The Challenges of Carbon Mitigation and Implications for South Africa in the post–2012 Context

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Introduction

Anthropogenic (man-made) climate change has been dubbed a 'tragedy of the commons'[2] because it is a global phenomenon caused by many countries (through their respective carbon emission levels) and its impacts will be felt across all countries, irrespective of the levels of their contribution to carbon emissions. Global climate change has already begun and will affect many states in terms of food security, water security and ultimately human security. The implication is that carbon mitigation[3] is not just a global issue requiring international co-operation between government and non-government actors. It also requires carbon-intensive countries to cut their emission levels.

The Kyoto Protocol is the current international climate change regime, which will remain in force until 2012. The second phase of the protocol is being negotiated, with talks on a post-Kyoto regime for 2012–2016 having taken place in Bali in December 2007, and in Bangkok, Bonn, Accra and Poznan in 2008. The final round of these talks, known as the Bali Road Map, will be in Copenhagen in December 2009; at this, a new treaty is expected to be signed and ratified by all states party to the present regime. To mitigate the long-term effects of climate change, universal compliance with the treaty is crucial. The next phase is expected to entail penalties for non-compliant states.

South Africa faces a significant challenge in this area; as a coal-dependent country with carbon-intensive mining and industrial sectors, it has one of the highest per capita carbon emissions in the world. In a move to reduce the impact of climate change, the South African government published a document called *Long-Term Mitigation Scenarios* which examined the potential for carbon mitigation in South Africa and presented four strategic options. In July 2008 the Minister of Environmental Affairs and Tourism, Marthinus van Schalkwyk, unveiled the *Vision, Strategic Direction and Framework for Climate Policy,* which outlined a number of broad policy themes. These were: carbon emission reductions; limits to the strengthening of energy efficiency policy; preparing for vulnerability and adaptation to climate change; and ensuring

that government and other stakeholders co-operate and are aligned with policies responding to climate change.

This chapter discusses the challenges and opportunities of greenhouse gas mitigation in South Africa and the country's ability to comply with the second phase of the Kyoto Protocol. It focuses on three issues: coal dependency, renewable energy and the implementation of a clean development mechanism (CDM). As it relates to energy security rather than carbon mitigation, nuclear energy is only discussed from the standpoint of its viability in South Africa.

For the purposes of this chapter, carbon or greenhouse gas mitigation means the policies and measures designed to reduce greenhouse gases in the atmosphere. Of these, only carbon dioxide, sulphur dioxide, methane and nitrous oxide are significant in South Africa.[4] In addition to their causal connection with climate change, now a matter of scientific consensus, these gases are harmful to the air quality and general health of the population.[5]

With the Bali Road Map picking up momentum, the international community and local stakeholders will be scrutinising South Africa more closely. The country will have to strike a fine balance between reducing its own greenhouse gas emissions and ensuring long-term energy security. It is in the unique position of being classified as a non-Annex 1 country[6] despite its high per capita greenhouse gas emissions,[7] meaning that it is not required to reduce emissions to 1991 levels during the Kyoto Protocol's 2008–2012 phase.

There are many questions about how the post-Kyoto treaty will affect South Africa: will it be legally compelled to reduce its carbon dioxide emissions?[8] Will focusing on reducing greenhouse gas emissions work against its macroeconomic and socio-economic objectives? In the current economic downturn, will the government continue to place a high priority on reducing greenhouse gases, or will there be trade-offs between climate change policy and development? If government can square the climate change and development agendas, it will be a remarkable achievement which will serve as an example to the rest of Africa.

