

# Energy policies for sustainable development in South Africa

Harald Winkler

Energy Research Centre, University of Cape Town, Private Bag Rondebosch 7701, South Africa  
E-mail: Harald.Winkler@uct.ac.za

*This paper summarises the results of a study that analysed ways of making South Africa's future energy development more sustainable. The South African economy is comparatively energy-intensive, with total primary energy supply of 11.7 MJ per US\$ of GDP on a purchasing power parity basis, compared to 7.9 MJ/\$ for Asia and 6.7 MJ/\$ for Latin America. Moreover, the high dependence on coal makes the country also very carbon-intensive, with energy related CO<sub>2</sub> emissions of 6.7 tonnes per capita, comparable to the OECD average of about 11 tCO<sub>2</sub> /cap., and far higher than the non-OECD average of 1.7 tCO<sub>2</sub>/cap. Important policy initiatives are already under way to improve energy efficiency as well as the share of renewable energy.*

*The impact of different energy policies, including alternative technologies for both supply and demand up to 2025, were analysed using the Markal model, a least-cost optimising tool. The reference case is close to the government's Integrated Energy Plan, with CO<sub>2</sub> emissions increasing from 337 million tonnes (Mt) in 2001 to 591 Mt in 2025. A cost-effective renewable energy policy scenario would increase the renewable electricity generation from 2,000 GWh in 2001 to almost 18,000 GWh in 2025, with significant contribution from solar thermal and biomass cogeneration technologies. Energy efficiency can make a substantial contribution, especially in industry. The combination of measures would reduce total energy system costs by 16 billion rands (\$ 2.2 billion) and CO<sub>2</sub> emissions by 770 Mt, each over a 25-year period. The policies analysed here can therefore contribute both to sustainable development and to climate change mitigation.*

## 1. Introduction

As the 21st century begins, South Africa faces important challenges in its energy development path. On the one hand, the challenges of development are urgent. Basic services need to be provided to large parts of the population, notably black people previously disadvantaged by apartheid. Delivering clean water, housing, sanitation and basic energy services are a formidable challenge.

On the other hand, environmental concerns pose a challenge to the way in which energy is used and supplied. South Africa's energy economy is largely dependent on coal, leading to high levels of CO<sub>2</sub> emissions relative to the size of the population and economy.

The challenge examined in the research project underlying this article is whether there are energy policies that will make South Africa's energy development economically, socially and environmentally more sustainable. Or in other words, how can energy policies for sustainable development become an approach to mitigating climate change.

## 2. A brief energy profile of South Africa

South Africa has a relatively energy-intensive demand sector. Demand for energy was historically dominated by mining, an energy-intensive sector [Fine and Rustomjee, 1996]. Under the democratic government after 1994, the focus shifted from supply to addressing demand, and par-

ticularly broadened to include household access to electricity and making energy services more affordable for the poor.

Energy consumption has contributed primarily to industry, mining and transport, as shown in Figure 1. Industrial demand has been the major source of recent increases in energy demand across all energy carriers. Some growth can be seen in the transport sector, while energy use in mining declined slightly towards the end of the past decade.

Although energy demand has shifted towards manufacturing and services, the availability of comparatively cheap energy – especially electricity – has led to its inefficient use. Table 1 shows how national energy intensities varied in the recent past, according to government statistics.

Compared to other middle-income developing countries, South Africa's energy intensity is relatively high. In 2004, total primary energy supply (TPES) per unit gross domestic product was 11.7 MJ/\$ (2000 US\$ on a purchasing power parity basis), compared to 7.9 MJ/\$ for Asian and 6.7 MJ/\$ for Latin American countries [IEA, 2006].

South Africa's relatively high energy intensity makes the more efficient use of energy particularly important. Important energy policy initiatives are already under way with respect to energy efficiency and renewable energy. Government and business have agreed on an "energy efficiency strategy", setting a goal for an improvement in energy efficiency of 12 % by 2014 [DME, 2005a]. The

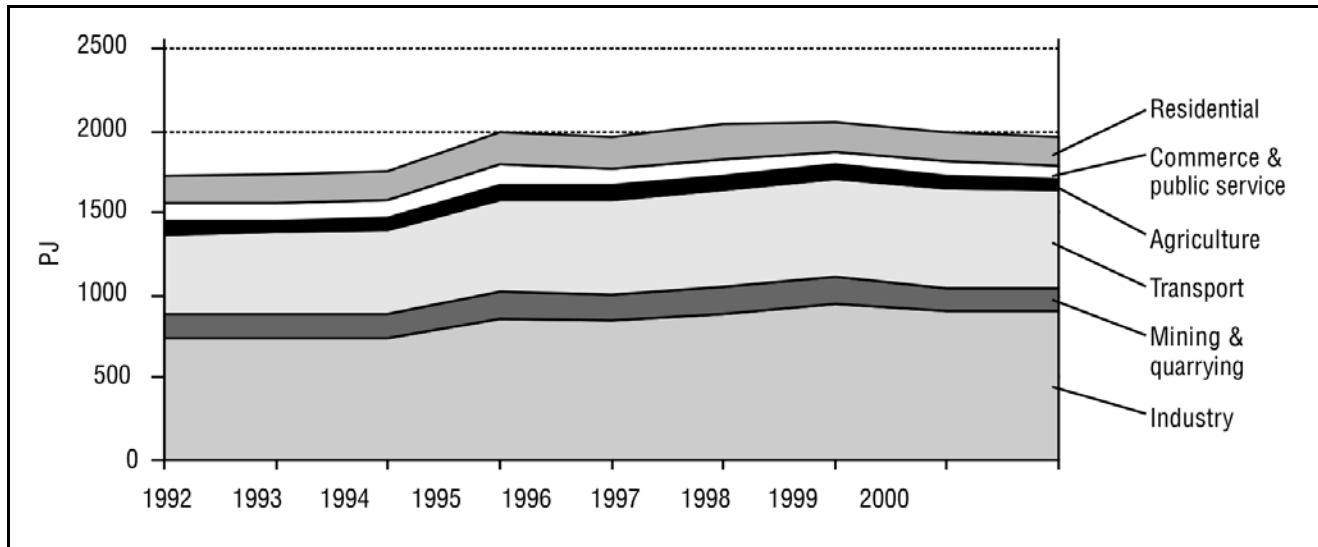


Figure 1. Energy demand by end-use sector, 1992-2000

Source: Based on data in energy balances [DME, 2002]

**Note**

The data displayed here do not include consumption of renewable energy and waste, due to data uncertainties.

