Climate Change Mitigation Potential in South Africa: A National to Sectoral Analysis

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Abstract

This paper discusses some of the impacts attributed to climate change that are likely to hit Southern Africa as a result of increasing global greenhouse gas emissions into the atmosphere. As South Africa is a significant contributor to greenhouse gas emissions and currently ranked first in Africa, the paper assesses the country's greenhouse gas emissions profile and possible future projections of emissions and their implications. It then discusses the strategic interventions proposed by South Africa in reducing the gap in emissions between what is required by science and what would happen if development continues at current rates without abating greenhouse gas emissions. Given that the majority of emissions are a result of energy consumption, the paper provides practical solutions to themes such as energy efficiency mostly for the industrial and commercial sectors. With international treaties on the reduction of greenhouse gas emissions (e.g. Kyoto protocol), there are business opportunities in the area of climate change mitigation. Thus, the paper finally discusses the Clean Development Mechanism (CDM) scenario in South Africa and how the country can benefit from other emission trading schemes being practiced in different regions of the world.

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[θ] Opinions expressed and conclusions are those of the authors and not necessarily to be attributed to the organizations they represent.

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1 Introduction

Climate Change is finally becoming a reality in the eyes of many in developing countries. People are becoming more aware of the subtle impacts of climate change. The science of understanding climate change is also improving with more research pointing to a series of impacts across the whole world. Two years ago, the Intergovernmental Panel on Climate Change (IPCC) released its Fourth Assessment Report (FAR) on Climate Change (IPCC 2007). The report highlights key impacts likely to affect certain parts of the world. In addition, Africa is the continent likely to suffer most. In the African continent, impacts range from increases in rate of desertification, reduction in moisture content of soils, species migration and extinction, evaporation of rivers and lakes, increases in incidence rate of vector dieses such as malaria, population migrations.

