been virtually no sizeable investment in clean energy in South Africa. Indicator 6 shows a small improvement on the 1990 value.

South Africa’s Star for the indicators is shown below.

**Figure 1: South Africa's Star Plot**



Source: values same as those in table 2.

## Analysis of Indicator Results

Of these indicators, the ones with new data (from 2003) from the International Energy Agency ((IEA, 2005a) and (IEA, 2005b) seem to have improvements that may be due to data methodology rather than actual improvements in the energy sustainability of South Africa.

### Indicator 1: Carbon Emissions

According to the IEA (IEA, 2005a), the carbon emissions per capita for South Africa for 2003 continue to be high, at 1,893 kgC/capita compared to 1,130 kgC/capita, the world 1990 average. A major reason for high carbon emissions is the fact that South Africa is endowed with huge reserves of coal on which previous governments decided to build large coal-fired thermal power plants. These are positioned almost exclusively in the Mphumalanga province, East of the industrial hub, Gauteng province where Johannesburg is located. These power plants now offer low-cost electricity to consumers, making it difficult to change to another technology. The environmental cost of the power plants, however, has not been quantified.

### Indicator 2: Local Pollutants

The local pollutants indicator shows little change according to the data used (from City of Cape Town air monitoring stations). The level of the pollutant selected (PM10) remains fairly constant between the year of first data (1995) and the latest survey year (2002). The main contributors to air pollution in the major population centres are industry and transport (City of Cape Town, 2003), while in parts of the Mphumalanga Province mainly, the exhaust fumes from the coal-fired power stations. In the parts of Cape Town with the poorer households, such as Khayelitsha, domestic use of low quality fuels such as firewood and coal for cooking and space heating make PM10 a major problem, both indoors and outdoors. This problem is typical of many urban areas of South Africa. For this reason, PM10 has been chosen.

In future, it will be easier to monitor this indicator for more areas of South Africa, and for a wide variety of pollutants. In January 2004, air monitoring stations were launched in Durban, as part of a national programme by the Department of Environmental Affairs and Tourism (Department of Environmental Affairs and Tourism, 2004).

### Indicator 3: Household Access to Electricity

This indicator shows a marked improvement in the period from the early 1990s because the state-owned electricity utility (Eskom) launched its 'national electrification programme' in late 1990 as the South African

political climate began to change during the fall of Apartheid (Van Horen C, 1996). It set out to electrify 2.5 million homes by the year 2000 - and achieved it (Van Horen C, 1996). The electrification rate for 2003 stood at 69.0%. As the electrification programme has continued, the electrification rate has decreased as the additional connections become less accessible.

#### **Indicator 4: Investment in Clean Energy**

Investment in clean energy was 0.85% of all energy sector capital investments in 2004, according to the data used in this report. This indicator is not changing much for the same reasons as those discussed in the discussion of indicator 1 above (low cost coal-based energy). The investments in clean energy noted for 2004 include a number of sources. The Eskom amount is estimated at R150million (included in what Eskom classified as 'environmental accounting' in its 2005 annual report). This Eskom expenditure, which is targeted, for example, at cleaning pollutant emissions and raising energy conversion efficiency, is included because it achieves the same effect as energy efficiency. EDC (the Energy Development Corporation) of the CEF (Central Energy Fund) made investments in clean energy, estimated at R10 million. Private sector investments in renewable energy, mainly in the form of solar PV (photovoltaic), solar water heating and wind pumping, but these are difficult to quantify. There is also the investment in biomass-based energy production in sugar milling, and would most probably not approach R50million. All these investments were dwarfed by total investments in energy (R23.4 billion), so that they only accounted for 0.85% of it.

There is some interest in South Africa, however, in both the public and the private sector, for renewable energy. In the absence of policy encouraging renewable energy investments, renewable energy investments will not grow rapidly.

An improvement in this indicator would require, among other interventions, a guarantee of the ability to sell renewable energy into the South African electricity grid, financing mechanisms (eg for solar water heaters, biogas production and solar PV), and easily accessible subsidy schemes where these would be seen to be favourable. A programme to increase awareness of the need to make greater use of renewable energy should also positively affect this indicator.

