HELIO INTERNATIONAL

SOUTH AFRICA

Sustainable Energy Watch
2002 Report

Energy and Sustainable Development in South Africa

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South Africa has made extensive progress on increasing access to electricity to the poor, but still derives three quarters of its primary energy from coal.

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Executive Summary

This is the second Sustainable Energy Watch report for South Africa. Estimates have been developed for all eight indicators, and 1990 or similar benchmarks are also included for six of the indicators. For each of these indicators, the value of 1 is either the global average or the historical trend for South Africa, while the value of 0 is the sustainability target.

South Africa is the closest to the sustainability target on the indicators for access to electricity (0.34) and resilience to external impacts (energy exports) (0.08). The former reflects the success of the ambitious mass electrification programme, which has been a key social and economic goal for the democratic government. Government commitment to continue this programme, and provide substantial funding for it, bodes well for continued improvement in this indicator.

The low value for resilience to external impacts (energy exports) may be somewhat misleading. While it is true that South Africa is not as vulnerable to international energy markets as the OPEC countries, there is significant concern in the country about how the implementation of the Kyoto Protocol will affect the coal industry, and the 61 000 workers that it employs (SANEA 1998). The DME, for example, commissioned its first ever major climate change research in early 2001 – and the top priority is to analyse impacts of the Kyoto Protocol on coal markets. A report from the International Energy Agency suggests that South Africa may be the most vulnerable fossil fuel-exporting country in the world to the impacts of the Kyoto Protocol (Pershing 1999). South Africa will have to drop well below 0.09 on this indicator, therefore, before it is less vulnerable to external impacts.

South Africa performs worst on the indicators for carbon emissions per capita (2.35) and energy intensity (2.21). The reasons for the energy and emissions intensity of the economy are described in more detail in the body of this paper, and include heavy reliance on energy-intensive industries for domestic economic production and export, high dependence on coal for primary energy, higher energy-intensity of synthetic petrol made from coal, low energy prices and poor energy efficiency of individual sectors. Continued high energy-intensity is potentially a competitive disadvantage for the South African economy. The National Economic Development and Labour Council, for example, a powerful triparite commission comprising representatives from government, industry and labour, has recently commissioned work to look at impact of the Kyoto Protocol on manufacturing in South Africa (as opposed to the coal industry), which focuses on the risk to energy- and emissions-intensive sectors.

High carbon emissions intensity makes South Africa increasingly vulnerable to pressure to take on some kind of commitment within United Nations climate change negotiations process. Although South Africa is still classified as a developing, or 'non-Annex I' country, its emissions per capita and per unit of GDP are considerably higher than most developing countries. On the other hand, this carbon emissions intensity makes South Africa an attractive candidate for Clean Development Mechanism[1] international investment projects, which could help to move the country onto a lower emissions intensity path. Nevertheless, government policy is urgently needed to address carbon emissions intensity in way that also promotes development – for example, through stimulating large-scale investment in cost-effective energy efficiency and diversifying South Africa's energy mix.

Investment in clean energy is only beginning in South Africa, so this indicator is also still quite high (0.99). As discussed in this paper, there are positive signs of both pubic and private sector commitment to increase investment in renewable energy and energy efficiency. The challenge is to maintain these goals through the restructuring of the energy

[1] The Clean Development Mechanism under the Kyoto Protocol to the UN Framework Convention on Climate Change allows industrialised countries to invest in project in developing countries that reduce greenhouse gas emissions, and claim part of the credit for these reductions against the industrialised countries' emissions limitation targets.

industry – particularly the electricity industry – so that restructuring does not spell the end of clean energy. The indicator for renewable energy deployment (1.04) also reflects the long road ahead for South Africa in developing renewable energy sources – and challenge to move beyond seeing these only as solutions to remote area energy problems.

Finally, while the indicator for local pollution remains high (0.85), the significant improvement since 1990 is encouraging. More research will be needed, however, to make this indicator accurately reflect the national progress on local air pollution, rather than progress in only one location.

In summary, the political commitments of the post-apartheid South African government recognise the importance of equity in access to affordable energy. Progress in this important area of sustainability is a major accomplishment. The new South Africa, however, is full of legacies from the old – including the energy-intensive economic structure and reliance on abundant domestic coal – and in some cases current policies are reinforcing these legacies. This poses a major challenge to policy makers, industry, and civil society. New policy documents recognise the importance of these issues, but progress 'on the ground' has been slow, and there are, at the same time, conflicting policies that push South Africa away from sustainability. Our hope is that these indicators, and the discussion of their implications, will provide an useful starting point for stakeholders to debate South Africa's future, and how co-ordinated policy and concrete action can create a more sustainable energy sector that supports the development and welfare of all South Africans.

The Eight Indicators of Energy Sustainability for South Africa

Indicator	**1990**		**1999**		**% chg**	
	Metric	*Vector*	*Metric*	*Vector*	*Metric*	*Vector*
1. Carbon emissions	2205	2.36	2194	2.35	-1%	-1%
2. Particulate concentrations*	180	1.00	150	0.85	-17%	-15%
3. Access to electricity**	35%	0.65	66%	0.34	89%	-48%
4. Clean energy investment***	*Nil*	*Nil*	0.54%	0.99	-	-
5. Energy trade – exports***	10.5%	0.11	8.2%	0.08	-22%	-20%
6. Burden of energy*** investments	-	-	0.52%	0.05	-	-
7. Energy intensity (PPP)****	20.70	2.05	22.23	2.21	7%	8%
8. Renewable energy****	5.1%	1.05	5.7%	1.04	12%	-1%

**** 1992 and 1999 ** 2001 *** 1994 and 2000 ****1994 and 1999***

Introduction

▶HELIO and Sustainable Energy Watch

HELIO International, a non-governmental organisation based in Paris, was founded in 1997 with the intention of helping to ensure sustainable energy development through the creation of its Sustainable Energy Watch (SEW). SEW combines a world-wide network of observers and regional co-ordinators to monitor and regularly report on a set of eight indicators intended to measure progress toward energy, social, and environmental sustainability. HELIO has assembled a group of international energy experts who continue to help develop the methodology and the set of indicators. Members of this Scientific and Technical Advisory Committee (STAC) meet annually to review the approach and ensure that the monitoring accurately reflects desired progress. A list of HELIO's Steering Committee, Executive Committee and STAC members can be viewed on HELIO's website: www.globenet.org/HELIO.

The Sustainable Energy Watch (SEW) program measures progress toward energy sustainability in individual nations as well as globally. A set of indicators of such progress (or, in many cases, regress) have been selected by SEW's Steering Group with input from several members of its Scientific and Technical Advisory Group. These eight indicators – two for each of four segments: Environment, Society, Economy, and Technology – are used by an expanding network of Observer-Reporters to file reports on the status of the indicators in each country. Node-Coordinators will use the country studies to prepare a regional report. Finally, the SEW Secretariat in Paris will assemble a global report by aggregating the country and regional reports.

Selecting indicators at once meaningful for a wide range of conditions and do-able by a network of dedicated non-specialists is a difficult task. The indicators have been chosen without reference to a comprehensive and unassailable definition of sustainability: the project's co-ordinators are less interested in what is ultimately sustainable regarding energy and societal/environmental impacts than simply measuring progress toward carefully chosen interim goals. The objectives may change, but there will exist accurate, meaningful, and documented measurements to adjust as goals and definitions are fine-tuned.

The criteria for selecting indicators were to derive a small number of meaningful indicators, clearly definable (even if sustainability eludes definition), for which data is available in or for every country, and, if calculation is required, it must be simple to accomplish. Other objectives include using a consistent set of indicators with applicability to most if not all countries. Naturally, the results – for each country as well as for the world – must be clearly communicated to decision-makers, the media, and the general public. For all of these reasons the involvement, critiques, and support of readers is encouraged.

For each of the indicators, a vector is presented with the value of 1 indicating some measure of 'status quo', either as a global average or historical national data, and the value of 0 being the sustainability goal. In other words, the underlying metric (eg energy use per unit of GDP) is normalised so that we can compare across indicators how close the country is to sustainability goals. The metric values that correspond to 1 and 0 on the vector are presented in each indicator section.

►Contributions to the Report

This is the second Sustainable Energy Watch report for South Africa. The report was compiled by Randall Spalding-Fecher of the Energy and Development Research Centre (EDRC), University of Cape Town. The author's hope is that these indicators, while by no means definitive or comprehensive, will stimulate debate within South Africa on energy and sustainable development goals – as well as how South Africa should track progress toward those goals. As a work in progress, we welcome comments from stakeholders and experts in South Africa and beyond. This feedback will help to improve the accuracy of the data, as well as the quality of the policy conclusions that are drawn from the data.

Estimates have been developed for all eight indicators, and 1990 or similar benchmarks are also included for six of the indicators. For each of these indicators, the value of 1 is either the global average or the historical trend for South Africa, while the value of 0 is the sustainability target. In some cases international time series data has been used instead of local data, but these have been checked against local research and estimates. South African energy statistics (and government statistics in general) have changed dramatically since 1993 and the end of the apartheid era. For this reason, some indicators can only be measured accurately from 1993 or 1994.

Many people have contributed data, insights and comments on this report. Those who helped with statistics and data include the following:

Many people have contributed data, insights and comments on this report. Those who helped with statistics and data include the following: Deon Stassen (DBSA), Anton Louis Olivier (UNCCEE), Hilton Trollip, Janneke Weidema (DME), Mark Howells (ERI, UCT), Anastassios Pouris (SCE), Steve Szewczuk (CSIR), Phillip Lloyd (UCT), Pierre Rubbers (Eskom), Kevin Nassiep (Eskom), Lawrence Edwards (UCT), Doug Banks (RAPS), Anthony Williams, Trudi Hartzenberg (DPRU, UCT) and Krzysztof Wojciechowicz (DTI). Harald Winkler and Lwazikazi Tyani of EDRC provided valuable comments on early drafts, and Ethney Waters helped to track down reports. Helene Connor from the SEW Secretariat provided valuable support in interpreting the indicators, as did Richard Heede of Rocky Mountain Institute and Emilio Lebre La Rovere from the Federal

Finally, thanks to Tim James for editing and layout. As always, the opinions expressed in the report and any errors remain solely the author's responsibility.