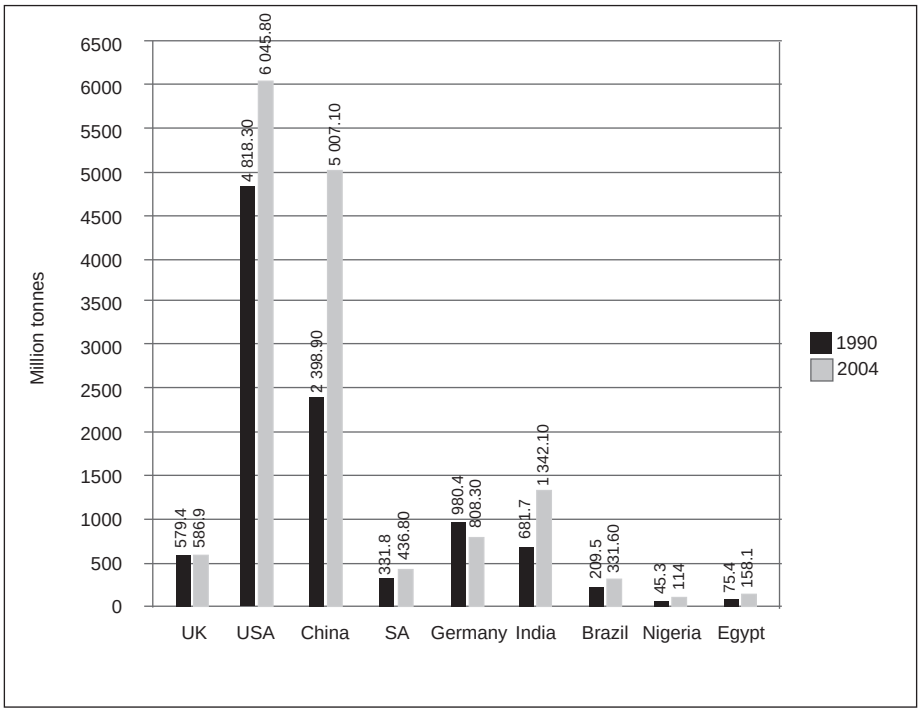
South Africa's emissions profile

South Africa is seen as a major power in Africa and an anchor state in the southern African region. It is among the continent's top 10 states in terms of economic growth and has a well-developed infrastructure compared with many neighbouring countries, while its financial system is considered one of the best in the world. With strong agricultural, mining, industrial and service sectors, it accounts for roughly 75% of the gross domestic product (GDP) of the Southern African Customs Union.[9] But South Africa's economic and infrastructural strength comes at a price: it is underpinned by a dependency on coal as its

primary energy source. When it is burnt, coal emits carbon dioxide (CO_2), methane (CH_4) and sulphur dioxide (SO_2).

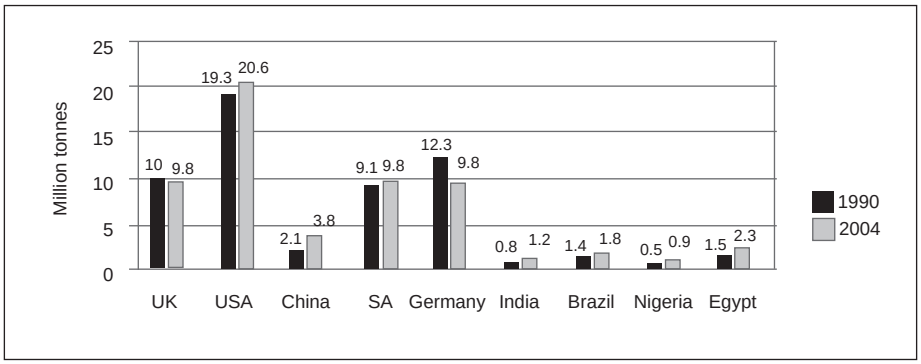
Compared to the developed economies classified under Annex 1 of the Kyoto Protocol, South Africa does not have high CO_2 emissions (see Figure 1). One per cent of global emissions were generated by South Africa in 2004. According to the *United Nations Human Development Report 2007/2008* (Figure 2), these totalled about 436 million tonnes in 2004, while the United States (US) and China emitted 6 045 million tonnes and 5 007 million tonnes respectively. But South Africa's per capita emissions were much higher than China's — with 9.8 million tonnes of CO_2 compared to 3.8 million as a result of industrial output. Its per capita emissions are also higher than those of the US and of other emerging economies and exceed the global average. In addition, its carbon output has increased significantly in the past 15 years (see Figure 3); with CO_2 emissions rising 2.3% between 1990 and 2004 (see Figure 2).