**Table 1. National energy intensities between 1993 and 2000**

		1993	1994	1995	1996	1997	1998	1999	2000
GDP – all industries at basic prices	R billion (constant 1995 prices)	472	486	500	521	534	538	549	571
Total final energy consumption (renewable and waste excluded)	PJ	1766	1789	2016	1996	2071	2098	2026	2003
Energy intensity (total energy consumption/GDP)	PJ/R billion	3.74	3.68	4.03	3.83	3.88	3.90	3.69	3.51

Source: DME, 2003b

**Note**

1 US\$ = 7.14 R (rand) as of January 2007, but in 1993 \$ 1 = R 3.27 and in 2000 \$ 1 = R 6.94. Please note that the energy intensities reported here, when converted by the market exchange rates quoted in this note, will differ from the figure reported in the main text on the previous page, which is based on purchasing power parity.

target is for energy consumption overall to be reduced in 2014 by 12 % below projected energy demand based on business-as-usual projections such as those in the electricity expansion plan [NER, 2004b]. For industry, the target is 15 %. In 2003, the government adopted a target of 36 PJ renewable energy consumption by 2013 [DME, 2003c]. A recent policy initiative on biofuels may increase the contribution that biofuels make to the renewable energy target [DME, 2006]. Many interventions have been proposed and studied in detail and these suggest that it makes economic sense to promote end-use energy efficiency and demand-side management. A key policy question, which is examined here, is why greater efficiency is not realised.

About 70 % of total primary energy supply in South Africa derives from coal [DME, 2005b]. Coal-fired power-stations provide 93 % of electricity production [NER, 2004a]. Given its coal-based energy economy, South African is one of the highest emitters of greenhouse gases when compared to other developing countries, whether this is measured in emissions per person or per unit of GDP.

Since most projections indicate that coal will continue to be used for some time to come, finding ways of using fossil fuels in a cleaner way is important during the transition to different energy systems. Cross-cutting policy instruments, such as energy-environmental taxes, could play an important role in the future.

The excess electricity capacity, which characterised South Africa's energy profile in the past, has come to an end, and the country now needs to invest in new capacity. Figure 2 shows how excess capacity peaked and was declining in the 1990s. The electricity crises in the Western Cape in early 2006 [AEJ, 2006] brought home to many consumers the reality that electricity supply capacity is running short – and that electricity needs to be conserved and used more efficiently.

Coal-fired power plants provide base load through some new pulverised fuel plants, and also through fluidised bed combustion. Options that depart from business-as-usual are domestic supply alternatives (various renewable energy technologies and nuclear power) and increased electricity imports (hydroelectricity, and gas for

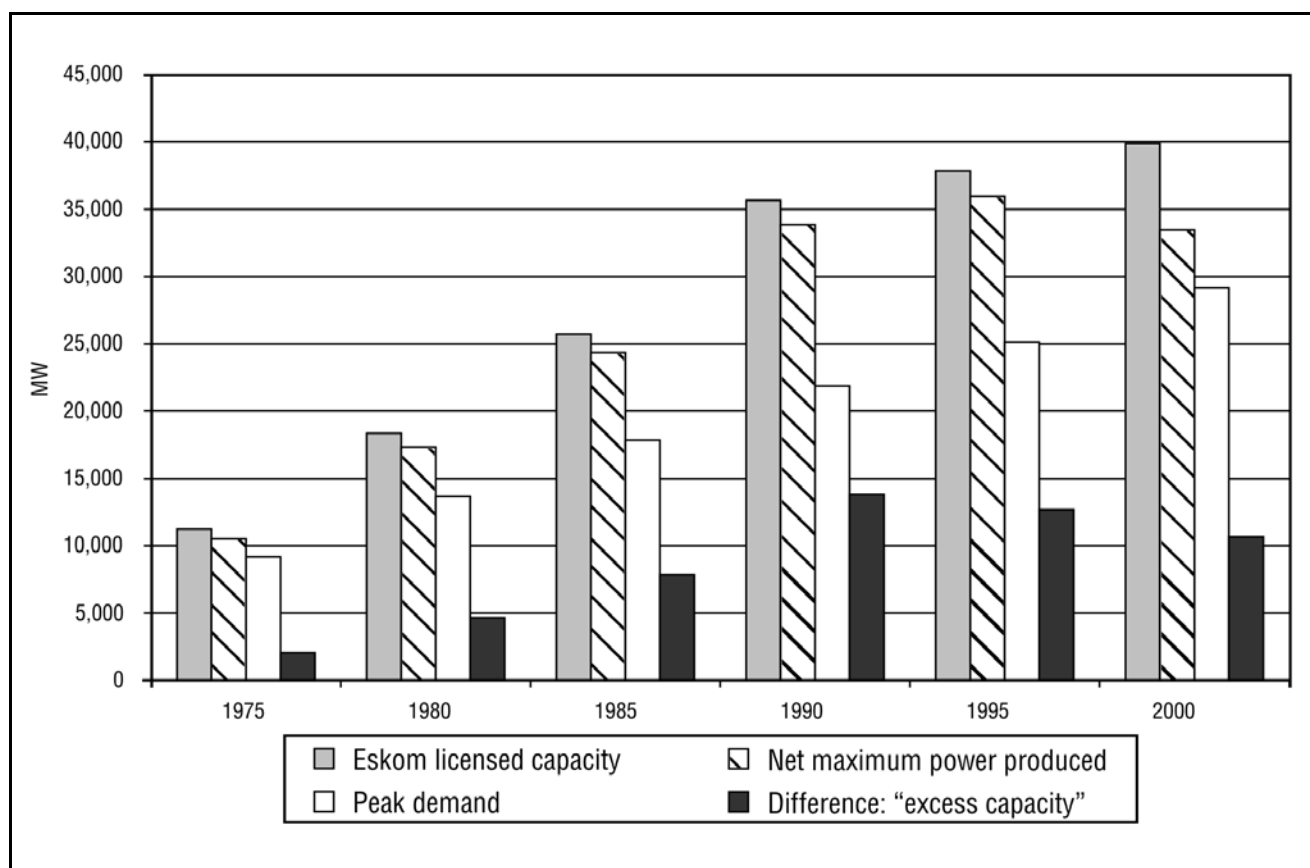


Figure 2. Licensed capacity and peak demand (MW) of the South African utility, Eskom  
Sources: Eskom 1987; 1996; NER, 2000