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Note that all references have been reported at the end, rather than within each indicator.

General discussion of South Africa

The last decade has witnessed an unprecedented transformation in South Africa in almost all spheres of life. The 1990 unbanning of the African National Congress, and the negotiations that led to the end of apartheid and the country's first democratic elections in 1994, were events almost unthinkable only a few years before. That this political and social transformation was accomplished with so little violence, after so many decades of oppression and violence under apartheid, makes it all the more impressive. In the last seven years, virtually every major national policy has been reviewed and replaced by one based on the new government's values of democracy, development and empowerment. The 1994 Reconstruction and Development Programme (ANC 1994) laid out important economic, social and environmental goals – with a special emphasis on poverty alleviation, service provision and redistribution. National policy reviews in all key areas followed this, with White Papers and new legislation across all sectors. The 'Growth, Employment and Redistribution' (GEAR) strategy that followed in 1996 laid out a new fiscal policy to reduce the deficit, thereby creating conditions for lower inflation and interest rates (DTI 1996). This in turn is expected to increase rates of investment, economic growth and job creation, although there is increasing controversy over the impacts of fiscal reforms on poverty alleviation and delivery of social services.

While, in some cases, it will take many years for these broad policy statements to transform all of the local regulatory, economic and social environment, dramatic change is already happening – and the energy sector is no exception. The shift in priorities for the energy sector in South Africa has been almost 180 degrees – moving from the apartheid era single-minded emphasis on energy security to a broader concern about access to affordable energy, economic efficiency, and environmental sustainability. Transforming an energy economy based on vast, inexpensive supplies of coal, large public investments in synthetic liquid fuels and nuclear power, and highly inequitable access to clean household fuels, however, presents a major challenge, and sets the context for this discussion of energy sustainability.

►Profile of South Africa

South Africa lies at the Southern tip of Africa and covers a wide range of climates – from Mediterranean coastal areas to arid interior deserts to tropical and Afro-montane forest. With roughly 43 million people on 1.2 million square kilometres, South Africa is a third the size of India with only one twentieth of the population. South Africa is blessed with large supplies of minerals, precious metals, precious stones, making it the largest producer of gold and platinum group metals, the number five producer of diamonds, the number four producer of hard coal, and the second largest exporter of hard coal in the world (DME 2001e). Importantly for sustainability in the energy sector, it also has one of the highest solar insolation rates in the world. Annual global solar radiation average is about 5.5 $kWh/m^2/day$ for South Africa, compared to about 3.6 $kWh/m^2/day$ for parts of the United States and about 2.5 $kWh/m^2/day$ for Europe and the UK (DME 2001c).

On many development indicators, South Africa compares well to 'upper middle income' countries, and is far better off than her neighbours in sub-Saharan Africa. As shown in Table 1, income, literacy, and education levels in South Africa are well above those of other African countries and on a par with middle-income Latin American countries. Life expectancy, however, as for much of sub-Saharan Africa, is still well below world averages. This is why South Africa's Human Development Index is not higher (UNDP 2001). The literacy rate and school enrolment rates are all the more impressive if we consider the systematic denial of adequate services to the poor, black majority under apartheid until 1994.

Table 1: Key development indicators for South Africa and the World, 1999

	Life expectancy at birth	*Adult literacy rate*	*First, second and third level gross enrolment ratio*	*Real GDP/ capita*	*Human Develop-ment Index*
	Years	*%*	*%*	*PPP$*	
South Africa	53.9	85%	93%	8908	0.702
Sub-Saharan Africa	48.8	60%	42%	1604	0.467
Latin Am & Caribbean	69.6	88%	74%	6880	0.760
All developing countries	64.5	73%	61%	3530	0.647
World	66.7	98%	65%	6980	0.716

Source: (UNDP 2001)

The new government has faced enormous challenges in dealing with the poverty and inequality that is the legacy of apartheid. In 1993, for example, the Gini coefficient index for South Africa – a measure of income inequality – was the fourth worst of 105 countries in a World Bank survey (World Bank 2000). More recently, Finance Minister Trevor Manuel announced that South Africa had an income distribution even more unequal than Brazil, which was ranked a more unequal in the World Bank survey (Anon. 2000). Moreover, in 1994, more than 10% of South Africans lived on less than $1 per day, while 35% lived on less than $2 per day (World Bank 2000). As Table 2 shows, although South Africa per capita GDP is in the 'upper middle income' category, private consumption per capita has fallen significantly over the last 20 years, in contrast to the growth in other upper middle income countries. As in all Sub-Saharan African countries, HIV/AIDS is becoming a major public health, social and economic crisis, with almost 13% of the population infected as of 1999 (Day & Gray 2001).

Table 2. Income per capita and growth in consumption

	GNP/cap ($PPP 99)	*Growth private cons per cap % pa 80-98*
South Africa	8 318	-0.1
Sub-Saharan Africa	1 450	-1.2
Upper middle income	8 320	1.5
Middle income	4 880	2.2
World	6 490	1.3

Source: (World Bank 2000)

In fact, as Figure 1 shows, in real terms GDP per capita and household disposable income per capita are still slightly below their 1990 levels (SARB 2002 p. S-149). What this also conceals is the enormous disparities in income between racial and ethnic groups. For

example, the 1996 census showed that 65% of white men earned more than R3500 per month ($810 at 1996 exchange rates), while 48% of African women earned less than R500 per month ($115) (SSA 1996). Only 6% of African men and 5% of African women earned more than R3500 per month.

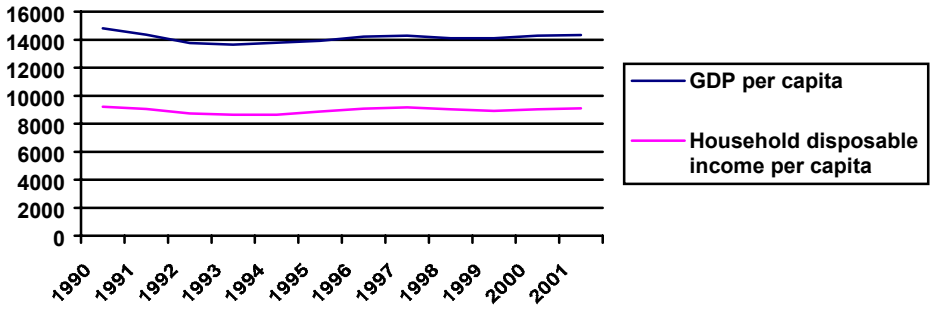


Figure 1. GDP and household disposable income per capita
(1995 constant Rands)(SARB 2002)

►South Africa's energy sector

The South African energy sector has historically been at the centre of the country's development. The origins of the electricity supply industry in the first years of the twentieth century, for example, were driven by the needs of the booming mining industry. The more calculated decisions of the apartheid government in the 1950s to develop a synthetic petroleum industry and a local nuclear capacity reflected the strains of isolation and later the oil embargo. Today, with the new government's focus on widening household access to electricity, the energy sector continues to be at the heart of structural developments in the economy (Spalding-Fecher *et al.* 2000b).

The energy sector has supported massive investments in heavy industry and mining. Much of the manufacturing sector is also linked to mining activities through minerals beneficiation and metals production. All of these activities are energy intensive, relying on the availability of cheap coal and electricity. The presence of the 'minerals-energy complex', with its links to mining products and reliance on low energy prices, underpins much of the South African economy. Massive power station projects initiated in the 1960s and 1970s, with the assumption of continued rapid increases in electricity demand, left the national utility with large excess capacity in the 1980s and 1990s, which has helped to keep electricity prices low, although this excess capacity will be exhausted within the coming three to five years (Eskom 2000b). The presence of low energy prices, including coal-generated electricity, has been one of South Africa's key competitive advantages and continues to drive much of new investment in industry.

Figure 2 illustrates the coal-dependence of the economy, with 74% of total primary energy supply (TPES) coming from coal (DME 2000). This compares to a share of 20% for the OECD and a world average of 24%(IEA 2001).

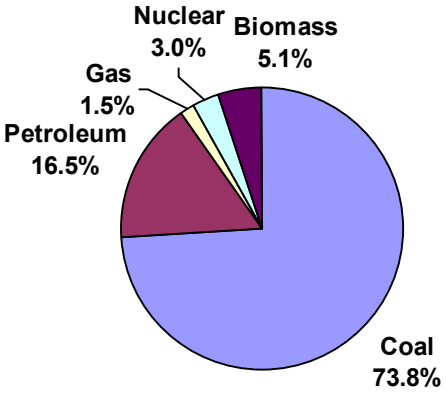


Figure 2. Share of total primary energy supply, 1999
Source: (DME 2001d)

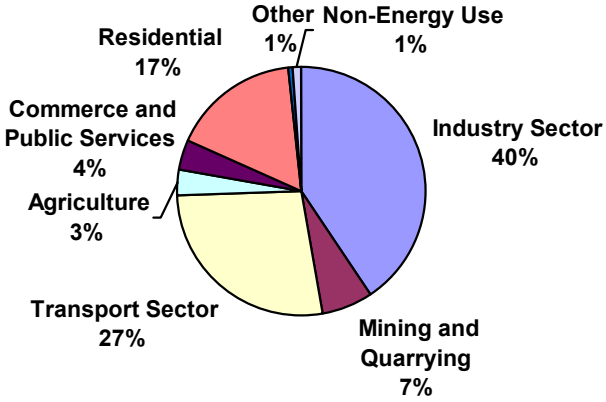


Figure 3. Share of final consumption, 1999
Source: (DME 2001d)

Figure 3 shows the large share of final energy consumed by industry, mining, and transportation. Energy consumption levels in South Africa are significantly higher than many other developing countries, particularly consumption of electricity – where South Africa consumes half of Africa's electricity with only 5% of her population(IEA 2001). Energy intensity - how much energy is required to generate a unit of economic output - is 50% higher than for OECD countries, even when taking into account purchasing power parity (PPP) to compare economic output (see Table 3).