Figure 1: Total CO_2 emissions per country



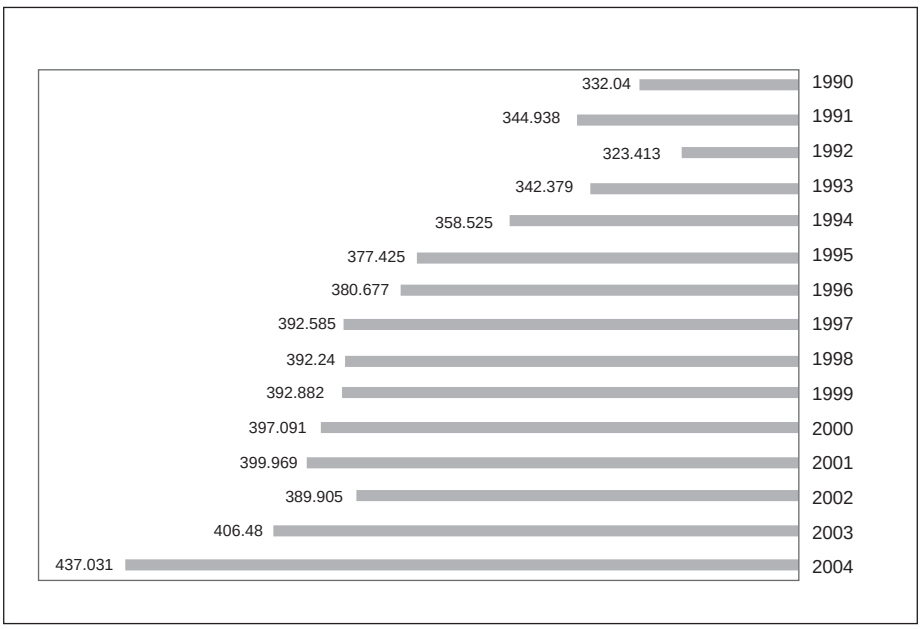
Source: Adapted from the United Nations Development Programme's (UNDP) *Human Development Report 2007/2008*.[10]

Figure 2: CO_2 emissions per capita



Source: Adapted from the UNDP's *Human Development Report 2007/2008.*[11]

Figure 3: Carbon emissions in South Africa, 1990–2004, in million tonnes of CO_2



Source: Adapted from the Millennium Development Goals Indicators, 2008.[12]

Industry and mass electrification are key factors in this, as the country's mining and manufacturing sectors are energy-intensive and energy is sourced from coal. South Africa's highest emissions occur in public electricity and heat

production, manufacturing and construction, and internal transportation.[13] Its carbon dioxide intensity is particularly high — 0.87 metric tons per thousand $1995.[14] As mentioned before South Africa is a non-Annex country and is not legally compelled to reduce emissions during the 2008–2012 phase of the Kyoto Protocol. But as one of the foremost adherents of the climate change regime, it should lead by example. However, this is difficult to achieve given the government's ambitious socio-economic agenda.

As part of its post-apartheid development path, the South African government embarked on a policy of providing electricity to all citizens, and by 2004 77% of urban households were electrified.[15] While successful at household level, this policy did not include increasing the capacity of the national electricity grid or diversifying the energy mix to increase the use of renewable energy.[16] Coal now accounts for 93% of the country's electricity output, despite being an inefficient and carbon-intensive energy source. For every kilowatt–hour of electricity produced, 0.5kg of coal is burnt and 1.29 litres of water consumed, while the by-products are 142g of waste ash and 0.9kg of carbon.[17]

South Africa's compliance with the international regime

International regimes have been defined as 'the set of rules, norms and decision-making procedures that co-ordinate state behaviour within a given issue area',[18] and also as '…principles, norms, rules, and decision-making procedures around which actor expectations converge in a given issue area'.[19] The Kyoto Protocol itself, the United Nations Framework Convention on Climate Change (UNFCCC), the Intergovernmental Panel on Climate Change and Kyoto's flexible mechanisms are key components of the current climate change regime. Other important elements are the protocol's member states and non-governmental organisations such as the Prototype Carbon Fund, the Global Emissions Fund, and the Climate Action Network. Co-operation between state and non-state actors is of paramount importance in resolving or negotiating aspects of a regime, especially Kyoto's second phase.

The Kyoto Protocol

Almost all members of the United Nations have ratified the Kyoto Protocol and embarked on adaptation and mitigation strategies.[20] Initial exceptions included the US and Australia, which although signatories to the UNFCCC, opposed the protocol, hindering early mitigation efforts. The US supported it under Bill Clinton's administration but refused to do so under the administration of George W Bush. The protocol only came into force from 2005 when the Russian Federation ratified it. In 2008, the administration of the newly elected

Australian premier, Kevin Rudd, ratified the protocol. It remains to be seen whether the US under President Barack Obama follows suit.

The Kyoto Protocol focuses on the reduction of greenhouse gases and carbon emissions to pre–1990 levels by 2012.[21] One of its key objectives is to use its flexible mechanisms to give an incentive to states to participate and co-operate in mitigating the impact of climate change. It helps developing countries do this through such mechanisms as the CDM, and assists former communist countries via the joint implementation mechanism. The protocol also encourages developed countries to trade emission credits, generated through proven emission reductions from CDM projects, on emission trading schemes, generally referred to as carbon markets.