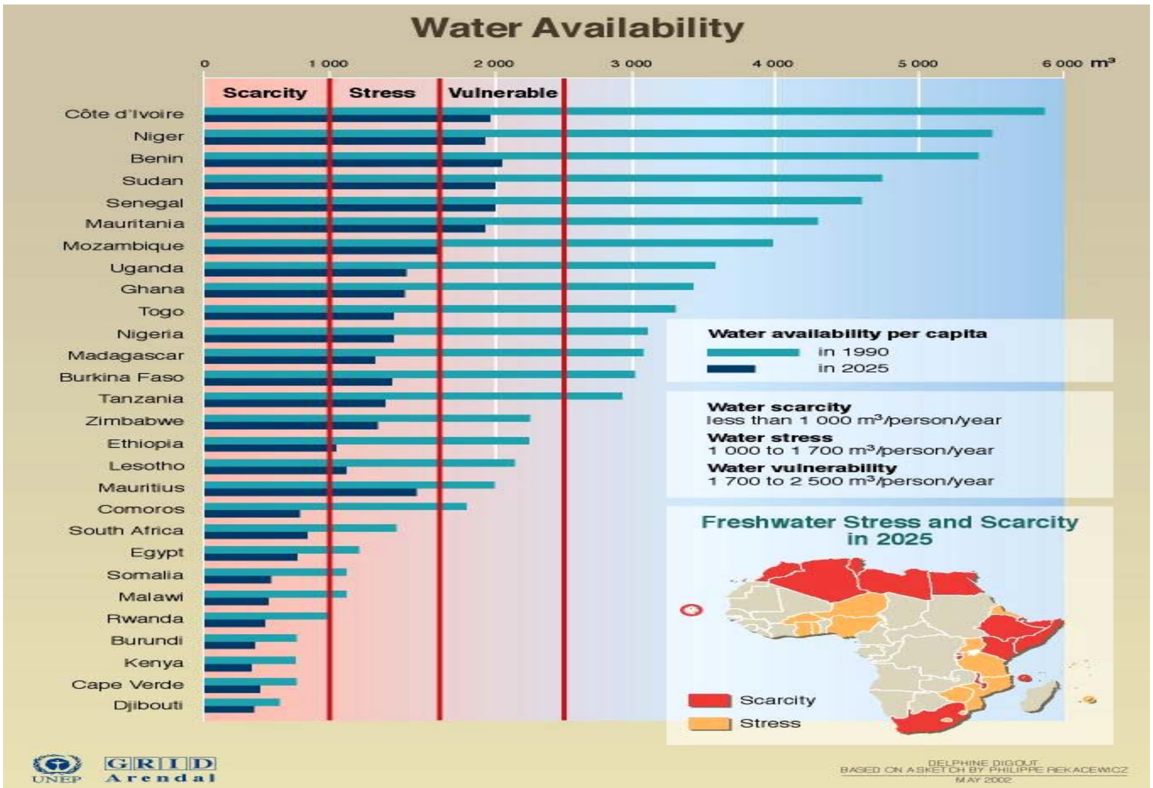
Responses to climate change are positioned along two agreed themes. Climate change "Mitigation" is the first theme which deals with policies and measures to reduce greenhouse gas emissions. Secondly, climate change "Adaptation" deals with policies and measures aimed at adapting or coping with the impacts of climate change. In the past couple of years, there has been a live debate as to which of these two responses is important for the developing world particularly African countries. The answer to this debate is not as straight forward as may seem. The initial thinking has always been that Adaptation is important given that the developing world is likely to suffer the most and also that it has not contributed largely to the current greenhouse gas emission profile that threatens the survival of our ecosystems. This argument however has tended to overlook two crucial realities. Firstly, a number of emerging developing countries such as the BRICS (Brazil, India, China and South Africa) continue to pose serious climate change loadings onto the atmosphere, thanks to their high economic growth rates. Secondly, because of strict commitments both locally and internationally (e.g. through the Kyoto protocol), the developed world are forced to develop mitigation technologies. Once these technologies are fully developed and are commercialized, we as the developing world will continue to suffer from the "dependence syndrome". In order to avoid these realities, we need a policy response approach that treats Mitigation and Adaptation in a holistic manner. Mitigating climate change has an added advantage in that it makes business sense and it synergizes well with the principles of sustainable development. Mitigating climate change at facility level means that a company becomes competitive through improved use of energy sources and process efficiency whilst reducing environmental loading. In fact, through carbon trading schemes, companies can generate revenues by investing in mitigating greenhouse gas emissions.