Table 3. Energy consumption and intensity indicators, 1999

	TPES/capita	*TPES/GDP*	*TPES/GDP*	*Elec. consumption per capita*
	toe/capita	*toe/000 1995 US$*	*toe/ 000 PPP 1995 US$*	*kWh/capita*
South Africa	2.60	0.67	0.30	4,480.05
Africa	0.06	0.86	0.33	49.25
Non-OECD	0.95	0.76	0.28	988.33
OECD	4.68	0.20	0.22	7,840.77
World	1.65	0.30	0.25	2,280.28

NB: TPES = total primary energy supply, toe = tonnes of oil equivalent, PPP = purchasing power parity, GDP = Gross domestic product

Source: (IEA 2001)

Other Energy-Related Developments

In 1998, the South African Department of Minerals and Energy released the long-awaited White Paper on Energy Policy (DME 1998), which contained a broad set of policy objectives, organised under five main themes: increased access to affordable energy service, improving energy governance, stimulating economic development, managing energy-related environmental impacts, and securing supply through diversity. In this section we review progress in 2001 toward meeting government's stated objectives.

Increasing access

The electrification programme has been a continued success, with 70% of households electrified at the end of 2000 and more than 3.1 million connections since 1994 (NER 2000). The off-grid electrification programme, which will target 350 000 homes for solar home systems, has stalled as negotiations among government, Eskom, and the concessionaires have dragged. In 2002, DME agreed to the subsidy level (Kotze 2001), so as soon as Eskom's role in the programme is clarified, roll out should commence in 2002. The ANC announced during the late 2000 local elections that they would provide free electricity and water to poor communities, and this is being implemented in pilot sites (Chalmers 2001). So far this programme is only being piloted in early 2002, although the Cape Town city council (controlled by the political opposition) has already instituted a free electricity scheme. The full costs and impacts of the proposed Electricity Basic Services Support Tariff are not known, but estimated are that it will cost the public sector more than 500 million Rands (Xundu & Chalmers 2001). An evaluation of the proposed 'poverty tariff' is also currently underway (UCT 2002).

Government removed the value added tax from paraffin in April 2001 in an effort to reduce the cost of the energy source must widely used by poor urban households. Because of significant increases in oil prices and the fact that the paraffin distribution chain includes many resellers and small shops that do not pay VAT in any case, however, it not clear that this has had any impact on consumer prices – although it is a loss of government revenue.

Guidelines for improving the thermal efficiency of low cost housing have been published by the Department of Housing, but these are not mandatory, and so are not used contractors in new low housing projects. No significant programmes are underway on improved biomass stoves or management of woodlands although the Department of Water Affairs and Forestry (DWAF) has introduced a Working for Water programme which has seen the commercial supply of wood increase as alien species have been cleared.

Improving energy governance

The passage of the Gas bill in 2001 sets up a Gas Regulator (RSA 2001b), which joins the National Electricity Regulator and the National Nuclear Regulator (established in 1999), will strengthen government's capacity to govern the energy sector. Although government has restructured their petroleum assets, combining Mossgas and Soekor and the former Strategic Fuel Fund into PetroSA (which is wholly owned by the Central Energy Fund)(Mlambo-Ngcuka 2002), there has been no progress on a petroleum sector regulator. A new state owned company called 'iGas' was also formed to be partner in the Mozambique-South Africa gas pipeline and other gas development projects (DME 2001a). Also in the liquid fuels industry, government is phasing out subsidies to Sasol, the coal-to-liquid fuel producer, and removing the requirement of petroleum marketers to buy Sasol liquid fuels, which will reduce the energy intensity of this sector.

The state has restructured electricity assets through passage of the Eskom Conversion Act (RSA 2001a), which is the first step in the restructuring of the electricity supply industry restructuring. The Bill makes Eskom a wholly state owned corporation that will pay tax and

dividends to government – although a tax exemption for 3 years was granted to allow for restructuring expenses within Eskom. The conversion is also widely seen as the first step in privitisation of Eskom, and government has announced that 30% of the company will be sold off by 2006 (Bain 2002). In addition, new independent power producers will increase competition in the sector. The introduction of competition in generation, and future privatisation of Eskom, will have dramatic impacts on the prospects for investment in renewables and efficiency – and many analysts have raised concerns that this impact will be negative without government intervention (Praetorius *et al.* 1998; Barberton 1999; Clark 2000; Clark & Mavhungu 2000) In addition, there are significant concerns about the impact of restructuring on energy provisions for the poor, such as the electrification programme, and the financial viability of municipalities that depends on electricity for revenue in the past.

In 2002, electricity governance will be revised somewhat in with the new Electricity Regulatory Bill, while the amended Petroleum Products Act will change the petrol stations licensing rules to give government more influence and the Petroleum Pipelines Bill is expected to establish pricing and access rules for oil and gas pipelines. These will be the first major changes in petroleum sector regulations in several years [two decades!!?]– and are revisions of regulations rather than full scale deregulation of the oil industry.

Stimulating economic development

Significant progress was made toward government's goal of 25% ownership of the liquid fuels sector by historically disadvantaged communities, with both Shell SA and BP SA announcing they were selling 25% ownership of their local assets to black economics empowerment (BEE) companies. This comes on top of the development a smaller wholly owned BEE companies that have taken a small stake in the market, namelly Zenex, Afric Oil and Tepco. Cabinet has also targeted 10% ownership of electricity generation by BEE companies no later than 2004, and Eskom is awarding significant contracts to BEE partners (NER 2001a; Bain 2002). In addition, the previously mentioned gas bill will support increased investment in that subsector, with the Mozambique-SA pipeline costing an estimated $600 million, excluding the cost of the gas processing facilities in Mozambique.

The restructuring of the electricity distribution industry, which has major implications for retail electricity prices and efficiency of the sector, was held up because of concerns over government plans to deny municipalities the right to distribute electricity, which the Constitution grants to local authorities (NER 2001a). By the end of the year, however, agreement was reached that the current 400 plus distributors will be consolidated into 6 Regional Electricity Distributors (REDs), with implementation commencing in 2002 (NER 2001a). The formulation of a Wholesale Electricity Pricing System, due to be rolled out in 2002, was another significant step in industry reform and opening the way for restructuring.

The special levies to fund regulators and energy agencies mentioned in the White Paper has been implemented in electricity and will soon be used for the gas industry as well. The petroleum sector Equalisation Levy did play this role to some extent in funding the Central Energy Fund, but this has been discontinued. CEF also does not have any regulatory role, since all petroleum regulatory functions are still inside the DME and Minister. The nuclear regulator is also funded from the Ministry of Minerals and Energy budget, rather than a levy on nuclear energy, and remains a contentious issue.

Progress on promoting energy efficiency and appliance labelling has been much slower. Mandatory commercial building standards have been established, but there are no standards for industrial equipment, household appliances, or residential buildings (only the guidelines mentioned above), although the DME was involved an National Energy Efficiency Association. The earlier research on appliance labelling (Marbeck Resource Consultants 1997) has not resulted in a programme.

Managing energy-related environmental impacts

To reduce indoor air pollution, DME launched a low smoke fuel programme, which culminated in a macro-scale experiment with various fuels in a major township in 1997. Subsequently DME commissioned an integrated decision support model to evaluate the most cost effective means of reducing local air pollution, and a study to evaluate how government should intervene in the supply chain for LSFs to get the most benefit (Qase *et al.* 2000). This will be followed in 2002 by a marketing campaign and the design of standards for fuels. A preliminary study on respiratory disorders among children exposed to wood and paraffin smoke has been done by the Medical Research Council and the World Health Organisation and has been presented to DME (Mathee & De Wet 2001).

Studies on paraffin safety have found that poisoning from children ingesting paraffin and the problems of paraffin relate fired and burns continues to be a major problem [Markinor]. These have continued despite electrification and industry, through the Paraffin Safety Association of South Africa, is implementing safety programmes to attempt to address this. Safety standards for paraffin stoves are also outstanding, although an SABS task team is tasked with developing these standards. In terms of reducing fires, the DWAF /Santam 'Ukuvuka' fire prevention programme has seen considerable success, and could provide a model for DME programmes.

DME has commissioned a number of studies on how to utilise coal discards, estimated at 950 million tonnes in 1999 (DME 2001a), but no specific programmes are in place. Similarly, the White Paper proposal to explore an environmental levy on energy has not been pursued.

Securing supply through diversity

South Africa is looking to more Southern African regional resources for energy supply, as opposed to purely domestic resources (Spalding-Fecher *et al.* 2000b). There are strong economic and environmental arguments in favour of using resources within the Southern African Development Community (SADC), which include considerable hydropower and natural gas potential (e.g. Rowlands 1998; Sparrow *et al.* 1999; Graeber & Spalding-Fecher 2000). The region's electricity regulatory authorities have formed a SADC regional regulators association to facilitate trade and greater regional co-operation (NER 2001d). The Southern African Power Pool, composed of the national utilities of all SADC countries, now has a operational control centre in Harare that will facilitate increased electricity trading in the region. Government's vision is for this to become a real time power exchange over time, although now most trade occurs through fixed contracts. Despite some ongoing conflicts over the price of importing electricity, the region's utilities are working on a combined regional power expansion plan, and Eskom has identified more than 9 000 MW potential for regional imports, even without considering the massive potential of the Grand Inga scheme in the Democratic Republic of Congo, which could supply 40 000 MW in the longer term (Eskom 1997). Regional co-operation on energy development is also a major drive within the New Partnership for Africa's Development, for which South Africa's President Mbeki is one of the main drivers (NEPAD 2001).