While South Africa is not obliged to reduce its carbon emissions to 1990 levels it should implement mitigation strategies, because it is such a major emitter.[22] Crucially, it should adopt less carbon-intensive technologies to ensure energy security while meeting the government's ambitious mitigation targets. The reason for this is that South Africa will potentially be severely affected by the impacts of climate change.

The effects of climate change in South Africa

The *Stern Review on the Economics of Climate Change* asserts that sub-Saharan Africa will be hardest hit by climate change.[23] At issue is more than a mere change in the weather: in addition to basic human survival and urban usage, agriculture and mining need water, and prolonged drought would harm these important sectors. Food scarcity would become a bleak reality for even more South Africans, while higher temperatures would increase the risk of destructive bush fires. Some multinational corporations could move to countries less affected by climate change.

Significant temperature increases would also affect the country's ecosystems, some of which boast unique flora and fauna. While some species would face extinction, others, such as mosquitoes, would proliferate, in turn increasing the incidence of diseases such as malaria and dengue fever.

Climate change could bring more than drought. Intense storms and flooding in water-rich areas and areas close to sea-level are also expected, and this has already started to occur. As a consequence, insurance costs and premiums would rise.[24] The overall result would be deterioration in the quality of life of South Africans.[25]

South Africa must develop alternative sources of energy which are less carbon-intensive than coal. Alternatives exist, but would take considerable time to develop and implement on a large scale. At the same time, domestic energy needs cannot be ignored in the short term and Eskom, the sole electricity provider, has undertaken to build more coal power stations to meet rapidly

growing demand.[26] South Africa's energy sector accounts for 80% of the country's greenhouse gas emissions, primarily in the form of carbon dioxide, methane, sulphur oxide and particle matter.[27]

South Africa's climate change policy

South Africa lacks legislation on climate change and emissions reduction, but the government has outlined a strategic framework which will underpin future legislation. One of the outcomes of the cabinet lekgotla of July 2008 was a decision to hold a national summit in March 2009 on policy development in response to climate change. This was expected to facilitate the adoption of a framework for climate change policy, followed by further consultation. A Green Paper on climate change will be published in April 2010, and the policy will be translated into a legislative, regulatory and fiscal package for implementation.

The government's *Vision, Strategic Direction and Framework for Climate Policy* mentioned earlier comprise six policy pillars which will guide South Africa's climate strategy. They are:

- greenhouse gas emission reductions and limits;
- building on, strengthening and/or scaling up current initiatives;
- implementing the 'business unusual' call for action;
- preparing for the future;
- identifying vulnerability and adaptation to climate change; and
- ensuring the alignment, co-ordination and co-operation of all actors.

The first pillar entails the 'peak, plateau and decline' emissions trajectory, in terms of which carbon emissions will stop growing by 2020–2025, stabilise at a plateau from 2030–2035 and fall in 2050–2060. Pillar two involves scaling up existing demand-side initiatives and interventions through regulatory instruments and mechanisms, including a proposed carbon tax. The aim of pillar three is to ensure that the renewable energy and transport sectors meet national targets for energy and emissions reduction respectively. Pillar four includes providing support for carbon-friendly technologies, especially in the energy and transport sectors, so that they meet research and development targets. Pillar five entails identifying South Africa's vulnerabilities to climate change and ensuring that adaptation interventions are undertaken. Under pillar six the roles and responsibilities of stakeholders will be clearly defined to ensure that all spheres of government are aligned and co-ordinated and work together.

Between February 2009 and 2012 the government plans a process which will lead to climate change legislation. The schedule is as follows:

- February 2009: summit on policy development in response to national climate change;
- February–June 2009: sectoral policy development work;
- Up to July 2009: post–2012 positions;
- December 2009: conclusion of the UNFCCC post–2012 negotiations;
- March 2010: updating of national policy to meet international commitments;
- April 2010: publication of the Green Paper for public comment;
- End of 2010: publication of the final national climate change response policy; and
- The period until 2012: translation of policy into a legislative, regulatory and fiscal package.