#### **Indicator 5: Vulnerability to Energy Trade**

Of all South African exports, only 7.33% (DTI, 2005 and SARB, 2005) were non-renewable energy exports, indicating that South Africa shows little vulnerability to energy trade and therefore good sustainability. South Africa exports coal in large quantities. While this is under threat due to climate change targets of annex 1 countries, especially as 60% of South Africa's coal exports go to the EU (Coaltrans, 2005), the indicator shows that South Africa would have other exports to rely on for foreign income.

There is, however, a scenario under which the obligations of annex 1 countries would cause greater medium term damage to the South African economy (to the benefit of the global environment). Such a scenario is if obligations to reduce greenhouse emissions promote activities such as material recycling on a large scale, reducing the need for minerals, which South Africa exports in large quantities.

### **Indicator 6: Burden of Non-Renewable Energy Sector**

This indicator shows a value of 0.57% (of a nominal GDP of R1,257 billion) in 2004 is lower than the 1990 value of 0.64% (of a nominal GDP of R289.8 billion) (SARB, 2005). This is due partly to the fact that Eskom, the state-owned utility paid off the loans on its large power station during the 1990s, leaving the utility without major capital expenditure. There is bound to be an increase in the burden of non-renewable energy expenditure by the state, as Eskom increases its capacity and replaces ageing infrastructure to the tune of R110 billion, as already mentioned earlier in the review 'other energy related developments'.

### **Indicator 7: Energy Intensity**

This indicator has normally shown little or no improvement on the 1990 value (Spalding-Fecher, 2002). There is a noticeable improvement in this report, showing an energy intensity of 17.01 MJ/(yr2000)US\$PPP, as compared to 20.5 MJ/(yr2000)US\$PPP for the 1990 value and 22 MJ/(yr2000)US\$PPP for the 2000 value (Spalding-Fecher, 2002). A look at how representative the results are, is discussed below in the section 'indicator considerations for South Africa'. The value of 14.4MJ/(2000)US\$PPP is still significantly higher than the 1990 world average of 10.64 MJ MJ/(2000)US\$PPP.

An important factor in this indicator is that South Africa is moving away from mining and manufacturing as mainstays of the economy. The rate at which it is moving is questionable. Hindrances here include inefficiencies which contribute to high cost in the transportation of people and goods and in telecommunications. An improvement in transportation and telecommunication efficiency would help to increase the size of the services sector in the South African economy, thereby lowering the energy intensity.

### **Indicator 8: Renewable Energy Deployment**

The 2003 value of the indicator is 0.972, corresponding to a renewable share of TPES (Total Primary Energy Supply) equal to 11.1%. The renewable energy deployment indicator has shown little improvement. The 2003 improvement of the renewable energy percentage of TPES by about 100% over the 2000 value of 4.4%, and the 1990 value of 5.38%, is not consistent with the energy sector situation in South Africa, and can be

seen as related to sources of data. If the IEA values are closer to the true picture, however, it could reflect a historical (over the past 15 years) error in the way the calculation has been done. The renewable energy data is acknowledged to be approximate.

It seems that this indicator will not improve much in the near future. This is due in a large part to the reasons stated in the analysis of indicator 1 above. There is little prospect of immediate improvement in this indicator, due to the fact that the medium term energy plan for South Africa, as outlined in the Energy White Paper of 1998 (Department of Minerals and Energy, 1998) and the White Paper on Renewable Energy (Department of Minerals and Energy, 2003) puts more focus on development than sustainability through renewable energy, and foresees coal as the main fuel of electricity provision for the medium term. Eskom is embarking on increasing its coal-based power production capacity, as discussed in the section on indicator 6 above.

In addition, petroleum-based fuels have virtually no medium term replacement. Ethanol and other biofuels have not been sufficiently developed, and it is also doubtful that the farming land can be found to replace the present consumption. A further escalation of the crude oil price (at about US\$65 in January 2005) would necessitate an improvement in mass public transport systems if South Africa is to remain sustainable and competitive. Such a move could improve the renewable energy contribution through lowering the contribution of liquid petroleum-based fuels.