One of the most important regional energy developments, and one which also impacts the synthetic fuels industry, is the increased investor interest in large off-shore natural gas fields in Namibia and Mozambique, as well as more recent finds off of South Africa [e.g. \(DME 2001b)Marrs, 2000 #321; Marrs, 2000 #322]. Sasol, for example, has taken over complete ownership of a gas field in Mozambique and intends to build a pipeline to South Africa, and the governments of South Africa and Mozambique have signed an agreement on the pipeline (Mlambo-Ngcuka 2002). Shell International is investigating building a gas pipeline from Namibia to Cape Town, to bring gas from the offshore Kudu fields to a potential gas-fired power station in Cape Town, as well as anchor industrial customers along the West Coast of South Africa [ibid.; \(NER 2001b)]. These investments could promote a significant shift away from coal as a primary energy source, and provide feedstock for high value added chemicals in the synfuels plants. The Petroleum Pipelines Bill will provide the regulatory framework for these investments, while an World Bank-funded study at the

Central Energy Fund is investigating the possibility of also using natural gas for smaller scale commercial and residential uses (World Bank 2001).

The Department of Mineral's and Energy developed a Renewable Energy Strategy paper in 2001, and took public comment – although a decision was made to instead convert this into a White Paper on Renewable Energy, which will be released for public comment in April 2002 (Mlambo-Ngcuka 2002). Existing renewable energy initiatives include a National Solar Water Heating Programme (which will be supported by a Global Environmental Facility Grant), an EU-funded solar cooking programme, and a solar water pumping programme. This are all in the demonstration and piloting phases, as are efforts to promote energy efficient housing (DME 2001a). Larger scale roll out will likely await the release of the White Paper on Renewable Energy. In addition, Eskom recently announced plans to develop 100-200MW renewable electricity demonstration projects using wind and solar thermal power (Lombard 2001). These would be the largest such investments ever in South Africa. The proposed Darling Wind Farm, a 5MW wind facility on the West Coast, was named a National Demonstration Project by the energy minister.

The most controversial development in the South African energy sector, however, is Eskom's plans to build a new generation of 'pocket size' nuclear reactors, for export as well as for domestic power generation. Eskom's is planning for a test site for these 100MW Pebble Bed Modular Reactors, with support from several local and international investors. The energy deputy minister said at an International Atomic Energy Agency that South Africa will expand its nuclear power capacity (Shabangu 2001) Eskom has also stated that , to meet future demand, they may bring back on line three old 'mothballed' coal-fired power stations in the near future.

Table 1. South African energy policy priorities and progress

Objective	*Priorities*	*Progress to date*
Increased access to affordable energy services	• Electrification policy and implementatio • Address off-grid electrification	• Initiate second phase of electrification programme, including renewables for o grid electrification • Zero-rating of VAT on paraffin • Initiate pilots of free electricity programme
	• Facilitate management of woodlands • Promote improved fuel wood stoves • Establish thermal housing guidelines	• no activity • Voluntary guidelines only
Improving energ governance	• Promulgate electricity regulatory bill • Manage deregulation of oil industry • Implement new regulation of nuclear • Restructure state energy assets • Restructure DME budget • Establish energy policy advisory board • Establish information systems and research strategy	• Postponed to 2002 • No petroleum regulator; Petroleum Products and Pipelines Bills in 2002 • Nuclear regulator established • Eskom conversion bill passed • PetroleumSA formed • iGas formed • Limited activity
Stimulating economic development	• Encourage black economic empowerme in energy sector • Manage electricity distribution industry restructuring • Remove energy trade barriers & facilita investment in energy sector • Introduce special levies to fund regulators & other energy agencies • Introduce competition in electricity • Establish cost-of-supply approach to electricity pricing • Promote energy efficiency and voluntar appliance labelling programme	• Two multinational oil companies have sold 25% of business to BEE firms • Plan for REDs agreed; implementation i 2002 • Only Gas Bill to encourage investment i natural gas • Implemented in all subsectors except nuclear • Outline of long term plans agreed by cabinet • Cost-of-supply and wholesale electricity tariff piloted • Limited activity outside of commercial building standard

Objective	*Priorities*	*Progress to date*
Managing energy related environmental impacts	• Improve residential air quality	• Pilot programmes to improve air quality through low smoke fuels • Proposals on ambient air quality standards under debate
	• Monitor reduction on candle/paraffin fir resulting from electrification	• Hazards still very significant
	• Introduce safety standards for paraffin stoves	• Under discussion
	• Develop policy on nuclear waste management	• Under discussion
	• Investigate options for coal discards	• Significant research, but no programme
	• Investigate environmental levy	• Not investigated
	• Evaluate clean energy technology	• Participation in Climate Change debate
Securing supply through diversity	• Develop Southern African Power Pool	• SAPP regional co-ordination centre established and some joint planning
	• Pursue international and regional co-operation	• SADC Regional Regulator's forum and NEPAD
	• Develop gas markets	• Mozambique gas to Sasol, and Namibia also under discussion
	• Stimulate use of new & renewable energy sources	• Piloting several programmes, Renewabl Energy White Paper in 2002
	• Stimulate energy research	• Declining research funds

Environmental sustainability

►Indicator 1: Per Capita Carbon Emissions

South Africa is one of the most carbon emissions-intensive countries in the world, due to the 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 near the OECD average (see Table 4). As discussed earlier, this is partly the result of energy intensive sectors such as mining, iron and steel, aluminium, ferrochrome, and chemicals to the economy – the same sectors that make up a large share of South African exports (Visser *et al.* 1999; Spalding-Fecher *et al.* 2000a). In addition, plentiful supplies of inexpensive coal have supported the development of large scale coal fired power stations and heavy reliance on coal within industry. Finally, because the specific energy efficiency of many sectors is also lower than average, emissions per unit of economic output are high. The energy sector contributed 78% of South Africa's total greenhouse gas emissions in 1994, and more than 90% of carbon dioxide emissions (RSA 2001c).

Table 4. Energy sector carbon emissions intensity and per capita, 1999

	CO_2/cap tonnes/capita	*CO_2/GDP Kg/1995 US$*	*CO_2/GDP PPP kg/1995 PPP US$*
South Africa	8.23	2.11	0.96
Africa	0.09	1.28	0.49
Non-OECD	2.24	1.79	0.66
OECD	10.96	0.46	0.52
World	3.88	0.71	0.58

Source: (IEA 2001)

For indicator 1, the value for 1 on the vector is 1 130 kgC/capita, which is the 1990 global average of carbon emissions from fossil fuel production. The value of 0 on the vector, or the sustainability goal, is 339 kgC/capita – a 70% reduction from 1990 levels.

According to the International Energy Agency, South Africa's energy sector carbon emissions for 1999 totalled 346.31 million metric tonnes (MMT) of carbon dioxide, or 964.45 MMT of carbon (IEA 2001). On a population of 43.05 million people (SSA 1999), this is 2 194 kgC/capita. This compares to 2 205 kgC/capita in 1990. This means that the vector values for South Africa are greater than one for both years – 2.40 for 1999 and 2.26 for 1990.

Metric (actual data) for 1990: 2 205 kgC/capita and 1999 2 194 kgC/capita
Vector values for 1990: 2.26 and 1999 2.40

Discussion:

South Africa entered the climate change debate relatively late, only ratifying the UN Framework Convention on Climate Change in 1997. Government has developed a climate change policy discussion document (DEAT 1998), and is currently working on a national response strategy, which will be circulated by mid-2002. In addition, South Africa recently ratified the Kyoto Protocol. The Discussion Document mentions a wide range of possible energy strategies, including greater use of renewables and energy efficiency, as well as cleaner fossil fuels, but no specific measures. Government released a draft First National Communication to the UNFCCC, and this should be officially submitted prior to the World Summit on Sustainable Development (RSA 2001c). The DME Energy White Paper states that

government will follow a 'no regrets' approach in the energy sector with regard to the potential global environmental impacts of energy activities (DME 1998). What precisely this means is unclear, but government strategies around renewable energy and energy efficiency – discussed in more detail below – will have a major impact on emissions. In addition, the Department of Environmental Affairs and Tourism is finalising the National Strategy Study for Clean Development Mechanism (Goldblatt 2001), which will identify areas in which South Africa can attract investment into greenhouse gas reduction projects using the mechanisms of the Kyoto Protocol to the UN Framework Convention on Climate Change.

Note that the data for this vector calculation were taken from the International Energy Agency report on carbon dioxide emissions from 1971-1999. The reason for choosing this data, rather than the official inventory, is mainly timeliness. South Africa's first national communication only reports greenhouse gas inventories for 1990 and 1994 – and this is not likely to be updated on an annual basis. The reference approach energy sector emissions reported in the National Communication for 1994 are about 2% higher than those reported by the IEA, although the difference for 1990 is around 10%. The reasons for these difference are primarily the use of default emissions factors by the IEA, as opposed to local emissions factors by the SA national inventory (Howells & Solomon 2000).

Notes to SEW or next year's Observer-Reporter:

The Department of Environmental Affairs and Tourism (DEAT) is discussing a system for regular GHG emissions inventories, which could also be linked to the DME annual energy balances to provide a 'Tier 1' Reference Approach inventory. Even if this system is put into place, however, the energy balances generally take two years to be published (the same as IEA data, which uses national energy balances as one of the main sources).

►Indicator 2: Most Significant Energy-Related Local Pollutant

As in all countries, energy production and consumption in South Africa has a wide range of local environmental impacts – from air quality and water use, to degradation of land, water and forest resources. Unlike many Northern countries, however, some of the most critical problems occur at the household level – from the consumption of fuels for cooking, heating and lighting – rather than mainly from large-scale industrial use. Similar to many developing countries, exposure to hazardous levels of indoor air pollution outstrips outdoor air pollution as a potential cause of illness and even death (Reddy *et al.* 1997; Holdren & Smith 2000) Studies on the environmental impacts of energy use, including the only study on economic valuation of these impacts, places particulate emissions at the top of the list of environmental hazards, with other indoor and local (ie ground level) pollutants close behind (Van Horen 1996a, 1996b; Freeman & Naude 1999; Lloyd *et al.* 1999). This is because these pollutants are so widespread, released in close proximity to people (often in confined space) and so damaging to human health at the concentrations common in developing countries. It is important to remember, however, that the household hazards of energy extend even beyond pollutants, to include the high risk of fires, burns and even poisoning from paraffin stove use and candle-burning in informal dwellings (Van Horen 1996b; Mehlwana 1999a, 1999c).