While the government has shown it has the political will to comply with the international climate change regime by outlining various policies and frameworks, parastatal entities such as Eskom and heavy carbon emitters in the private sector are under increasing pressure to co-ordinate and align their policies so that the government's objectives are met. Three areas of challenge and opportunity, which feature in the climate policy, are coal dependency, renewable energy and CDM implementation. The viability of nuclear energy in South Africa is also briefly examined in the next section.

Challenges and opportunities in carbon mitigation

Coal dependency

Eskom foresaw that South Africa would be hit by an electricity supply shortage in 2007.[28] To meet current and future energy demand, it has embarked on a strategy that includes building two more coal-fired power stations, Medupi and Kusile,[29] with the aim of raising total generating capacity to 80 000 megawatt (MW) over the next 20 years.[30] What is particularly worrying about this is that Eskom's projected carbon emissions are set to increase even further. Eskom's 2008 annual report, tabled in parliament, reveals that its emissions rose from 208.9 million tonnes in 2007 to 223.6 million tonnes in 2008, while nitrous oxide increased from 2.7 to 2.9 kilotons and sulphur dioxide from 1 875.7 to 1 983.9 kilotons.[31] By 2025 emissions could increase between 350 million and 450 million tonnes, depending on whether Eskom can cut coal from 90% to 70% of its energy production mix.[32] Unless steps are taken to implement such

technologies in the medium term, the country risks missing the targets set in the government's various strategy documents.

Carbon capture and sequestration (CCS) technologies are designed to reduce emissions from coal-fired power stations and other plants fired by fossil fuels by capturing carbon dioxide and storing it, instead of releasing it into the atmosphere. Depending on the plant type, they have the potential to reduce CO_2 emissions by up to 90%. The leading technologies for carbon capture in power plants are the integrated coal gasification combined cycle, pulverised coal power plant and natural gas combined cycle. CO_2 storage takes three forms: gaseous storage in deep geological formations, liquid storage in oceans, and solid storage by reacting carbon dioxide with metal oxides to produce stable carbonates. However CCS technologies are expensive and most have not yet been implemented on a large scale.[33] One proposed solution is financing through the Kyoto Protocol's clean development mechanism and carbon credits. However, this can only be done if the criteria for clean energy projects are met and approved in terms of verification standards.

Nuclear energy

According to environmental expert David Fig, the claims that nuclear energy is carbon-friendly are not altogether accurate. During the entire generation cycle –which encompasses mining, milling, conversion, enrichment, fuel fabrication, construction, transport, waste disposal, reprocessing, decontamination, and decommissioning about 40g of CO_2 per kilowatt of nuclear energy is emitted into the atmosphere. This leaves out of account the cost of nuclear energy and other drawbacks, such as the radiation risk, transportation dangers, and problems of waste disposal, risk of nuclear weapons proliferation, a nuclear industry skills deficit and South Africa's difficulties in regulating the industry.[34]

There are plans to establish a nuclear waste management agency, and both Eskom[35] and the National Electricity Regulator of South Africa insist that high standards apply to the management of waste and its disposal at the Vaalputs facility in Namaqualand, Northern Cape. Eskom has built-in safeguards for dealing with high-level nuclear waste. It is stored in 10-metre-deep trenches and the site is fenced off and constantly monitored.

The government has touted a new technology, the pebble-bed modular reactor (PBMR), as the answer to South Africa's energy needs. The technology involves the use of tennis ball-sized pebbles of graphite containing enriched uranium, which will be imported through a harbour, possibly on the KwaZulu-Natal coast, heightening worries about the safety of nuclear energy in South Africa.

The financial implications of the PBMR project are also grounds for concern. Lakhani and Black predicted in 1998 that the first reactor would cost R1 billion and create 'thousands' of jobs. Ten years later R1,5 billion has been spent on the design and feasibility process, and Lakhani and Black contend another R10 billion will be required to build the first pilot reactor and fuel plant.[36] Critics also argue that the PBMR will create many fewer jobs than the renewable energy industry. It has been estimated that if South Africa reaches 15% generating capacity from renewable energy, it will create 34 400 direct jobs by 2020.[37] Using an investment of R12 billion as a benchmark, Earthlife Africa estimates that one 165 MW PBMR would create 80 full-time jobs and 1 400 construction jobs of a year's duration. By contrast, 1 700 MW of wind power would create 850 full-time jobs and 3 000 local construction jobs, while generating 5 700 MW of solar photovoltaic power would create 680 full-time jobs and 8 800 construction jobs. About 795 MW of generating power would be saved by providing solar water heating for 1.2 million houses.[38]

Nuclear energy has been presented as a pragmatic alternative to coal dependency, but critics question its sustainability and safety. Public awareness of the issues needs to be heightened, and it is imperative that public awareness is raised on these issues and that policy-makers weigh their options carefully and are guided by the public interest.