## Conclusions and Policy Recommendations

This report shows that South Africa's energy sector is fairly sustainable in a number of sectors such as energy vulnerability (indicator 5), public sector investments (indicator 6) and access to electricity (indicator 3). Indicators 2 (local pollution), 4 (investment in clean energy) and 8 (renewable energy deployment) are unsustainable to an extent approximately equal to the definition of the unsustainability reference for those indicators. Indicators 1 (carbon emissions) and 7 (energy intensity) are unsustainable to an extent equal to about twice their respective unsustainability references. The results generally show that South Africa has a way to go before achieving sustainability on most fronts.

There is much that South Africa can do to promote environmental and social sustainability. Present policies are much more in favour of short to mid-term economic sustainability. A number of crises in the present situation present opportunities for the implementation of sustainable energy policies and the general pursuit of a more sustainable energy path.

Initiatives to improve the situation could include improving the transport infrastructure for transportation of people and goods, including public transport as well as infrastructure for non-motorised transport. Such transport initiatives would most certainly improve indicators 1 (carbon

emissions), 4 (investment in clean energy), 7 (energy intensity) and 8 (renewable energy deployment). If such an intervention were successful, improvement in indicator 8 would be as a result of a decrease in the amount of fossil-based transport fuels used, while the renewable energy amount at the least remained unchanged.

A second possible way to improve the indicators would be to improve the efficiency in the telecommunications sector. The indicator that would be most improved by this intervention is indicator 7 (energy intensity), as unlocking economic activity previously stifled by high telecommunications costs would result in greater economic productivity. At present, the way to achieve this goal is seen as the introduction of competition for Telkom, the land-based-telecommunications monopoly up until now. The second land telephone network operator was licensed at the end of 2005, and was scheduled to begin services around mid 2006. The interaction between the two land-based telecommunications entities will need to be monitored to prevent a situation whereby they collude, for example through differentiated product offerings that make it difficult for customers to compare pricing, while keeping prices high. Such is perceived to be the present climate in the South African banking sector for example. Another case of failed competition is the case of the mobile phone network operators in South Africa, which are said to charge unreasonably high rates which are the subject of a review process (CUASA, 2005).

Encouraging clean energy investments, in the form of energy efficiency and renewable energy would be crucial to improving indicators 1, 2, 4, 6, 7 and 8. Ways of achieving this goal include guaranteed access to the grid as a place to sell renewable energy - such a scheme has been in use in Germany (EPIA, 2005), where there is a feed-in tariff for solar photovoltaic energy, making it attractive for private homes to install solar photovoltaic cells on their roofs. Other possible interventions include financing mechanisms for renewable energy investments, subsidies where these would have a clear mid to long term benefit, and funded awareness programmes to educate on the necessity of shifting to renewable energy. The setting of renewable energy targets by the government is another way that promises to advance renewable energy deployment. There are already more than 30 countries with renewable energy targets, as reported by the IEA (IEA, 2005b). These are high income countries as well as some middle income countries. While many of the targets are modest, the targets will no doubt help to establish the technologies. South Africa has a non-binding target in the White Paper on Renewable Energy (Department of Minerals and Energy, 2003), set at only 4% contribution to final energy consumption by 2013, which would be of greater benefit if made binding.

At a global level, promoting energy efficiency, renewable energy and sustainable energy framework in general would be much facilitated by a move to a binding global legislative framework for pollutant emissions, such as the Kyoto protocol. Other interventions that should be critical include a trade framework that does not allow cost cutting at the expense of the environment. This approach is more in line with the policies of UNCTAD (United Nations Conference on Trade and Development), as

opposed to the more 'laissez-faire' policies of the WTO. These interventions would level the rules for commerce and development across the globe, so that entities in the global arena could not sacrifice sustainability for short-term progress.