Table 2. Energy sector carbon dioxide emission intensity (per capita and per unit GDP) in 2002 and cumulative CO<sub>2</sub> emissions, 1950-2000

	CO <sub>2</sub> /cap	CO <sub>2</sub> /GDP	CO <sub>2</sub> /GDP PPP	Cumulative energy CO <sub>2</sub> emissions from 1950 to 2000	
	t/capita	kg/1995 US\$	kg/1995 PPP US\$	Mt CO <sub>2</sub>	Proportion of world total (%)
South Africa	6.65	1.65	0.75	10,165	1.29
Africa <sup>[1]</sup>	0.89	1.16	0.45	13,867	1.75
Non-OECD	1.65	1.33	0.45	318,117	40.23
OECD	10.96	0.44	0.56	472,635	59.77
World	3.89	0.68	0.56	790,753	100

Sources: IEA, 2004; WRI, 2003

**Note**

1. CO<sub>2</sub> includes emissions from fossil fuel use and cement. The small difference between cumulative emissions in South Africa and sub-Saharan Africa (including South Africa) is due to the large share of CO<sub>2</sub> emissions from land use, land-use change and forestry (LULUCF) in other African countries. Forestry in this context connotes activities that result in increasing CO<sub>2</sub> emissions, such as deforestation. Taking cumulative CO<sub>2</sub> from both energy and LULUCF from 1950 to 2000, Africa accounted for 53,652 Mt CO<sub>2</sub>, South Africa for 10,214 Mt CO<sub>2</sub> [WRI, 2003].

combined-cycle gas turbines). In the liquid fuel sector, options examined are the extension of refinery capacity and introduction of biofuels, which raise important policy questions regarding energy for sustainable development.

A major social aspect is access to modern energy services as a key goal. An important policy challenge is to make such access affordable for poorer households. Experience with the "poverty tariff" (which provides 50 kWh per month of free basic electricity for households) [DME,

2004; 2003a] raises important issues about the role of subsidies [UCT, 2002; Gaunt, 2005; Mapako and Prasad, 2005].

South Africa's profile in terms of greenhouse gas (GHG) emissions derives from the patterns of energy use and supply described above.

Its high emissions of CO<sub>2</sub> are due to its energy-intensive economy and high dependence on coal for primary energy. South African per capita emissions are higher than

those of many European countries, and four times the average for developing countries (see Table 2). This emissions profile poses a significant challenge in developing the energy sector, providing more affordable access to energy services, while contributing to climate change mitigation.

### 3. Scenarios of future energy policies and indicators of sustainable development

Against this background, a study conducted by the Energy Research Centre of the University of Cape Town considered possible energy futures for South Africa [Winkler, 2006]. A range of energy policies for the period 2000–2025 were modelled and the results are evaluated against energy indicators. The model used – the Markal model framework – is a least-cost optimising tool, rich in technologies and capable of including environmental constraints. The method of using indicators of sustainable development provides a sound means for policy-makers to identify synergies and trade-offs between options, and to evaluate their economic, social and environmental dimensions.

Using Markal, the authors analysed both demand-side and supply-side policies for their contribution to energy objectives and also to broader sustainable development goals. On the demand side, the policy options modelled covered the industry, commerce, residential and transport sectors; on the supply side, they covered electricity and liquid fuels. The types of policy instruments investigated include both economic and regulatory instruments.

The results show that the tools used in this analysis – a modelling framework combined with indicators of sustainable development – provide researchers and policy-makers with a useful way of examining trade-offs, while at the same time providing scope for compromise.

### 4. The reference case

The base reference case (“current development trends”) is close to the government’s Integrated Energy Plan [DME, 2003b]. For electricity, the second National Integrated Resource Plan (NIRP) [NER, 2004b] was used.

On the demand side, fuel consumption in industry and transport dominates, with transport growing most rapidly among all sectors.

On the supply side, the energy sources used to generate electricity consist of existing and new sources of coal, supplemented by both open-cycle and combined-cycle natural gas power plants and new fluidised-bed combustion using discard coal. Smaller contributions come from existing hydroelectric schemes and sugar-cane bagasse, electricity imports (from the Southern African Power Pool), existing and new pumped storage and interruptible supply<sup>[1]</sup>. The key characteristics of new power stations used in the study [Winkler, 2006] are shown in Table 3.

The supply of liquid fuel is met mostly from some expansion to existing refineries, together with a small proportion of imports of finished petroleum products. Just less than two-thirds of road transport fuel comes oil refineries (63 %), with the balance being supplied by

SASOL’s coal-to-liquids plant (30 %) and gas-to-liquids at PetroSA [Singh, 2006].

Emissions of both local and global air pollutants increase steadily in the reference case, over the period 2000–2025. Carbon dioxide emissions increase from 337 Mt CO<sub>2</sub> in 2001<sup>[2]</sup> to 591 Mt CO<sub>2</sub> in 2025 – an increase of 75 % over the entire period. Policy interventions are needed to move to a different energy development path.

### 5. Policies modelled

A set of energy policy cases was modelled and compared to the base case as shown below.

#### 5.1. Higher energy efficiency in industry

Industrial energy efficiency meets the national target of 12 % referred to above. This is achieved through greater use of variable speed drives, efficient motors, compressed air management, efficient lighting, heating, ventilation and cooling (HVAC) system efficiency, and other thermal saving. Achievement of this goal depends on forcefully implementing the policy, as is the case for efficiency in the commercial sector (discussed below).

#### 5.2. New commercial buildings designed more efficiently

HVAC systems are retrofitted or new systems have higher efficiency; variable speed drives are employed; efficient lighting practices are introduced; water use is improved, both with heat pumps and solar water heaters (SWHs). In addition to specific measures, fuel-switching for various end-uses is allowed.