Renewable energy

In the 2003 White Paper on Energy Policy, the government targeted a renewable energy contribution of 10 000 gigawatt–hour (GWh) to South Africa's overall energy consumption by 2013. Achieving this target will contribute 1 667 MW of new renewable energy capacity.[39] Renewable energy options include hydro-electricity, wave, wind and solar/photovoltaic power.

Hydro-electric power

To generate hydro-electric power, moving water drives turbines. South Africa has eight small licensed hydro-electric facilities with a combined capacity of 68 MW. The power generation potential of small hydro-electric schemes amounts to 9 900 GWh annually. Regionally the Southern African Power Pool provides for the free trading of electricity between Southern African Development Community member countries, giving South Africa access to the vast hydro-power potential of the Inga Falls in the Democratic Republic of Congo. The Lesotho Highlands Water Scheme also has the capacity to contribute about 72 MW of hydro-electrical power to the system in the short term.[40]

Wave power

Wave power involves a collector to capture the wave energy and a turbo-generator to transform this into electricity. The department of minerals and energy believes there is significant wave energy potential along the Cape coast, which it estimates at 56 800 MW. However, the technology has not been fully developed and the estimated cost of energy conversion is enormous.[41]

Wind power

Wind energy is generated either by windmills or large wind turbines grouped in 'wind farms'. The wind power potential of most coastal and escarpment areas is fairly good, with mean annual wind speeds of more than six metres per second. Current estimates are that wind power could supply 198 000 GWh, or at least 1%, of South Africa's projected electricity needs.[42] Eskom is currently generating electricity at the Klipheuwel Wind Farm 40km north of Cape Town, whose three wind turbines have a combined generation capacity of 3.16 MW.

Solar and solar photovoltaic power

Photovoltaic power is generated by using reflective surfaces to capture sunlight and converting it into electricity. Photovoltaic systems are used in telecommunications networks, small-scale remote stand-alone power supplies for domestic use, game farms and household and community water pumping schemes. Current capacity is estimated at 12 MW.[43]

Challenges and opportunities in renewable energy

Hydro-power is limited in South Africa because of geographical constraints and lack of water, and while other forms of renewable energy have been tried, their capacity is limited by high initial costs. The Renewable Energy Feed-In Tariff (REFIT) Bill is expected to be tabled in parliament. This bill provides for the integration of a Feed-in Tariff into the price of renewable energy, as a means of effectively subsidising renewable energy generators.44 The overall objective of such an instrument is to create an incentive for the production and generation of renewable energy, because producers will have a guaranteed price for their commodity. According to the National Energy Regulator of South Africa (NERSA) the Feed-in Tariff is the preferred regulatory mechanism (in comparison to mandated targets or tendering systems), because South Africa still needs to establish its renewable energy industry.45 The Feed-in Tariff has had considerable success in Germany, where it resulted in €7 billion in business and employed approximately 240 000 people.46 Although the Feed-in Tariff will stimulate investment in this sector, it will not lower the cost of electricity

for the consumer. Another possibly contentious issue is that Eskom has been appointed the sole buyer for all renewable energy generated during the 15-year contract period.47

Another opportunity is green power trading, a concept that is slowly gaining ground and provides an incentive to increase investment in renewable energy production. Tradable renewable energy certificates (TRECs), also known as green tags or green certificates, are issued for each megawatt–hour of green electricity generated. The Association of Issuing Bodies defines green electricity as that generated by wind, solar, water (small hydro-electric and wave), geothermal sources and biomass. It excludes electricity generated from nuclear fuels and landfill waste. Green power trading is also not considered as forming part of carbon trading.

Certified emission reductions (CERs) form part of the CDM process and complement TRECs. The latter provide a mechanism for the supply of green electricity in a voluntary market in Southern Africa, while CERs provide a framework for funding and transacting global emission reductions in terms of the Kyoto Protocol. CERs can be generated from any project that reduces emissions, provided that the project is registered as part of a CDM, while TRECs access the wide-ranging benefits associated with green electricity.[48] In addition to emission reductions, these include enhanced price certainty, diversification of generation, better job creation opportunities and the establishment of a viable renewable energy generation industry.