For the reasons above, we choose to use a measure of air quality in low-income areas as a key indicator of energy sector environmental impacts. The Soweto Air Monitoring (SAM) Project was initiated in 1991, and has tracked ambient concentrations of particulate matter in Soweto since that time (Annergarn & Sithole 1999). Results up to 1999 show that winter concentrations of total particulate matter have declined by about 15%. The intention is to update this data for 2000, but at the time of writing this was not complete, so the data presented here is the same as in the SEW 2001 report for South Africa.

For this indicator, the value for 1 on the vector is the 1990 level of pollution – or in this case, we use 1992 because this is the earliest year for which the monitoring was conducted. The 1992 measurements showed an ambient concentration of particulate matter of 180 micrograms per cubic metre. The value for 0 on the vector set at 10% of the base 1992 value, so 18 □g/m^3 for this particular pollutant measurement. The 1999 vector value is therefore 0.85.

Metric (actual data) for 1992: 180 µg/m^3 and 1999 150 µg/m^3□
Vector values for 1992: 1.00 and 1999 0.85

Discussion:

For the Soweto data, it is not possible to attribute all of this change to changing energy use patterns – namely electrification and the decline household use of coal. Some of this particulate matter also comes from the burning of refuse (Annergarn & Sithole 1999), although smoke from coal is one of the largest contributors.

The problem here is the lack of a national air quality monitoring system – for either emissions or ambient air quality. While DEAT collects information on major pollutant emissions from large stationary sources, this data is all self reported and not validated by government (Spalding-Fecher *et al.* 2000a). The data also tends to be fairly out of date (eg the most recent national inventory is for 1993). Eskom probably has the most extensive air quality monitoring network in the country, although the sites are chosen to assess the impact of emissions from power stations (with generally high stacks) rather than other industry or pollutants from household energy use. If government is to implement the far-reaching National Environmental Management Act passed in 1998, therefore, significant improvements in data collection and monitoring of air quality will be essential. Otherwise, it will not be possible to track progress against any national or local goals.

Notes to SEW or next year's Observer-Reporter:

The O-R should follow up to get the 2000 trend data as soon as it is available. It may also be possible to get average air quality data near power stations from Eskom, although this data may be difficult to aggregate.

The National State of the Environment Report (www.environment.gov.za/soer/nsoer/index.htm) should also be consulted, to assess other possible indicators of environmental quality and trends – although these do not separate out the impacts of the energy sector on emissions.

Social sustainability

►Indicator 3: Households with Access to Electricity

The South African mass electrification programme has been one of the most successful elements of the South African Reconstruction and Development Programme. Initiated by Eskom in 1991, and included as a key government programme after the 1994 elections, the programme has brought electricity to more than 4 million homes since 1991 (NER 1999, 2000; Mlambo-Ngcuka 2002). The annual connections made by Eskom and the local authorities in charge of distribution for most municipalities are shown in Figure 4.

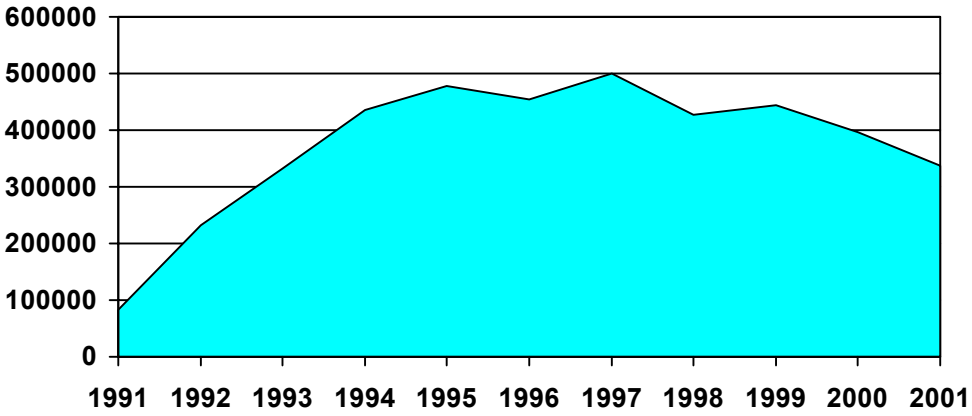


Figure 4. Annual electricity connections, 1991-2001
Source: (NER 1999, 2000; Mlambo-Ngcuka 2002)

According to World Bank estimates, only 17% of the population of Africa has access to electricity, while 23 African countries have less than 10% access.(O'Sullivan & Hamaide 2002) In South Africa that share stood at roughly 66% at the end of 2001, with 77% and 49% of urban and rural households having access, respectively (Mlambo-Ngcuka 2002). This is up from less than 35% access in 1990 (Eberhard & Van Horen 1995).

For this indicator, the value for 1 on the vector is 0% access, while the value for 0 is 100% access. For vector value for South Africa in 2001 is therefore 0.34, and 0.65 for 1990 (ie one minus the share with access).

Metric (actual data) for 1990: 35% and 2001 66%
Vector values for 1990: 0.65 and 2001 0.34

Discussion:

The electrification programme is likely to slow down, as costs per connection have started to rise and as the target-driven approach is being replaced with a 'market-related' one. Most of the connections in the 1990s were in urban areas and rural areas where the financial returns to the utility from selling electricity were closer to the investment cost for the electrification. The challenge facing government is how to further extend access in the face of rising costs and declining average consumption (Borchers *et al.* 2001), given the fact that electrification has social and environmental benefits not captured by the utility and electricity prices (Spalding-Fecher 2000). While Eskom originally estimated the customers would need to use 300 kWh per month for the electrification investment to break even, average use among these customers five years after electrification is less than 140 kWh (NER 1996).

Two important shifts in this programme are the new government commitment to off-grid electrification in rural areas, and the change in electrification financing. The DME has launched a programme under which seven concessionaires will be in charge of providing off-grid electrification to a total of 350 000 homes (NER 2001c). This market is discussed in more detail with Indicator 4. On the second point, in the past Eskom financed their electrification connections internally, essentially subsidising electrification for the poor from revenues from other customers. The DME has proposed shifting this funding back into government. Eskom would pay tax and dividends to government, which they have not in the past, and part of this funding would go into the National Electrification Fund, which would fund both Eskom and local authority connections.

The restructuring of the National Electrification Programme should allow continued increases in access to electricity, particularly in rural areas, while promoting renewable energy through the off-grid electrification concession programme (NER 2001c). The pending restructuring of the electricity distribution industry could be a major barrier to implementing energy efficiency programmes (Clark 2000).

Notes to SEW or next year's Observer-Reporter:

The National Electricity Regulator regularly publishes electrification statistics, which are updated annually.

►Indicator 4: Clean Energy Investment

A growing body of research world-wide is showing that an investment led strategy of promoting renewable energy and energy efficiency can create far more jobs than traditional supply driven, capital intensive energy investments (eg IWG 2000; Krause 2000; Krause et al. 2000; Renner 2000. Tracking investment in 'clean energy'[2] as a share of total energy sector investment is therefore an important tool to measure the contribution of the energy sector to employment generation and social welfare. The difficulty, however, is that investment data on the energy sector is notoriously difficult to find, particularly in developing countries. A combination of lack of government statistics, lack of data from private or non-listed companies, and the diffuse nature of the energy market (especially if we include demand-side investments), make this one of the most difficult indicators.

In South Africa, the energy supply industry is still highly concentrated. Eskom, the national utility, generates 96% of all electricity (NER 1999), while only three coal-mining companies (Sasol Mining, Ingwe Coal and Amcoal) contribute 83% of total coal production (Chamber of Mines of South Africa 1999). The members of the South African Petroleum Industry Association (SAPIA), along with Sasol Synthetic Fuels, would also supply almost all of the liquid fuels for the country.

Capital investment in 2000 by Eskom was 3 263 million Rands (Eskom 2000a), while the SAPIA companies invested 2 314 million Rands (SAPIA 2000). Mossgas, the state-owned gas to liquid fuels company, has embarked on a major capital investment plan in new gas development, so their capital expenditure in 2000 was 1 333 million Rands (Mossgas 2002) For the coal industry, the Chamber of Mines has estimated the capital commitments for this subsector will total 9 360 million over from 2000 to 2004, so we have assumed 1 872 million Rands for 2002 (Chamber of Mines of South Africa 2001). Sasol capital investments in synthetic fuels and oil have been estimated based on those divisions' share of total turnover, and amount to 1 202 million Rands for 2002 (Sasol 2000). There are no public estimates of investment by Soekor, the state oil exploration company, or the Strategic Fuel Fund, which overseas storage of strategic oil reserves. While Eskom is doing research and planning demonstration plants for renewable electricity, so far all of the investment captured above is in non-renewable energy – a total of 9 984 million Rands.

Data on renewable energy and energy efficiency investment are even more scarce. Based on a recent report ((EC *et al.* 2000; Stassen 2001), we estimate that the baseline (i.e. outside of the major government programmes) solar home system market was roughly 28 million Rands in 2000, net of the schools and clinics electrification programmes. This does not include the off-grid concessions programme, which is only starting in 2002. The Shell/Eskom joint venture for solar PV electrification, however, did contribute an estimated 14 million Rands (4000 systems) in 2000 (DME 2001a; Spalding-Fecher 2002).

The EU schools electrification programme is providing 15 million Euros for 1999-2001 off-grid electrification, with approximately 45 million Rands in 2000 (DME 2001a). This follows the earlier programme funded by the Dutch government and the RDP from 1995-97. The clinics off-grid electrification programme, funding through the Independent Development Trust (SA), is largely complete, and contributed 14 million Rands to renewable electricity from 1997 to 1999 (Spalding-Fecher 2002).