#### 5.3. Cleaner and more efficient use of energy in the residential sector

Water-heating is provided through increased use of SWHs and geyser<sup>[3]</sup> blankets. The costs of SWHs decline over time, as new technology is accepted more widely in the South African market. More efficient lighting, using compact fluorescent lamps (CFLs), spreads more widely, with a further reduction in costs. The shells of houses are improved by insulation, prioritising ceilings. Households switch from electricity and other cooking fuels to liquified petroleum gas (LPG). Subsidies are required to make interventions more economic for poorer households.

#### 5.4. Biodiesel production increases

A key policy option regarding liquid fuels for transport is the supply of biodiesel to reduce high dependence on petroleum. In the underlying study, biodiesel production increases to 35 PJ by 2025, with a maximum growth rate of 30 % per year from 2010 [Winkler, 2006]. These energy crops do not displace food production, and sustainable production means the fuel is effectively zero-carbon. Subsequent to this analysis, the government has published a draft biofuels strategy, proposing an “average market penetration of 4.5 %, of liquid road transport fuels (petrol and diesel) in South Africa by 2013, which is achievable without excessive support by utilising surplus agricultural capacity” [DME, 2006]. The strategy derives the overall target by a combination of 8 % ethanol blended into petrol and 2 % biodiesel in diesel. Estimates by the Energy Development Corporation suggest that a slightly more ambitious target is possible for ethanol, up to a 10 % blend into petrol [Singh, 2006].

Table 3. Characteristics of new power plants used in the study

Type	Units of capacity (MW)	Investment cost, undiscounted (R/kW)	Fixed O&M cost (R/kW)	Variable O&M cost (c/kWh)	Life time (yr)	Lead time (yr)	Efficiency (%)	Availability factor (%)
<b>Coal</b>								
New pulverized fuel plant	642	9,980	101	1.1	30	4	35	88
Fluidised bed com-bustion (with FGD <sup>[1]</sup> )	233	9,321	186	2.9	30	4	37	88
<b>Imported gas</b>								
Combined-cycle gas turbine	387	4,583	142	11.5	25	3	50	85
Open-cycle gas turbine (diesel)	120	3,206	142	16.2	25	2	32	85
<b>Imported hydro</b>								
Imported hydro	9200 GWh/yr			2.1	40	6.5		
<b>Renewable energy</b>								
Parabolic trough	100	18,421	121	0	30	2	100	24
Power tower	100	19,838	356	0	30	2	100	60
Wind turbine	1	6,325	289	0	20	2	100	25, 30, 35
Small hydro	2	10,938	202	0	25	1	100	30
Landfill gas (medium)	3	4,287	156	24.2	25	2	-	89
Biomass cogeneration (bagasse)	8	6,064	154	9.5	20	2	34	57
<b>Nuclear</b>								
PBMR <sup>[2]</sup> initial modules	165	18,707	317	2.5	40	4	41	82
PBMR multi-modules	171	11,709	317	2.5	40	4	41	82
<b>Storage</b>								
Pumped storage	333	6 064	154	9.5	40	7	-	95

Source: [Winkler, 2006], drawing on [NER, 2004c]

**Notes**

1. FGD = flue gas desulphurization
2. PBMR = pebble bed modular reactor

*5.5. The share of renewable electricity increases*

The share increases to meet the target of 10 TWh by 2013. The shares of energy from solar thermal, wind, bagasse and small hydroelectric sources increase beyond the base case. New technology costs decline as global production increases.

The modelling did not prescribe *which* renewable energy technologies would meet this target. The portfolio of renewable energy technologies resulting from the analysis is shown in Figure 3. It can be seen that existing renewable energy sources – mostly small hydroelectricity and some bagasse – are supplemented initially, primarily by new biomass cogeneration plants, able to use both fossil fuel and biomass and generating electricity and heat. From 2011, some landfill gas is introduced, as well as the solar “power tower” or central receiver. The solar thermal trough technology was also made available to the model, but was not chosen due to its lower availability factor. Solar technology takes over a much larger share of the renewables supply towards the end of the period (2025)

as its costs become competitive.

*5.6. PBMR modules increase the capacity of nuclear energy production*

Nuclear capacity is increased to 4,480 MW by introducing 32 PBMR modules. Significant funds, both public and from Eskom, have been invested in the development of this technology. Costs decline with national production and initial investments are written off.

*5.7. An increase in imported hydroelectricity*

The share of hydroelectricity imported from the Southern African Development Community (SADC) region increases from 9.2 TWh in 2001, as more hydroelectric capacity is built in southern Africa.

*5.8. An increase in imported natural gas.*

Sufficient gas is imported to provide 5,850 MW of combined-cycle power plants, compared to 1,950 MW in the base case.

*5.9. Tax on coal for electricity generation*

The use of economic instruments for environmental fiscal reform is being considered by the national Treasury. The