## Indicator Considerations for South Africa

The availability of data from a particular source from year to year is invaluable in this exercise. This is clearly demonstrated here in the country energy balance required in indicator 8. The energy balance published previously by the DME of South Africa shows values lower than those published by the IEA (IEA, 2005c). The IEA values seem to also show a higher percentage of renewable energy deployment. This would indicate a different way of determining the share of renewable energy as the change is significant, from 4.4% compared to 11.1%) over a few years (2000 to 2003) when there were seemingly no significant developments that would change in the South African energy mix. In the case of indicator 7, the IEA values show greater energy productivity, which is probably the result of differing methodology. In the previous report (Spalding-Fecher, 2002), quoting South African 2001 values from the DME and the SARB, the values showed a much lower energy productivity at about 22 MJ/(yr2000)\$PPP, compared to the latest IEA value for 2003 (IEA, 2005a), of 14.4 MJ/(yr2000)\$PPP.

There are a number of inadequacies which come up from country to country, which the indicators cannot capture. In the case of South Africa, indicator 3 (access to electricity) will give information on household access to electricity, but not say much about the state of the electricity infrastructure or quality of electricity supply service. In the case of Johannesburg, South Africa, the adequacy of the electricity distribution equipment has not been desirable, and there have been a high number of power outages (City of Johannesburg, 2005). In the case of Cape Town, South Africa, the long-distance high voltage power lines from the main power generation units over 1000 km away in Mphumalanga province have become inadequate in capacity to carry a larger electrical energy load from a sufficient supply to a willing purchasers of that energy. More power lines are required. The result in Cape Town has also been power outages, especially when there has been re-fuelling or other stoppage problems at the regions primary power plant, Koeberg nuclear power station.

## Appendix

### Selection and Calculation of the Indicators

#### Indicator Selection

SUSTAINABLE ENERGY WATCH (SEW) has created a baseline set of indicators from which to infer progression towards or regression from energy-related sustainability. By concentrating on feasible, policy-relevant, energy-related indicators at the intersection of economic, social, technological and environmental sustainability this tool can deliver a usable set of goals and measurements to citizens and decision-makers alike. However, important as the indicators are, they are only carefully chosen statistics and merely give one part of the story. The most interesting contribution of the reports prepared by SEW comes from the qualitative personal assessment given by the observer-reporters in each country. Indeed this is the component that generates the greatest added-value in the SEW reports.

Several criteria have guided the selection of SEW's indicators:

Each indicator must:

- be clearly definable, simple to understand, and easily communicated to citizens and decision-makers alike;
- be relevant to actual or anticipated policies;
- reflect an important aspect of the social, economic, environmental, or technological elements of the energy system;
- measure something of obvious value to observers and decision-makers; and,
- have durability and long-term relevance.

The underlying metric —the actual measurement or statistic used— must be generally available for most, if not all, countries. This combines measurability, data availability, and achievability; in other words, data collection and vector calculation must be do-able;

If calculation is required to derive an indicator, it must be simple to do;

The indicator set as a whole is indicative of a country's and the world's progress towards energy-related sustainability; and

Improvement in an indicator's measurement is indicative of genuine progress toward an energy system that sustains and improves human health and happiness.

The aim of this indicator set is to be applicable to the current energy situation in a given country and to highlight what is pertinent and achievable. SEW has selected eight indicators. Each indicator has been chosen because it reflects an underlying and measurable value; ultimately an indicator value should be as small as possible, reflecting a smaller footprint, i.e. impact.

SEW has determined this set of "sustainability objectives," not so much as absolute goals—for nobody knows what a sustainable goal really entails—but to act as a series of benchmarks. It is better to be approximately right than precisely wrong.

## **Overview of SEW Indicators**

### *Indicators for Environmental Sustainability*

- Indicator 1 - Per capita energy sector carbon dioxide emissions

Global environmental impact is measured by carbon dioxide (CO<sub>2</sub>) emissions per capita. Each nation's per capita emissions will be compared to the 1990 global average. The long term objective is a convergence towards a reduction of seventy percent of global emissions (Intergovernmental Panel on Climate Change - IPCC).

- Indicator 2 - Most significant energy-related local pollutant(s)

Selecting the indicator for the most significant local environmental pressure is done by SEW local observer-reporters. It is necessary to choose a pollutant that strongly impacts local human or environmental health, i.e. impacting human respiratory, reproductive, and immune systems, negatively effecting forestry, lakes and rivers, agriculture, domestic animals, fisheries, or infrastructure etc. Such pollution sources are frequently related to industry, mining, fuel refineries, manufacturing, or electric power plants. Non-point pollution sources such as vehicles often pose the greatest hazard to health and are often difficult to mitigate. If information is available their emission rates could be used. The objective is a nine-tenth reduction of the selected pollutant(s).