The solar water heating market is estimated 18 million Rands in 2000 (similar to earlier estimate by EC *et al.* 2000; Purcell 2002), although this is poised to increase dramatically with the National Solar Water Heating Programme receiving a major grant from the Global Environmental Facility (GEF).

There have been no major hydropower or wind power investments from 1995 to 2000, although the Darling Wind Farm has invested more than 4 million Rands on feasibility work

[2] Within the Sustainable Energy Watch framework, clean energy is defined as all renewable energy source, excluding large dams, and energy efficiency investments

already (Oelsner 2001). The bagasse-based cogeneration plants operated by the large sugar companies were also built prior to the mid-1990s.

There are several major renewable energy investments under discussion – including Eskom's proposed 100MW wind and solar thermal plants, the smaller 5MW Darling Wind Farm (which is a National Demonstration Project), and even a proposed 200MW 'solar chimney' project in the Northern project (Otto 2000; Stinnes 2001).

On the energy efficiency side, there is the least data of all. While Eskom has spent considerable resources in their residential, commercial and industrial energy efficiency advisory services, as well as research and development, very little of this could be called capital investment. The most significant investment is in the Bonesa company set up to implementation the national Efficient Lighting Initiative. This company has received 48.8 million Rands from Eskom for 2000 to 2002 and US$ 2.5 million from the International Finance Corporation, as part of a GEF grant. For 2000, this would be an average total investment of 24 million Rands (exchange rates from SARB 2001).

Of course, there are also companies investing in more energy efficient equipment. A project run by the Energy Research Institute, with Technology Services International, NOVEM (Holland) and ETSU (UK), recently helped three large industrial firms – South African Breweries, South African Pulp and Paper Industries, and Anglogold's Elandsrand mine – identify more than five million Rands of energy efficiency investment that would pay back within one year (ERI 2000).

The total clean energy investment for 2000 is estimated at 129 million Rands. Although it is possible there is some double counting between this amount and the total investment calculated above (e.g. if Eskom ELI investment is captured in 2000 financial statements as a capital expenditure), this is likely to be quite small.

Based on the limited data available, therefore, we estimate the share of energy sector investment going to clean energy at 1.3 percent. For this indicator, the value for 1 on the vector is supposed to be the 1990 share of clean energy investment out of total energy sector investment, while the value for 0 would be 95% clean energy investment relative to total. Because of the low levels of investment in clean energy, we can say that the 1990 was probably close to zero. This means that the vector value for 2000 is 0.986 (i.e. (0.95-0.013)/0.95).

Metric (actual data) for 2000: 0.013
Vector values for 2000: 0.986

Discussion:

The share of clean energy is set to increased as the solar markets start to develop. Certainly renewable energy markets are poised to increase rapidly, given the appropriate policy framework. Energy efficiency, particularly in electricity use, is, however, potentially endangered by the restructuring of the electricity supply industry and the break up of Eskom (Clark 2000). The National Electricity Regulator's attempts to enforce integrated resource planning as a standard practice across the industry, as well as reform in legislation related to independent power producers, will also be crucial to providing support for efficiency and renewable electricity generation (Ellman 1999; Clark & Mavhungu 2000)

This and indicator number 6 are by far the most difficult to assess in South Africa – and this is likely to be true in many other developing countries. While it may be easier with more research to begin to track clean energy investment, tracking total energy sector investment will always be very difficult. It is also not clear how investments in energy transmission and distribution should be counted, because, for example, wires can carry renewable or non-renewable electricity.

Notes to SEW or next year's Observer-Reporter:

Keeping up with the major renewable and efficiency initiatives will be the main task for this indicator. Whether it be Eskom's wind and solar proposal, or industrial energy efficiency, these contacts should be followed up each year. We should also watch the DME off-grid concessions programme carefully, since this will be one of the largest renewable energy markets in the short run.

Economic sustainability

►Indicator 5: Resilience to External Impacts: Energy Trade

Although South Africa relies on imported petroleum for 60-65% of liquid fuels supplies, it is a net exporter of energy, primarily because of coal exports. South Africa is the world's number 5 producer of hard coal, at 225 Mt in 2000, and number 2 exporter of hard coal, at 66 Mt, just behind Australia (IEA 2001). South African also exports significant volumes of refined petroleum products, including 2.8, 0.58, and 0.30 billion litres of diesel, petrol, and kerosene, respectively (DME 1999: 7)

According to the Trade and Industrial Policy Secretariat on-line trade database, total exports for South Africa for 2000 were 226 billion Rands (TIPS 2002). TIPS data for coal and petroluem exports for 2000 at 9.5 and 9.1 billion Rands, respectively. While the coal export data match data provided by the Department of Trade and Industry, the petroluem export data from TIPS is considerably lower than the DTI for earlier years (Wojciechowicz 2002). We have therefore use TIPS as the source for coal exports and total exports, while DTI for petroleum product exports. Electricity exports, which are almost 100% based on non-renewable energy, totalled 0.47 billion (Eskom 2000a). Total non-renewable energy export were therefore 19.1 billion, or 8.4% of the total.

For this indicator, the value for 1 on the vector is 100% non-renewable energy exports share of total national exports, while the value for 0 on the vector is 0%. The vector value for 2000 is therefore 0.084. Earlier years have not been reported here due to data problems (see discussion below).

Metric (actual data) for 1998: 0.084
Vector values for 1998: 0.084

Discussion:

The coal-mining industry has increased coal exports considerably until recent years, when the worldwide industry slump has hurt growth. It is also likely that petroleum product exports have grown – particularly because the relatively low diesel to petrol demand ratio in South Africa means that refineries must export excess diesel as demand for petrol grows. This is one of the reasons behind government's proposal to convert the nation's minibus taxi fleet from petrol to diesel.

As mentioned above, there is disagreement between different sources of data for energy trade. Coal exports as reported by the Chamber of Mines, for example, are 10-20% higher than those from TIPS and DTI, although this could be because trade within the South African Customs Union (i.e. Lesotho, Swaziland and Botswana) is not captured in international trade statistics.

Similarly, the amounts of liquid fuel exports reported by the DME in their statistical publications (which is from the South African Revenue Services) do not match the data in the national energy balance (DME 1999, 2000). Given that all data on the petroleum industry was classified until 1993, most of the trade data before then is likely to be suspect. More analysis is needed to understand whether these differences are due to classification categories, pricing and taxation, or other reasons.

Notes to SEW or next year's Observer-Reporter:

Because South Africa does import most of its petroleum, an analysis of resilience from the perspective of imports should be an important next step. This would show the share of South Africa's total primary energy supply that comes from imported non-renewable energy.

In addition, more effort should be put into developing trends over time for this indicator, and discrepancies between different data sources reconciled.

►Indicator 6: Burden of Energy Investments

The South African government has been heavily involved in energy sector development, as in many countries. The electricity industry is dominated by the state-owned utility, Eskom, while local authorities handle most urban electricity distribution. The state's Central Energy Fund owns PetroSA, which comprises the oil and gas exploration company Soekor and the gas-to-liquid fuels producer Mossgas. In addition the coal-to-liquid fuel supplier Sasol was originally a state company, although it is not private. State-owned Petronet runs the national liquid fuel pipeline system, while Portnet controls the ports used for import and export of fossil fuels. The nuclear industry was funded through the parastatal Nuclear Energy Corporation of South Africa (NECSA, formerly the Atomic Energy Corporation), which still absorbs more than 40% of the Ministry of Minerals and Energy's budget vote (down from almost 80% in the late 1980s) (DME 2001a). Many of these parastatal companies have received loans and subsidies of billions, or tens of billions, of Rands in the past several decades. The national government budget, therefore, only represents a small part of the state's involvement and financial burden of the sector (Trollip 1996). This does not, however, mean that all of these institutions are a drain on state resources. Eskom, in fact, is a very profitable enterprise, and, with the passage of the Eskom Conversion Bill, will start paying taxes and dividends to government. Whether government would receive more revenue from a privitised utility is highly doubtful, and depends on the value of the implicit subsidies government provides for Eskom, such a forward cover on exchange rates through the Reserve Bank.

Quantifying the level of state involvement, and tracking this on a regular basis, is challenging for several reasons. First, some enterprises such as NECSA, and even Eskom, have significant non-energy businesses. In fact, the NECSA (or the AEC) has arguably not made any contribution to electricity production in decades, since the actual nuclear power plant at Koeberg is owned and operated by Eskom and the fuel is imported (and when the fuel was produced in South Africa, it used so much energy that it may well have offset electricity production from Keoberg). Second, much of the investment and expenditure in the industry is only seen in changes in balance sheets, rather than as explicit investment. In 1994/95, for example, the Central Energy Fund increased its provision for non-repayment of loans made to Soekor by more than 110 million Rands – and this is, in essence, a state subsidy (Trollip 1996). Thirdly, it is difficult to distinguish between 'investment' by the state (ie procuring fixed assets) and 'expenditure' (ie operating expenses for government or parastatals) – and it would be misleading to call all of the operating expenses a 'burden', because the state companies may have revenue in excess of these expenses. This is certainly true for Eskom, which has posted healthy profits in recent years even after funding the majority of the electrification programme internally.

Eskom and Mossgas investment in 2000 totalled 4 596 million Rands (Eskom 2000a; Mossgas 2002). From this we have subtracted Eskom's investment in the Efficient Lighting Initiative and half of the estimate investment by the Eskom/Shell solar home system joint venture (see indicator 4). Total public non-renewable energy investment is therefore 4 573 million Rands. GDP in 2000 was 874 billion Rands (SARB 2001), so non-renewable energy public investments are 0.52% of GDP.

For this indicator, the value for 1 on the vector is non-renewable energy investment as 10% of GDP. This is taken as the benchmark for unsustainability. The value of 0 on the vector – the sustainability goal – is zero public investment in non-renewable energy. South Africa's vector for 2000 is therefore 0.052 (i.e. 0.0052/0.1).