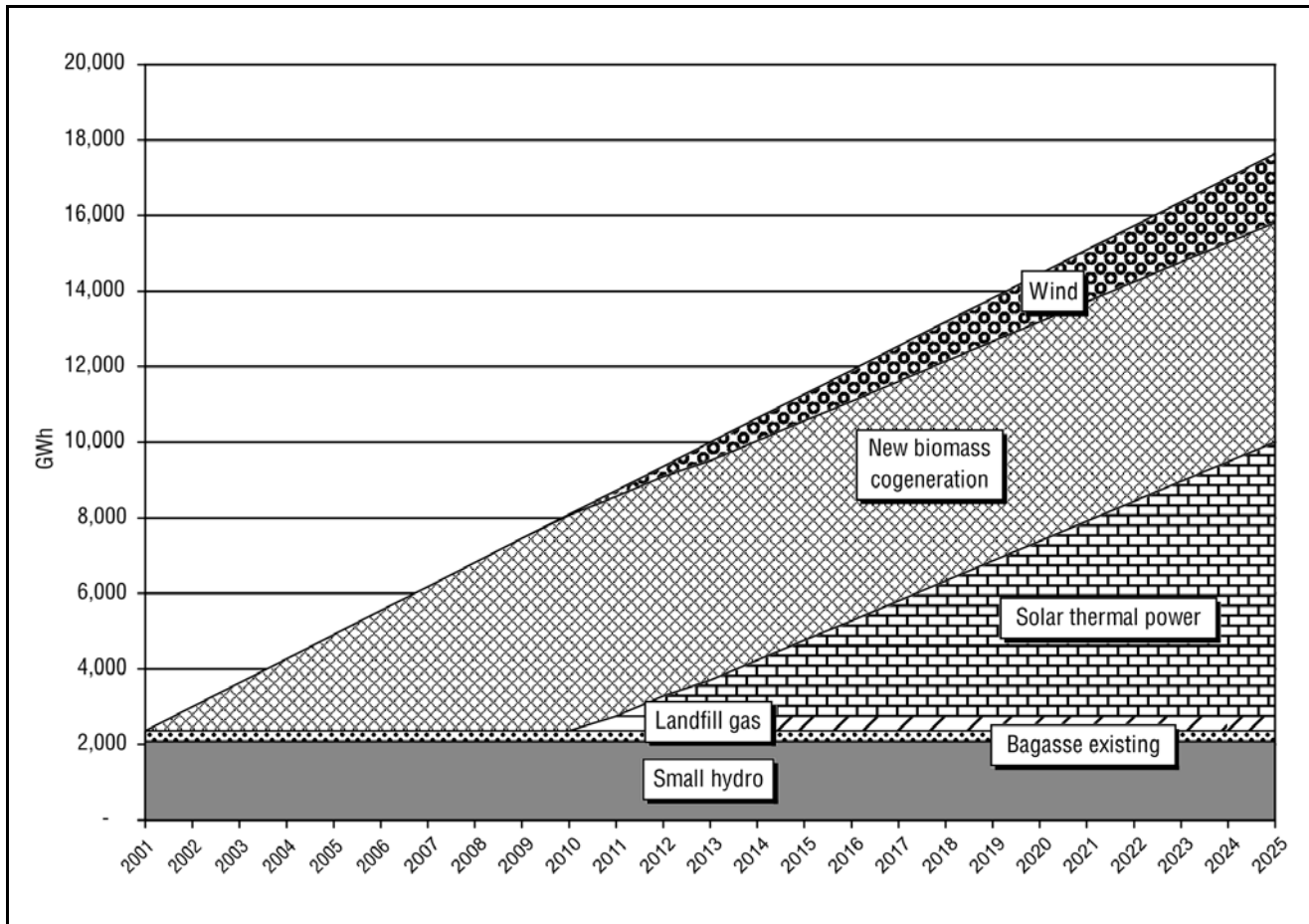


Figure 3. Renewable energy technologies for electricity generation in the policy case

option of a fuel input tax on coal used for electricity generation is analysed. Such economic instruments could be extended to coal for synthetic fuel (synfuel) production and industrial use. Alternatively, the environmental outputs could be taxed directly, e.g., in a pollution tax, although this is not analysed in this study.

## 6. Key results

On the demand side, energy efficiency policies were found to be particularly important. The overall strategy of reducing final energy demand by 12 % can be implemented most effectively in the industrial sector. Industrial energy efficiency is effective both in lowering the cost of the energy system<sup>[4]</sup> by R 18 billion over 25 years, and in reducing CO<sub>2</sub> emissions and local air pollution. Carbon dioxide emissions are reduced by 770 Mt CO<sub>2</sub> over 25 years. Greater efficiency has benefits in delaying the need for investment in power stations, with new base-load power stations postponed by four years, and peaking power plant by three years.

### 6.1. Higher energy efficiency in industry

Realising the potential for industrial energy efficiency requires forceful and determined, even aggressive, implementation. Current practice is often not economically optimal and clear signals are needed to induce industry to invest in options that must be shown to make financial sense. The agreement between industry and government

to implement the energy efficiency strategy [DME, 2005a] and the recent announcement that a dedicated Energy Efficiency Agency is to be established bode well in this regard.

Figure 4 shows some of the efficiency measures modelled and provides a sense of the contribution that each can make to the overall 12 % reduction in final energy demand. A 12 % reduction in energy consumption by 2025 is equivalent to 116 PJ (32 TWh).

### 6.2. New commercial buildings designed more efficiently

A strong legal and institutional framework is needed for the commercial sector. The modelling suggests that a 12 % energy efficiency target is achievable and can save R 13 billion over 25 years. However, the results also suggest that the cost of optimal energy efficiency improvements are 2-3 % lower than the 12 % of the government target and that these savings thus come at a cost (which works out at about 5 % of investment costs). Buildings last longer, so that energy savings are relatively small in a short time-frame, until the large savings potential in new buildings can take effect. The government can play an important role here by taking the lead in making its own buildings and practices more efficient.

### 6.3. Cleaner and more efficient use of energy in the residential sector

The residential sector is particularly important for social sustainability. A sustainable development approach aims to deliver services that meet basic human needs, but in a