CDM implementation

Challenges in implementing the CDM include the limited scope of existing projects, the complexities of the CDM project cycle, the rigorous regulatory framework and the financing of such projects. By mid-January 2009 proposals for more than 97 CDM projects had been submitted to the Designated National Authority falling under the Department of Minerals and Energy, while only 14 approved and registered projects were operational, three of which have been issued with CERs.[49] South Africa leads the continent in implementing CDM projects, but lags behind India and China, which have 426 and 562 registered projects respectively.[50] Registered operational CDM projects in South Africa are:

- the Kuyasa low-cost urban housing energy upgrade project in Khayelitsha;
- the Lawley Fuel Switch Project;
- the Rosslyn Brewery Fuel-Switching Project;

- the Petro-SA Biogas to Energy Project;
- the Durban Landfill-gas-to-electricity project;
- the Tugela Mill Fuel Switching Project;
- the EnviroServ Chloorkop Landfill Gas Recovery Project;
- the Omnia Fertilizer Limited Nitrous Oxide (N2O) Reduction Project;
- the Mondi Richards Bay Biomass Project; and
- the Sasol Nitrous Oxide Abatement Project.[51]

The main aim of such projects is to reduce emissions by using clean technologies. They also contribute to technology transfer and sustainable development — a 2% levy on the emissions credits is allocated to the UN Adaptation Fund, used to help developing countries adapt to the current and future effects of climate change. However, Erion *et al* assert that some CDM projects are financially and ecologically unsustainable, describing them as 'low-hanging fruits' which have little effect in reducing greenhouse gases while receiving a high yield of emissions credits as having a negative impact on the health of nearby residents, and failing to take the concerns of the local populace into account when implementing the projects.[52]

Stowell[53] correctly describes the CDM project cycle as complex, as it requires the following: extensive project design and formulation (through a project design document, a PDD); host country approval (through the Designated National Authority, which is the Department of Mineral Affairs and Energy in South Africa); validation (by a certified Operational Entity), and registration with the CDM executive board, project financing (through investors); monitoring (through the project participants); verification and certification (by another independent operational entity, which is PricewaterhouseCoopers in South Africa); and the issuance of certificates from the CDM Executive Board of the UNFCCC.[54] Emissions trading depend on the type of Clean Development Mechanism verification that the project received. Ashdown[55] explains that projects which achieve Gold Standard verification will have their emissions credits (classified as CERs) traded on the largest compliance market, the European Union Emissions Trading Scheme. Voluntary compliance markets are reserved for projects that that are not subjected to stringent regulations. While regulations are crucial to ensuring the validity of projects, the processes required are lengthy and drive up the cost of emissions credits. The largest voluntary compliance market, the Chicago Climate Exchange, trades renewable energy certificates and verified emissions reductions (VERs). A third type of exchange, the voluntary carbon market, is used for a wider range of applications

than compliance and voluntary compliance markets, and credits traded on them do not require compulsory validation. The credibility of some VERs has been questioned, but the trade-off is that they are generated more quickly — a lucrative incentive for investors in CDM projects.

Conclusion

In the run-up to the UNFCCC's Conference of the Parties (COP15) in Copenhagen, South Africa should emphasise the mitigation policies and initiatives it has begun implementing. Because it is a developing economy with an abundance of coal, and energy security is central to its development path, it has some justification for the continued use of coal. However, the successful implementation of the government's long-term strategies on climate change is essential if South Africa is to comply with a cap on emissions that could be proposed during the Bali Road Map negotiations. An increase in CDM projects is crucial, but these projects should not ignore the needs of the local communities affected by them. Increased investment in renewable sources of energy is also important, but the government should ensure that the costs of such energy sources are lower than those of carbon-intensive fuels such as coal. Effective legislation is needed to promote a renewable energy sector, which will create more jobs and reduce emissions. South Africa needs a combination of market-based instruments and increased energy efficiency, as well as more thorough-going implementation of sustainable development objectives.

Emissions mitigation efforts should be integral to sustainable development and, in particular, cleaner production methods. Mitigation demands a long-term shift from coal dependency to a diverse energy mix. But it should be coupled with increased energy efficiency and investment in renewables. The benefits of nuclear energy cannot be ignored, as the technology exists and produces more energy than coal at the same capacity. But the concerns of environmental advocacy groups about the environmental safety and security of stored radioactive waste should be taken into account.

There is no simple way to ensure energy security while reducing greenhouse gas emissions. Renewable sources of energy, although clean, have not yet emerged on a large scale in South Africa. However, given the ambitious targets set in the country's climate change policy, it is crucial that Eskom introduces clean coal technology and that the government introduces legislation to promote renewable energy production.