### *Indicators for Social Sustainability*

- Indicator 3 - Households with access to electricity either through the transmission grid or by stand-alone systems

Access to electricity is considered a social good; it helps spread literacy and education, it contributes to improved health through the refrigeration of medicines, and to increased communication and awareness. While western standards of electric consumption need not be adopted, access to some level of affordable power is appropriate.

- Indicator 4 - Investment in clean energy (a proxy for employment)

Several studies show that investment in clean energy—renewable energy and energy efficiency—create more jobs and generates faster growth than comparable investment in conventional energy. For this social indicator new employment in clean energy projects could be measured, e.g. employment in cleaning up conventional energy projects through the installation of pollution control equipment or the reclamation of mined areas or wetlands restoration etc. However, comprehensive data on employment gains are not available in most countries. SEW has therefore

selected a substitute indicator for which data are generally available: investment in renewable energy and energy efficiency.

#### *Indicators for Economic Sustainability*

- Indicator 5 - Energy resilience: energy trade benefits

Many countries are highly dependent on imported fuels for transportation, heating, cooling and lighting of buildings and electric power generation. The threat of supply interruption is real, primarily for unforeseeable political reasons but also due to pipeline accidents, system vulnerabilities, embargoes, terrorism, and civil strife. The more universal threat is price fluctuations that can destabilize both importing and exporting nations. The development of improved extraction technologies and new discoveries of reserves have led to increased fossil fuel supplies that have out-paced consumption. Indeed, contrary to price forecasts, energy prices have declined strongly in real terms since the mid-1970s. The latest international problems brought about by disruption of supplies, e.g. war in the Middle East, hurricanes, however have recently raised the price of fuels significantly.

Separate metrics have to be selected for import-dependent and export-dependent countries. In order to provide an incentive for net energy importers without discouraging imports of renewable energy, imports of non-renewable energy are measured as a fraction of non-renewable energy consumption.

Importing countries can improve sustainability by reducing either imports or consumption of non-renewables or increasing imports or consumption of renewable energy.

- Indicator 6 - Burden of public energy investments

This indicator compares government investment in non-renewable energy supply to total Gross Domestic Product (GDP) as a measure of the burden of energy development on the economy. The primary purpose of this indicator is to measure the level of public funds in the energy supply sector and to provide incentives for investment in cost-effective renewable energy supplies and end-use efficiency. Government enterprises and deals with private entities tend to shift scarce resources into capital-intensive buys. Such investment should either be decreased or shifted to the private sector, or both should occur.

#### *Indicators for Technological Sustainability*

- Indicator 7 - Energy intensity (energy consumption/GDP)

This indicator measures each nation's progress towards increasing the level of economic activity per unit of energy consumed. Many nations already track such progress and the World Bank, United Nations, International Energy Agency and the OECD publish periodic comparative reports. However, this simple calculation is complicated by a number of

factors. The available data compare economies with widely different geography, economic development, climate and levels of industrialisation. Some sources compare indices of energy efficiency, e.g. fuel economy of personal vehicles, others compare specific sectors, e.g. industrial energy use per dollar of industrial output, while others aggregate the nation's economy. Only consumption of commercial energy is typically counted, thus ignoring large quantities of "traditional" fuels such as wood, charcoal, bagasse, and other biomass fuels used in many countries. A consistent definition of what is meant by economic output is not clear-cut either; the convention of counting GDP output at current exchange rates works better for comparing industrialised countries than developing nations. In the latter cases, purchase power parity (PPP) accounts of GDP are more appropriate.

- Indicator 8 - Renewable energy deployment

Global use of renewable energy is growing faster than the use of fossil fuels and electricity. Globally, wind power capacity is increasing annually. The use of photovoltaic cells—semiconductor devices that turn solar radiation directly into electricity—is expanding nearly as fast as wind power. Fossil fuels and nuclear power—heavily subsidised and politically favoured for decades—still generate a large fraction of the world's electricity. Yet the market is changing, as is political and popular support. Renewable costs are falling and are becoming more competitive even without counting the multiple benefits of clean, environmentally superior power. India, Germany, and Denmark are now leading the world in installed wind power capacity.