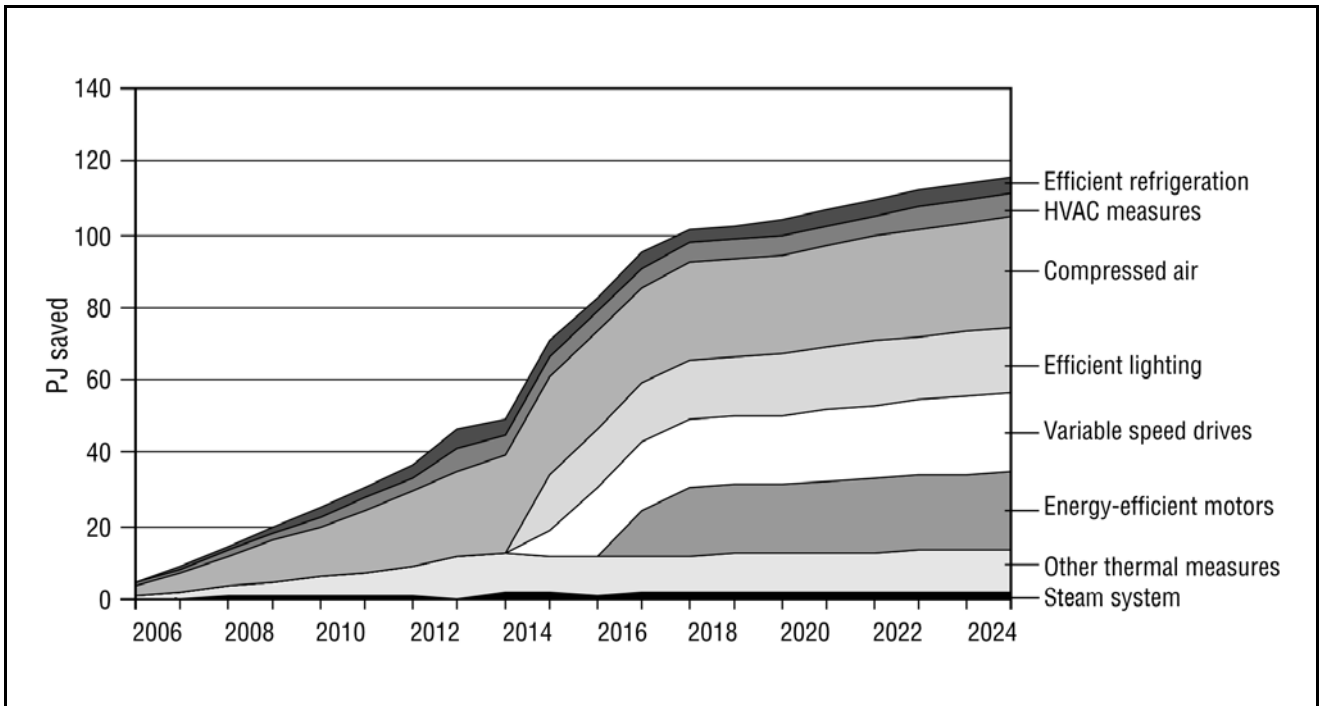


Figure 4. Electricity saved by energy efficiency technology. HVAC refers to heating, ventilation and air conditioning systems; other thermal measures to a variety of energy management options.

cleaner and more efficient manner that can be sustained in the long term. The policy interventions that are modelled focus on end-uses – solar water heaters and geyser blankets, and CFLs for lighting. Making social housing more energy-efficient through simple measures, such as including insulation in ceilings, should be adopted as a general policy.

All policy cases assume near-universal electrification, and in the residential case we find that the share of other commercial fuels (LPG and paraffin) also increases. Overall fuel consumption, however, is lowered compared to the base case (8.13 PJ less in 2025), because of increasing efficiency and the use of solar energy for water heating. Not all interventions are used by all household types – for example, energy-efficient houses are only taken up by urban higher-income electrified households. The lower costs of geyser blankets – both upfront costs and costs per unit of energy saved – suggests that they are appropriate policy interventions in poor electrified households.

Access to energy in physical terms needs to be accompanied by affordability in economic terms. The findings suggest that a relatively small subsidy can make energy efficiency interventions economic for poorer households. The order of magnitude of the once-off subsidy required to make efficient housing as affordable for poorer households as for richer ones is less than R 1000.

#### 6.4. Supply-side measures

On the supply side, four policy cases focused on electricity supply – imported natural gas, imported hydroelectricity, generating electricity domestically from PBMR nuclear, and renewable energy technologies. A sustained move towards greater diversity requires more than a single technology option or energy source.

#### 6.5. An increase in imported hydroelectricity and imported gas

Imported hydroelectric power potentially reduces investment costs, but increases the share of imported energy as a percentage of total primary energy supply (TPES). Imported gas increases the share of imports, while making little difference to total energy system costs.

#### 6.6. PBMR and renewable energy options

The PBMR case with imported fuel (uranium in prepared “pebbles”) also shows an increase of imported energy reaching 4.3 % of TPES in 2025. Renewable energy technologies perform better, although they too include a substantial proportion of imported components. Investing in the PBMR and renewable energy options increases the costs of the energy system, while imported gas has a much smaller effect, and hydroelectricity imports actually reduce costs. While the increased costs for both the PBMR and renewables are only 0.06 % of the costs of the energy system, they nonetheless amount to over R 3 billion over the period. In unit costs (R/kW of new capacity), gas is significantly cheaper than other options, followed by a mix of renewable energy technologies, hydroelectricity and the PBMR. These options show quite substantial emission reductions – 246 Mt CO<sub>2</sub> for the PBMR and 180 Mt CO<sub>2</sub> for renewable energy technologies, both over the 25-year horizon. Both reduce local pollutants, notably sulphur dioxide, by 3 % and 1.6 % respectively.

#### 6.7. Biodiesel production

The potential to produce 1.4 billion litres (Gl) of biodiesel was modelled to start in 2010 and reach a market share of 9 % of transport diesel by 2025. Moving to biodiesel production can avoid an average of 4,500 barrels/day (1 barrel = 146 kg approximately) of oil-refining capacity can be avoided. Total reduction in CO<sub>2</sub> reaches 5 Mt CO<sub>2</sub>

per annum in 2025 and the cumulative savings are 31 Mt CO<sub>2</sub> for the entire period. There are also reductions in local pollutants. The present value of the total system cost for this scenario is R 2.4 billion higher than for the reference scenario.

6.8. Tax on coal for electricity generation

The results for a tax on coal for electricity generation show that the reductions of CO<sub>2</sub> emissions from coal for electricity generation are small relative to the reference case. The economic difference lies less in system costs (R 67 million over 25 years) and more in the tax revenues. These revenues, while imposing added costs on producers, could also generate economic benefits if recycled. More detailed analysis of this policy option is required,

for instance possibly extending the tax to coal for synfuels and industry, and quantifying the indirect economic effects of tax recycling and the impacts on other policy objectives.

6.9. Emission reductions

Table 4 summarises the potential for reducing emissions of South Africa’s primary GHG, carbon dioxide. Consistent with the descriptions above, it can be seen that major opportunities to reduce emissions (compared to the base case) exist in greater industrial efficiency, as well as electricity supply. Since this analysis was conducted, the government has indicated that it may build a second synthetic fuel plant, in addition to the existing SASOL plant at Secunda. The existing plant generates some 50 Mt CO<sub>2</sub> per year, so that finding alternatives to this will require more detailed investigation in future.