Metric (actual data) for 2000: 0.52%
Vector values for 2000: 0.052

Discussion:
This estimate of public investment does not capture a range of other institutions – such as the local electricity distributors and the transport/pipeline companies – the investment by the subsidiary state oil companies, research and development in energy that is funded outside the DME (eg from Eskom and the National Research Foundation), or expenditures on infrastructure such as ports for coal handling.

Notes to SEW or next year's Observer-Reporter:

The sources for this indictor should be followed up, and enquiries made to Soekor/Central Energy Fund regarding their investments. The Association of Municipal Electricity Undertakings (AMEU) and the National Electricity Regulator should also be contacted for investment by local authorities in electricity.

Technological sustainability

►Indicator 7: Energy Intensity

As mentioned in the overview of South Africa, the South African economy is highly energy-intensive, comparable to the economies in transition in Eastern Europe and the former Soviet Union or the oil-producing countries in the Middle East. The reasons for this include the structural dependence of the economy on energy-intensive industries such as mining and metals, as well as the higher specific energy intensity of some industrial processes compared to OECD countries (Spalding-Fecher *et al.* 2000b).

Two different versions of this indicator are useful to report. The first is to report total primary energy supply (TPES) divided by GDP at nominal exchange rates. This gives a comparison with other countries on how much energy they use to generate a unit of GDP. Because of differences in the purchasing power of currencies across countries, however, using nominal exchange rates can understate GDP, and so overstate the energy intensity. A second version of the indicator, therefore, is to report commercial primary energy (ie excluding household use of biomass) per unit of GDP at purchasing power parity (PPP) exchange rates.

According to the DME, TPES and commercial energy supply for 1999 were 4 637 and 4 447 petajoules (PJ), respectively (DME 2001d). Commercial energy is estimated from TPES less household biomass use (i.e. total renewables and biomass less use for industrial cogeneration). Nominal GDP in 1999 was 796 billion Rands, or 331 billion 1990 Rands. Based on atlas exchange rates, this is 128 billion 1990 US dollars, while at purchasing power parity (PPP) rates it is 200 billion 1990 US dollars (SARB 2001). South Africa's energy intensity for 1999 was then 36.2 MJ/1990 US$ (based on TPES) or 22.2 MJ/1990 US$ PPP (based on commercial energy).

The value for 1 on this indicator is the 1990 global average energy intensity of 10.6 MJ/US$1990. The value for the zero on the vector is 1.06 MJ/US$1990, or 10% of the 1990 world average. This means that the vector value for South Africa is considerably greater than 1, or almost 4 if exchange rate GDP is used.

Metric (actual data) for 1999: 36.2 MJ/US$ 1990 GDP or 22.2 MJ/US$1990 GDP PPP
Vector values for 1998: 3.67 (using exchange rates) or 2.21 (using PPP)

Discussion:

The White Paper on Energy Policy recognises that the South African economy is highly energy-intensive, but also that low energy prices (one of the reasons for high energy intensity) have provided a competitive advantage for South African industry. South Africa has some of the lowest energy prices in the world, and the cost of electricity production is among the world's lowest (SANEA 1998). Many of the policy proposals included in the White Paper, such as greater diversity of energy supply sources, cost reflective pricing, promoting renewable energy and energy efficiency in a range of sectors, and the development of a natural gas market, have the potential to reduce energy intensity. The White Paper also calls for 'cost-reflective pricing' – in other words to move energy prices to reflect their true marginal cost of production. Current electricity prices, for example, largely reflect the fact that Eskom's power stations are already paid off and were financed at very low interest rates. Future investments, however, will likely come at much higher cost and may reflect private sector demand for higher returns if part of the industry is privatised. The price signals that people receive today, therefore, including investors in energy-intensive industry, do not reflect the marginal cost of electricity – or what it will cost to generate the next additional amount of electricity that requires new generation plant.

Furthermore, a key element of South African industrial strategy is the establishment of so-called 'spatial development initiatives', which refer to locations where government hopes to facilitate industrial development through public-private partnerships, the improvement of infrastructure, the establishment of strategic anchor projects and the creation of industrial clusters and industrial parks. The two main types of spatial development initiatives are 'industrial' and 'eco-tourism'. The former includes initiatives such as the Maputo Development Corridor and the Coega Industrial Development Zone. The key to success for these spatial development initiatives is investment in energy-intensive anchor projects, such as the proposed zinc smelter near Port Elizabeth. The risk of these policies is that, while they may promote industrial development in the short run, they carry a high risk of 'locking in' the economy into energy-intensive industries, when environmental, economic and social pressures may push South Africa in the opposite direction. The reason for this 'lock in' is that, once a major investment like a smelter is made, there are very limited opportunities to improve the energy efficiency or also the production process. Recent investments in steel and aluminium bear this out – while the processes may be optimised for that technology, the wholesale switch to a more efficient technology is very costly after construction (Visser *et al.* 1999).

Notes to SEW or next year's Observer-Reporter:

Total energy consumption is available from DME, while the South African Reserve Bank reports real GDP and exchange rates.

►Indicator 8: Renewable Energy Deployment

Renewable energy has long been considered the 'poor cousin' of large-scale, centralised fossil fuel and nuclear energy production in South Africa. In fact, the phrase 'energy for development' under the apartheid-era government effectively meant that renewable energy technologies would only be used for 'developing areas' (ie poor black communities) in remote rural areas (Marquard 1999). That has changed significantly since the new government promulgated the White Paper on Energy Policy, which includes a range of initiatives to promote renewable energy. Much of this effort, however, still is only focused on rural areas, where renewable energy is more financially cost effective than extending the electricity grid. The Department of Minerals and Energy developed a renewable energy strategy, which will be tabled as a draft White Paper on Renewable Energy in 2002 (Mlambo-Ngcuka 2002).

Renewable energy in most Africa countries means biomass, first and foremost. This has also been true in South Africa. Except for a few small hydroelectric facilities, cogeneration by sugar and paper companies, and a small number of other renewable energy demonstration projects, traditional biomass use has been the only significant source of renewable energy until very recently. Quantitative research on national biomass consumption, however, has been very limited, with the DME Biomass Initiative being the most authoritative report (Williams *et al.* 1996).

As discussed above in Indicator 4, several large demonstration projects are under discussion in South Africa, including ones that would supply centralised renewable electricity generation. In addition, the off-grid concessions programme will be one of the largest programmes of its kind in the world, and will create a market for solar home systems that could top $70 million per year (EC *et al.* 2000).

According to the DME energy balances, South Africa's share of renewable energy to TPES in 1999 was 5.7%. This includes commercial and household biomass use, domestic hydropower (which are fairly small scale), and electricity imports that are sources from hydropower in Mozambique, Zambia and Democratic Republic of Congo. For this indicator, the value for 1 on the vector is the world average renewable energy supply as a share of total primary energy supply (TPES) in 1995, which was 8.64% (HELIO International 2000). The value for 0 on the vector, which is our sustainability goal, is 95%. This means that South Africa's value on this vector is 1.04.

Metric (actual data) for 1998: 5.7%
Vector value for 1998: 1.04

Discussion:

The greatest barrier to *tracking* the deployment of renewable energy in South Africa is the lack of good data on household biomass consumption. Biomass production and use reported by government statistics varies widely from year to year, largely because there is no authoritative primary data source. Even the 1998 energy balance, probably the most thorough to date, relies on a 1996 Biomass Initiative report from the DME for the biomass consumption estimates, and these data would have been based on data from earlier years (Williams *et al.* 1996; Pouris 2001). The data used here have been taken from the DME energy balance, therefore, assuming that household use of biomass has remained fairly constant at 190 PJ per year, similar to what the Biomass Initiative estimated.

Even if we knew total biomass production and consumption, however, it is not clear how much of this is 'sustainable' – in other words, how much is sustainably harvested. The level of uncertainty about land-use change, such as deforestation, impacts on South Africa's greenhouse gas emissions, for example, is high. There are no reliable estimates from government on the net changes in fuelwood stocks (Williams 2001).