## Calculation of Indicator Values for South Africa

The indicators cover the following aspects:

*environmental*

- CO2 emissions per capita (global pollution)
- ambient energy-related emissions (local pollution – PM10 in this case)

*social*

- guaranteed access to electricity
- investments in clean energy

*economic*

- energy resilience
- burden of public energy investments

*technological*

- energy intensity
- renewable energy deployment

Two indicators are used for each aspect of sustainability.<sup>1</sup> The selected indicators are presented followed by examples. In order to observe the

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<sup>1</sup>Sometimes it is necessary to use more than one parameter to calculate an indicator, as in the case with Indicator 2. In this instance, the final indicator value will be the average of two intermediary indicators.

progression of indicator 1990 is to be used as the reference year.<sup>2</sup>

### Indicators for Environmental Sustainability

#### *Indicator 1 – Per capita energy sector carbon dioxide emissions*

Parameters

X = emissions for current year and those for 1990

W = 1130kgC/capita (world average for 1990)

Y = 339 kgC/capita (3/10 the world's average for 1990)

Z = 791 kgC/capita

Equation:  $I = (X - 339) / 791$

Calculation:

South Africa 2003

X = 1893 kg of carbon emitted per capita (IEA, 2005a)

**Indicator value "I"** =  $(1893 - 339) / 791 = 1.964$

1990 value for South Africa is from (IEA, 2003)

#### *Indicator 2 – Energy-related local pollutant*

Parameters

X = selected pollutant for current year and for 1990

W = 1990 value

Y = 1/10 of 1990 value

Z = W - W/10 = 9W/10

Equation:  $I = (X - 0.1W) / 0.9W$

Calculation:

South Africa 2002 – single pollutant (micrograms of PM10 per m<sup>3</sup> of atmospheric air). This indicator is used because PM10 is a serious cause of illness in the form of upper respiratory illness, mostly among poor households cooking and space heating with low quality fuels, especially indoors.

Data source: (City of Cape Town, 2003).

X(2002) = 34 micrograms per m<sup>3</sup>.

<sup>2</sup> Signatories countries to the Kyoto Protocol agreed to limit their greenhouse gas emissions, relative to the levels emitted in 1990

$W = 33$  micrograms per  $m^3$ , corresponding to 1995, the earliest recorded value for the data set, used in place of 1990 value (as change in value with time is small).

$Y = 3.3$  micrograms per  $m^3$  (equal to 1/10 of 1990 value)

$Z = 33 - 3.3 = 29.7$  micrograms per  $m^3$ .

**Indicator value "I"**  $= (34 - 3.3) / 29.7 = 1.034$

### Indicators for Social Sustainability

#### *Indicator 3 – household access to electricity*

Parameters

$X$  = percentages of households who have access to electricity in current year and in 1990

$W = 0\%$  of households that have access to electricity

$Y = 100\%$  of households have access to electricity

$Z = -1$

Equation:  $I = (X - 100\%) / -1$

Calculation:  
South Africa

69.0% of households have access to electricity (2003).  
Data from (NER, 2004).

**Indicator value "I"**  $= (69.0\% - 100\%) / -1 = 0.310$

The 1990 value for household access to electricity has been estimated at 35% (Eberhard and Van Horen, 1995).

#### *Indicator 4 – Investments in clean energy*

Parameters

$X$  = the ratio between investment between clean energy investment and the total investment in the energy sector

$W$  = the value of  $X$  in 1990

$Y = 95\%$  of energy sector investment

$Z = W - 95\%$

Equation:  $I = (X - 95\%) / (W - 95\%)$

Calculation:

South Africa, 2004

South Africa invested a total of R0.2billion in clean energy (source of data below, after calculation). It invested a total of R23.444 billion in energy infrastructure.

$W = 0.04885 \text{ billion Rand} / 9.149 \text{ billion Rand} = 0.53 \%$  (Using 1998 as the 1990 reference).