Table 4. CO<sub>2</sub> emissions in the base case, and emission reductions for different policy cases (Mt CO<sub>2</sub>)

	2001	2005	2015	2025
Base case	350	389	492	596
Biodiesel		0	-1	-5
Commercial		-1	-5	-12
Industry		0	-28	-44
Gas		0	-5	-12
Hydroelectricity		0	-13	-17
PBMR nuclear		0	-7	-32
Renewables		-3	-7	-15
Residential		0	-1	-4
Fuel tax		0	-2	-2

If combined, the emission reductions achieved by all the policies analysed here add up to 50 Mt CO<sub>2</sub> by 2015 and 142 Mt CO<sub>2</sub> for 2025, which amounts to 14 % and 24 % of the projected base-case emissions respectively. One important conclusion is that significant emission reductions (“avoided emissions”) compared to business-as-usual are possible.

The climate change mitigation effect of all policies combined is shown in Figure 5. However, this should be understood together with a second conclusion, which is that stabilising emissions levels (e.g., at 2010 levels) would require some *additional* effort from 2020 onwards. Projected emissions in 2025, even with the above policies, are still slightly above the levels in the base year.

7. Conclusions

Over the 25-year time-frame considered here, energy

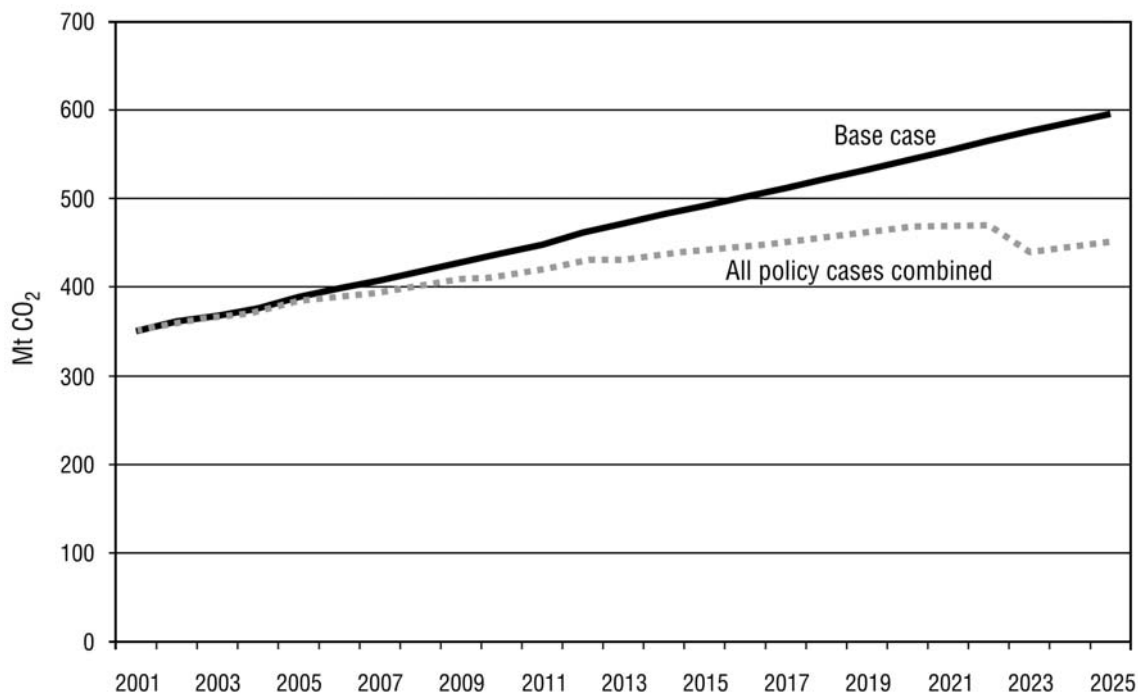


Figure 5. CO<sub>2</sub> emissions for base case and with emission reductions from all policy cases combined



efficiency makes the greatest impact when seen against indicators of sustainable development. Industrial efficiency, in particular, shows significant savings in energy and costs, with reductions in air pollution. Commercial energy shows a similar pattern, although on a slightly smaller scale. Residential energy efficiency is particularly important for social sustainability. Even small energy savings can be important for poorer households. In the short term – the 2006 to 2015 decade – we can conclude that energy efficiency will be critical to making South Africa's energy development more sustainable.

In the longer term – the next several decades – transitions which include the supply side will become increasingly important. To achieve greater diversity there will need to be a combination of policies, since single policies on their own will not change the share of coal in TPES by very much. The various alternative electricity supply options show potential for significant emission reductions and improvements in local air quality. However, they will require a policy of careful trade-offs in relation to energy system costs, energy security and diversity of supply.

The global costs (discounted total energy system costs) for the combined scenario are lower than for the base case by some R 16 billion over the full 25-year period (2000-2025). Thus, the savings due to the combined efficiency measures more than justify the additional costs of investing in a diversified electricity supply.

The policies analysed here can make energy development more sustainable. A portfolio of policies in the residential, commercial, transport and industrial sectors could be combined with interventions in electricity supply and refineries. This would provide a mix that provides, overall, a durable balance of economic development, social sustainability, and both local and global environmental benefits. Much of what is good for sustainable development in the national energy system also has global benefits in mitigating climate change. Energy policies that meet local sustainable development objectives are a promising approach for South Africa to make a contribution to climate change mitigation. ■

### Acknowledgements

This article summarises a much more detailed study conducted at the Energy Research Centre on energy policies for sustainable development [Winkler, 2006]. The inputs to the longer work by several contributors are gratefully acknowledged, as is the support for the research project by the United Nations Department of Economic and Social Affairs (UNDESA) and the second phase funded by the International Atomic Energy Agency (IAEA). Contributors to the longer study were Ogunlade Davidson, Harald Winkler, Andrew Kenny, Gisela Prasad, Debbie Sparks, Mark Howells and Thomas Alfstad, with contributions from Stanford Mwakasonda, Bill Cowan and Eugene Visagie. The reports were edited into a single publication by Harald Winkler, and language-edited by Robert Berold and Mindy Stanford. It is downloadable at [www.erc.uct.ac.za/publications/Energy%20policies%20for%20SD.pdf](http://www.erc.uct.ac.za/publications/Energy%20policies%20for%20SD.pdf).