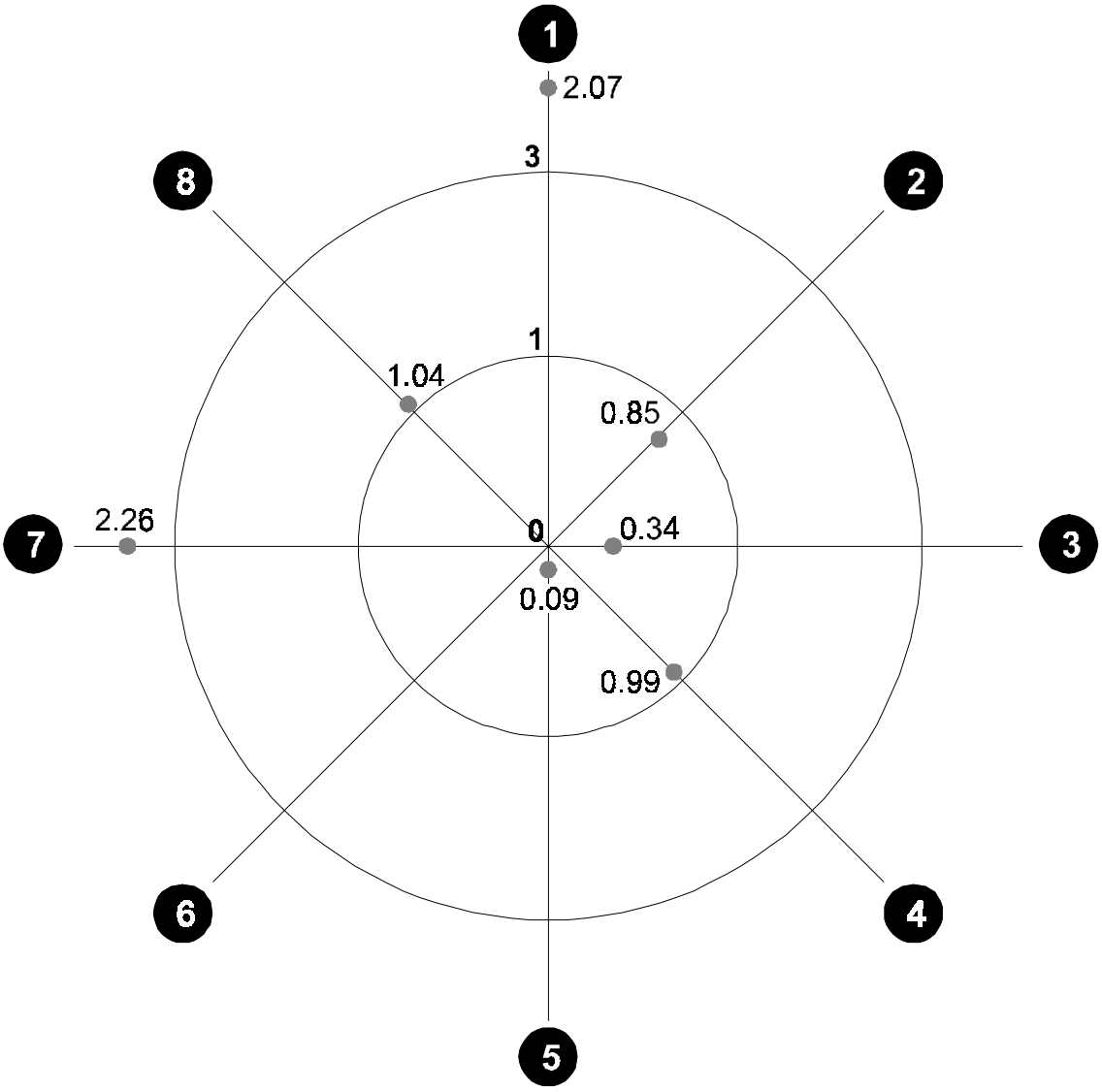
For this indicator to be a useful reflection of South African energy development, and for government to have any understanding of the impact of national policy on the poor, rural populations that still depend heavily on biomass, more systematic data collection and analysis is urgently needed. For countries such as South Africa to push for renewable energy development without a major emphasis on the sustainable and efficient use of local biomass resources would be an expensive, and possibly inequitable, strategy for sustainable development.

In addition, while much of the current and proposed SADC hydropower stations are either run-or-river or have relatively small impoundment areas, there are still questions about the sustainability of large hydropower projects. This has been raised by the World Commissions on Dams (WCD) in their review of large dam projects, but it has not been possible to do a review of the sources for SA imports for this report.

Notes to SEW or next year's Observer-Reporter:

The reporter should consult the DME and the consultant who does the energy balances (Dr A Pouris) to see if any additional research on biomass is available. The reporter should consult the WCD studies and bibliography for information on the dams from which SA imports power.

South Africa's 'Star'



Conclusions

►Reporter's Conclusions on all Indicators

To summarise the results for South Africa on the indicators, it is helpful to review how the vectors were created. In each case, the value of 1 on the vector represents the 'status quo' – either by reflecting world averages in the last decade or the actual country's performance in the last decade. The value of 0 on the vector represents the sustainability goal. Moving all the way to zero on a given vector means that the country's energy system is highly sustainable along that particular dimension, whether it be economic, social, environmental or technological. Vector values greater than 1 either mean that the country is even more unsustainable than the global average, or is getting worse than the performance in the last decade.

South Africa is the closest to the sustainability target on the indicators for access to electricity (0.34) and resilience to external impacts (energy exports) (0.08). The former reflects the success of the ambitious mass electrification programme, which has been a key social and economic goal for the democratic government. Government commitment to continue this programme, and provide substantial funding for it, bodes well for continued improvement in this indicator.

The low value for resilience to external impacts (energy exports) may be somewhat misleading. While it is true that South Africa is not as vulnerable to international energy markets as the OPEC countries, there is significant concern in the country about how the implementation of the Kyoto Protocol will affect the coal industry, and the 61 000 workers that it employs (SANEA 1998). The DME, for example, commissioned its first ever major climate change research in early 2001 – and the top priority is to analyse impacts of the Kyoto Protocol on coal markets. A report from the International Energy Agency suggests that South Africa may be the most vulnerable fossil fuel-exporting country in the world to the impacts of the Kyoto Protocol (Pershing 1999). South Africa will have to drop well below 0.09 on this indicator, therefore, before it is less vulnerable to external impacts.

South Africa performs worst on the indicators for carbon emissions per capita (2.35) and energy intensity (2.21). The reasons for the energy and emissions intensity of the economy are described in more detail in the body of this paper, and include heavy reliance on energy-intensive industries for domestic economic production and export, high dependence on coal for primary energy, higher energy-intensity of synthetic petrol made from coal, low energy prices and poor energy efficiency of individual sectors. Continued high energy-intensity is potentially a competitive disadvantage for the South African economy. The National Economic Development and Labour Council, for example, a powerful triparite commission comprising representatives from government, industry and labour, has recently commissioned work to look at impact of the Kyoto Protocol on manufacturing in South Africa (as opposed to the coal industry), which focuses on the risk to energy- and emissions-intensive sectors.

High carbon emissions intensity makes South Africa increasingly vulnerable to pressure to take on some kind of commitment within United Nations climate change negotiations process. Although South Africa is still classified as a developing, or 'non-Annex I' country, its emissions per capita and per unit of GDP are considerably higher than most developing countries. On the other hand, this carbon emissions intensity makes South Africa an attractive candidate for Clean Development Mechanism[3] international investment projects, which could help to move the country onto a lower emissions intensity path. Nevertheless,

[3] The Clean Development Mechanism under the Kyoto Protocol to the UN Framework Convention on Climate Change allows industrialised countries to invest in project in developing countries that reduce greenhouse gas emissions, and claim part of the credit for these reductions against the industrialised countries' emissions limitation targets.

government policy is urgently needed to address carbon emissions intensity in way that also promotes development – for example, through stimulating large-scale investment in cost-effective energy efficiency and diversifying South Africa's energy mix.

Investment in clean energy is only beginning in South Africa, so this indicator is also still quite high (0.99). As discussed in this paper, there are positive signs of both pubic and private sector commitment to increase investment in renewable energy and energy efficiency. The challenge is to maintain these goals through the restructuring of the energy industry – particularly the electricity industry – so that restructuring does not spell the end of clean energy. The indicator for renewable energy deployment (1.04) also reflects the long road ahead for South Africa in developing renewable energy sources – and challenge to move beyond seeing these only as solutions to remote area energy problems.

Finally, while the indicator for local pollution remains high (0.85), the significant improvement since 1990 is encouraging. More research will be needed, however, to make this indicator accurately reflect the national progress on local air pollution, rather than progress in only one location.

In summary, the political commitments of the post-apartheid South African government recognise the importance of equity in access to affordable energy. Progress in this important area of sustainability is a major accomplishment. The new South Africa, however, is full of legacies from the old – including the energy-intensive economic structure and reliance on abundant domestic coal – and in some cases current policies are reinforcing these legacies. This poses a major challenge to policy makers, industry, and civil society. New policy documents recognise the importance of these issues, but progress 'on the ground' has been slow, and there are, at the same time, conflicting policies that push South Africa away from sustainability. Our hope is that these indicators, and the discussion of their implications, will provide an useful starting point for stakeholders to debate South Africa's future, and how co-ordinated policy and concrete action can create a more sustainable energy sector that supports the development and welfare of all South Africans.

►Recommendations to SEW

*** conflict between indicators – access before no public investment

This section raises several issues about the indicators, and how they are used for a country such as South Africa. Changes to how the indicators are measured, or which indicators are used, could improve the quality of reporting – and also reduce the time required to produce the reports.

1. Access to affordable energy

While indicator 3, access to electricity, is one important indicator of the social equity side of energy systems – and a relatively easy one to measure – it does not really tell us whether people can *afford* the energy to which they have access. Research in South Africa suggests that many electrified households still do not use electricity – and may even use traditional, highly polluting fuels – because they can not afford to pay for the electricity (Mehlwana 1998; Thom 2000). There are also a variety of social and cultural reasons why people may still choose to use non-electric fuels (Mehlwana 1999b). Of course, simply tracking the price of energy is not the answer, because we are concerned about *services* (eg home heating, cooking, hot water) rather than energy use and prices, per se. Perhaps an additional measure could be 'the cost of cooking a meal for the poor', which would reflect not just energy costs but the efficiency of the appliances and fuels available to households. We recognise that the data for this will be hard to find for many countries, but there is a substantial information on cooking stove efficiency and often data on the share of households that use particular appliances. It might be possible to make some estimates at least that would provide a valuable social metric.

2. Indicator 4: Clean Energy Investment

As mentioned in the text, having to compare clean energy investment to the total requires significant additional research and analysis. Maybe it would be just as effective to compare clean energy investment to energy sector GDP. Of course, the sustainability goal would not be 100%, because annual investment will only be a fraction of energy sector GDP. Additional analysis would be needed to define a sustainability target, but it would be easier to use GDP and annual investment.

3. Indicator 5 – resilience and trade

The conclusion for South Africa discusses why a relatively low value on this vector is not necessarily good news. It may be necessary to scale this vector so that even 10% of total exports to non-renewable energy is still relatively close to one. This could be done with a logarithmic scale. More county reports should be analysed to see whether this would be feasible.

4. Indicator 6 – burden of public investment in energy

Our proposal is that this indicator should measure investment and not state expenditure. Ideally it should include R&D investment, but this may be difficult. This is explained under the discussion of indicator 6 in this report.

5. Indicator 7

There has been some discussion in the past about whether this indicator should be energy productivity (GDP/energy) or energy intensity (energy/GDP). While energy productivity is a more positive concept, to convert the information to a vector with 0 being the best, we would still have to use the inverse of productivity.

▶Notes to Future Observer-Reporters

Most of the necessary comments to observer-reporters have been included under the individual indicators. In addition, the spreadsheet containing the data and calculations for the indicators is available from the author (randall@energetic.uct.ac.za). A list of contacts for the data and reports will also be included.

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