$X (2004) = 0.2 \text{ billion Rand} / 23.444 \text{ billion Rand} = 0.85\%$

$Y = 95 \%$

$Z = 0.53\% - 95\% = -94.47\%$

**Indicator value "I"**  $= (0.85\% - 95\%) / -94.7\% = 0.997$

2004 value from (Eskom, 2005), (SASOL, 2005), (SAPIA, 2005), (CEF, 2005), (estimate from COM, 2003).

1998 value from (Eskom, 2001), (SAPIA, 2002), (SASOL, 2002), (COM, 2002), (Spalding-Fecher, 2002).

## Indicators for Economic Sustainability

### *Indicator 5 – Energy resilience*

Parameters - country that is a net importer of energy

$X$  = ratio between imports of non-renewable energy and the consumption of non-renewable energy (in Joules)

$W = 100\%$

$Y = 0\%$

$Z = 1$

Equation:  $I = (X - 0\%) / 1 = X$

Parameters - country that is a net exporter of energy

$X$  = ratio between the export of non-renewable energy and the value of all exports (in monetary value)

$W = 100\%$

$Y = 0\%$

$Z = 1$

Equation:  $I = (X - 0\%) / 1 = X$

Calculation:

South Africa (a net exporter of energy), 2004

Exports of coal and petroleum oils in 2004 were, according to DTI (DTI, 2005), R15.788 billion and R6.984 billion respectively, making a total of R22.72 billion. The total exports, according to the South African Reserve Bank (SARB, 2005) were R310.525 billion in 2004.

$X = 22.72 / 310.5 = 0.073$

$W = 100\%$

$Y = 1$

$Z = 1$

**Indicator value "I"**  $= 0.073 / 1 = 0.073$

For 1990 value, use earliest recorded (1994), Spalding-Fecher (2002)

*Indicator 6 – Burden of energy investments*

## Parameters

X = ratio between public investment in non-renewable energy and GDP

W = 10%

Y = 0%

Z = 0.1

Equation:  $I = (X - 0\%) / 0.1 = 10X$

## Calculation

South Africa 2004

State-owned entities in South Africa spent R7.956 billion on energy infrastructure (CEF, 2005) and (Eskom, 2005). The nominal GDP of South Africa in 2004 was R1,386.7 billion (SARB, 2005).

Dividing 7.956 billion Rand by the GDP =  $7.956/1,386.7 = 0.00574$  or 5.74%

**Indicator value** "I" =  $10X = 10 \times 0.00574 = 0.0574$

1990 value from (Eskom 2003) and (Spalding-Fecher 2002)

**Indicators for Technological Sustainability***Indicator 7 – Energy productivity (energy consumption/GDP)*

## Parameters

X = ratio between energy consumption and GDP

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

Y = 1.06 MJ/euros which corresponds to 1/10 W

Z =  $10.64 - 1.06 = 9.58$

Equation:  $I = (X - 1.06) / 9.58$

## Calculation

South Africa 2003

South Africa's energy productivity according to (IEA, 2005a) is 14.39 MJ/(2000)US\$ (calculated from 0.26 toe/(2000)US\$).

**Indicator value** "I" =  $(14.39 - 1.06) / 9.58 = 1.391$

1990 value from South African Reserve Bank Quarterly Reports, Department of Minerals and Energy (SA).

*Indicator 8 – Renewable energy deployment*

## Parameters

X = ratio between renewable energy consumption and total primary energy consumption

W = 8.64% which corresponds to the ratio between global consumption of renewable energy and total global consumption of primary energy for 1995

Y = 95%

Z = 8.64% - 95% = -0.8636

Equation:  $I = (X - 95\%) / -0.8636$

## Calculation:

South Africa, 2003.

According to the IEA (IEA, 2005c) South Africa consumed 4,979,772 TJ of primary energy, of which 552,720 TJ was supplied by "renewables", primarily biomass.

The proportion of renewable energy is  $X = 552,720 / 4,979,772 = 0.1110$  or 11.10%

**Indicator value "I"** =  $(11.1\% - 95\%) / (-0.8636) = -0.8390 / -0.8636 = 0.9715$

1990 value (using 1993 value) is from (Department of Minerals and Energy, 2000).

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