This article is the responsibility of the author, and any remaining errors are his responsibility. It does not claim to represent the views of any organisation.

### Notes

1. Interruptible supply agreements allow Eskom to interrupt power to some customers, in exchange for a lower tariff. Customers make their own plans for back-up power.
2. The base-year number is fairly close to the CO<sub>2</sub> emissions reported in the Climate Analysis Indicator Tool [WRI, 2005] for 2000 – 344.6 Mt CO<sub>2</sub>. It is somewhat higher than the 309 Mt CO<sub>2</sub> from fuel combustion reported in the Key World Energy Statistics for 2001 [IEA, 2003].

3. Storage-type electric water heater. Geyser blankets refers to thermal insulation around storage tanks which reduce thermal losses from the water heater.
4. "Costs of the energy system" refer to discounted total energy system costs.

### References

- A EJ (African Energy Journal), 2006. "Western Cape power debate", *African Energy Journal*, 8(5), pp. 18-19.
- DME (Department of Minerals and Energy), 2002. *South Africa National Energy Balance 2000*, Department of Minerals and Energy, Pretoria.
- DME (Department of Minerals & Energy), 2003a. "Electricity basic services support tariff (free basic electricity) for the Republic of South Africa", *Government Gazette*, Vol. 457, No. 25088, Republic of South Africa, Pretoria, <http://www.info.gov.za/gazette/notices/2003/25088.pdf>.
- DME (Department of Minerals and Energy), 2003b. *Integrated Energy Plan for the Republic of South Africa*, Department of Minerals and Energy, Pretoria, [www.dme.gov.za](http://www.dme.gov.za).
- DME (Department of Minerals and Energy), 2003c. *White Paper on Renewable Energy*, Department of Minerals and Energy, Pretoria, [www.dme.gov.za](http://www.dme.gov.za).
- DME (Department of Minerals and Energy), 2004. *Free Basic Energy Policy Guidelines (Low Income Household Energy Support Programme)*, Department of Minerals and Energy, Pretoria.
- DME (Department of Minerals and Energy) 2005a. *Energy Efficiency Strategy of the Republic of South Africa*, March, Department of Minerals and Energy, Pretoria, DME, [http://www.dme.gov.za/energy/pdf/ee\\_strategy\\_05.pdf](http://www.dme.gov.za/energy/pdf/ee_strategy_05.pdf).
- DME (Department of Minerals and Energy), 2005b. *South Africa National Energy Balance*, Department of Minerals and Energy, Pretoria, <http://www.dme.gov.za/energy/pdf/Aggregate%20balance%202001.pdf>.
- DME (Department of Minerals and Energy), 2006. *Draft Biofuels Industrial Strategy of the Republic of South Africa*, Pretoria, [www.dme.gov.za/pdfs/energy/renewable/Biofuels\\_Strategy\\_SA.pdf](http://www.dme.gov.za/pdfs/energy/renewable/Biofuels_Strategy_SA.pdf).
- Eskom, 1987. *Statistical Yearbook 1987*, Eskom, Sandton.
- Eskom, 1996. *Eskom Statistical Yearbook 1996*, Eskom, Sandton.
- Fine, B., and Rustomjee, Z., 1996. *The Political Economy of South Africa: from Minerals-Energy Complex to Industrialization*, C. Hurst, London.
- Gaunt, T., 2005. "Meeting electrification's social objectives in South Africa, and implications for developing countries", *Energy Policy*, 33, pp. 1309-1317.
- IEA (International Energy Agency), 2003. *Key World Energy Statistics from the IEA*, International Energy Agency, Paris.
- IEA (International Energy Agency), 2004. *Key World Energy Statistics from the IEA*, International Energy Agency, Paris.
- IEA (International Energy Agency), 2006. *Key World Energy Statistics from the IEA*, International Energy Agency, Paris.
- Mapako, M., and Prasad, G., 2005. "The Free Basic Electricity (FBE) policy and rural grid-connected households, solar home system (SHS) users and unelectrified households", paper presented at Domestic Use of Energy conference, Cape Technikon, Cape Town, 28-31 March.
- NER (National Electricity Regulator), 2000. *Electricity Supply Statistics for South Africa 2000*, National Electricity Regulator, Pretoria.
- NER (National Electricity Regulator), 2004a. *Electricity Supply Statistics for South Africa 2004*, National Electricity Regulator, Pretoria, [www.ner.org.za/pubs.htm](http://www.ner.org.za/pubs.htm).
- NER (National Electricity Regulator) 2004b. *National Integrated Resource Plan 2 (NIRP2) 2003/4*, National Electricity Regulator, Pretoria, [www.ner.org.za](http://www.ner.org.za).
- NER (National Electricity Regulator), 2004c. *National Integrated Resource Plan 2003/4, Reference Case*, draft 27 February, compiled by ISEP (Integrated Strategic Electricity Plan)-Eskom (Resources and Strategy) and Energy Research Institute, University of Cape Town, and the National Electricity Regulator, Pretoria, [www.ner.org.za](http://www.ner.org.za).
- Singh, M., 2006. "Economics of biofuels for the transport sector in South Africa", *Energy for Sustainable Development*, X(2), pp. 40-47.
- UCT (University of Cape Town), 2002. *Options for a Basic Electricity Support Tariff: Analysis, Issues and Recommendations for the Department of Minerals and Energy and Eskom*, Cape Town.
- Winkler, H., (ed.), 2006. *Energy Policies for Sustainable Development in South Africa: Options for the Future*, ISBN: 0-620-36294-4, (contributors: O. Davidson, H. Winkler, A. Kenny, G. Prasad, D. Sparks, M. Howells, T. Alfstad, S. Mwakasonda, B. Cowan and E. Visagie, Energy Research Centre, Cape Town, [www.erc.uct.ac.za/publications/Energy%20policies%20for%20SD.pdf](http://www.erc.uct.ac.za/publications/Energy%20policies%20for%20SD.pdf)).
- WRI (World Resources Institute), 2003. *Climate Analysis Indicators Tool (CAIT)*, Washington, DC, [www.wri.org](http://www.wri.org).
- WRI (World Resources Institute), 2005. *Climate Analysis Indicators Tool (CAIT)*, version 3.0, Washington, DC, <http://cait.wri.org/>.