The government should be commended for appreciating the intricacies of carbon mitigation. But policy planning must be followed by substantial implementation if South Africa is to deliver on its own targets.

Endnotes

[1] AURIEL NIEMACK was a Konrad Adenauer Stiftung intern at the South African Institute of International Affairs during 2008. With thanks to Mr Suryapratim Roy for his insight and advice.

[2] Zacher M, 'Uniting Nations: Global regimes and the UN system', *Working Paper 23*. University of British Columbia: Institute of International Relations, August 1998, p. 12.

[3] Throughout this chapter 'carbon mitigation' and 'greenhouse gas mitigation' are used interchangeably, as carbon dioxide is the most significant greenhouse gas in the atmosphere.

[4] Wilreker GI, 'A comparative study of emissions from coal-fired power stations in South Africa and other selected countries', 2005, p. 48, <http://etd.rau.ac.za/theses/available/etd-08292005-095210/restricted/AComparative.pdf>. In her comparative analysis of emissions, Wilreker observes that South Africa 'has high SO_2 emissions because of high-sulphur coal used with no desulphurisation technologies installed. It also has the second highest nitrous oxide emissions.'

[5] Intergovernmental Panel on Climate Change (IPCC), 'Summary for policymakers', in *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. Cambridge, United Kingdom: Cambridge University Press, 2007, pp. 2–3.

[6] Department of Environmental Affairs and Tourism (DEAT), International Conventions and Protocols on Climate Change, 2008, <http://www.environment.gov.za/Documents/Documents/2003May26/climate_change_conventions_26052003.html>.

[7] Trollip T, *The Kyoto Protocol and Emissions*. Webber Wentzel Attorneys, 2008, <http://www.wwb.co.za/wwb/view/wwb/en/page3972?oid=8893&sn=Detail%20-%20Search%20Results>.

[8] Christian Aid, 'The climate of poverty: Facts, fears and hope', 2006, <http://www.christianaid.org.uk/Images/climate-of-poverty.pdf>. It is possible that emerging powers such as India, Brazil, China and South Africa will be compelled to enter into a legal agreement to reduce greenhouse gas emissions after 2012. At the time this article was written, the Bali Road Map was only half-completed so it remains to be seen during 2009 whether this expectation will be realised.

[9] Chevallier R, 'South Africa: An international actor and partner for the EU', 2008, <http://www.saiia.org.za/index.php?option=com_content&view=article&id=813:south-africa-an-international-actor-and-partner-for-the-eu&catid=41:eu-africa-programme-euaf>.

[10] United Nations Development Programme, *Human Development Report 2007/2008*. CO_2 emissions, total Mt CO2. < http://hdrstats.undp.org/indicators/232.html>.

[11] United Nations Development Programme, *Human Development Report 2007/2008*. CO_2 emissions per capita. < http://hdrstats.undp.org/indicators/237.html>.

[12] United Nations Millennium Development Goals Indicators, 'Carbon dioxide emissions (CO_2), thousand metric tonnes of CO_2 (CDIAC)', 2008, <http://millenniumindicators.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=710>.

[13] International Energy Agency (IEA), 'Carbon dioxide emissions by economic sector 2005', <http://earthtrends.wri.org/pdf_library/data_tables/cli2_2005.pdf>.

[14] Carbon intensity is measured by CO_2 emissions per unit of GDP. The Organisation for Economic Co-operation and Development estimated that in 2001, coal accounted for 75% of South African energy consumption. See the *World Energy Use and Carbon Dioxide Emissions, 1980–2001*. Energy Information Administration, April 2004, <http://tonto.eia.doe.gov/ftproot/environment/energycarbon2004.pdf>.

[15] DEAT, State of the Environment, Energy, 2008, <http://soer.deat.gov.za/Printpage.aspx?m=385>.

[16] See *The Engineer Online*, 18 September 2008, <http://www.theengineer.co.uk/Articles/307986/Power+to+the+people.htm>.

[17] DEAT, *op. cit*.

[18] Kegley CW & ER Wittkopf, *World Politics: Trend and Transformation*, 9th edition. United States: Thomson Wadsworth, 2004, p. 253.

[19] Krasner S, 'Structural causes and regime consequences: Regimes as intervening variables', *International Organizations*, 36, 2, Spring 1982, pp. 185–205.

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