Responding to climate change also demands behavioral change. Unfortunately, changing behavior is not easy and even worse; the climate change crisis requires immediate action within the next 10-15 years if we are to keep the global average temperatures to below 2^oC by maintaining the global carbon dioxide (CO_2) emission at 550 ppm[1] (DEAT 2007, IPCC 2007b). An average global temperature above this level has far-reaching implications for Africa. Some of the key impacts related to the Southern Africa region are discussed below.

1.1 Climate Change and Water

Rising land-surface temperatures causes water evaporation and thereby reducing water stocks in rivers and lakes around the continent. In South Africa, the problem is compounded further by observed yearly reductions in annual rainfall. With consistent high temperatures, precipitation is reduced and water in the form of vapour remains suspended in the air and can easily be transported elsewhere in the presence of moderate to high winds. South Africa, already regarded as having reached the water stress level in terms of water availability, is predicted to reach the water scarcity level by 2025 "UNEP 2007".

Figure 1: Water Availability in Africa by 2025.



Source: UNEP 2007

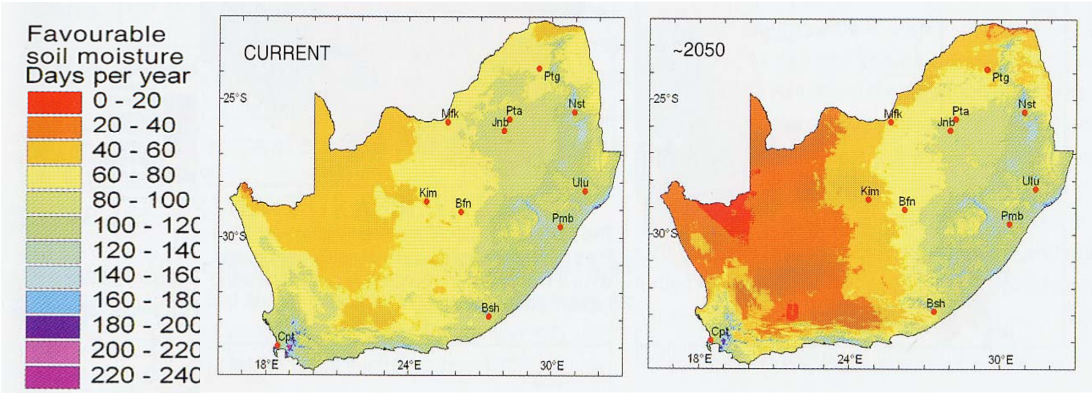
1.2 Agriculture and food production

Agricultural production and food security (including access to food) in many African countries will be severely compromised by climate change. This has secondary effects such population migration as people will move to areas were food availability may not be an issue. Agricultural activities particularly in coastal and low-lying areas are at risk due to predicted global sea level rise. Food security, already a humatarian crisis in the continent is likely to be further aggravated by climate variability and change, aggravated by HIV and AIDS, poor governance and poor

[1] ppm- parts per million

adaptation. Fig.2 reveals a discouraging future projection of 'soil moisture days' by 2050. A large part of the country, particularly in the west, soil moisture days are to be between 20 and 40 days, which is often not enough for some plant and crops to grow.

Figure 2: The effect of global climate change on "soil moisture days' in South Africa (number of days when both soil moisture and temperature are suitable for plant growth)



Source: ERC 2009

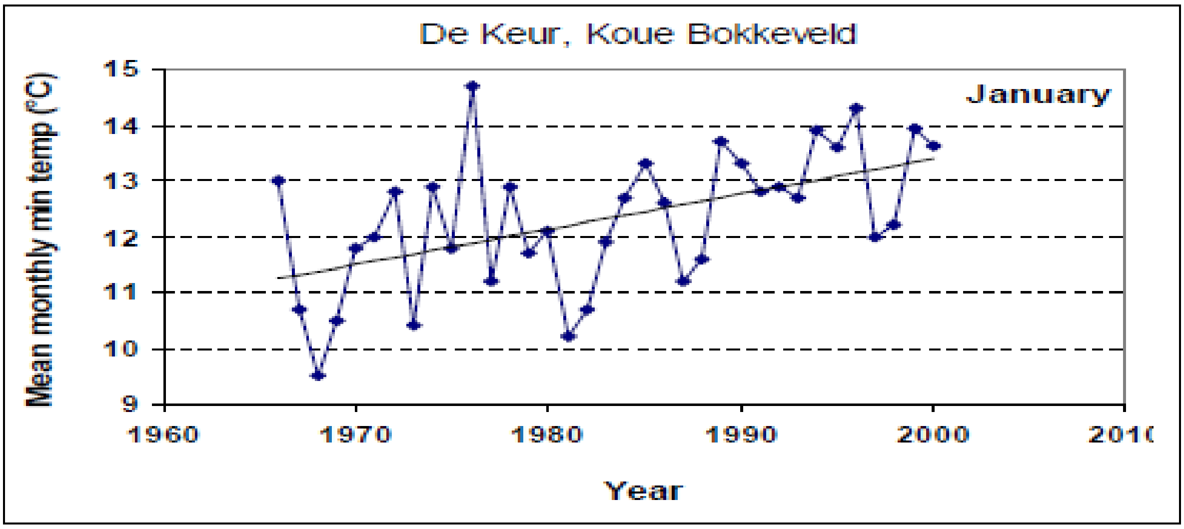
1.3 Climate change and Vector diseases: Malaria

Previously malaria-free highland areas in Ethiopia, Kenya, Rwanda and Burundi could experience modest changes to stable malaria by the 2050s, with conditions for transmission becoming highly suitable by 2080s. All these areas also suffer due to lack of heath infrastructure which could compound the problem of new diseases and spread of epidemics in the future world affected by climate change.

1.4 Climate change and Temperature profiles

Time series records of temperature are also showing significant increases. Fig.3 shows a temperature trend for a period of over 30 years for the Western Cape. The line of best fit on this plot shows that temperature is increasing far more than it has done in the past. This has implications for the Western Cape such sea level rise, destruction of unique species (Fynbos), displacement of human settlements, reductions in agricultural yields and so on.

Figure 3: Impacts of Global warming on local temperature increases: An assessment for the Western Cape



Source: ERC 2009

2 The National Greenhouse Gas Problem

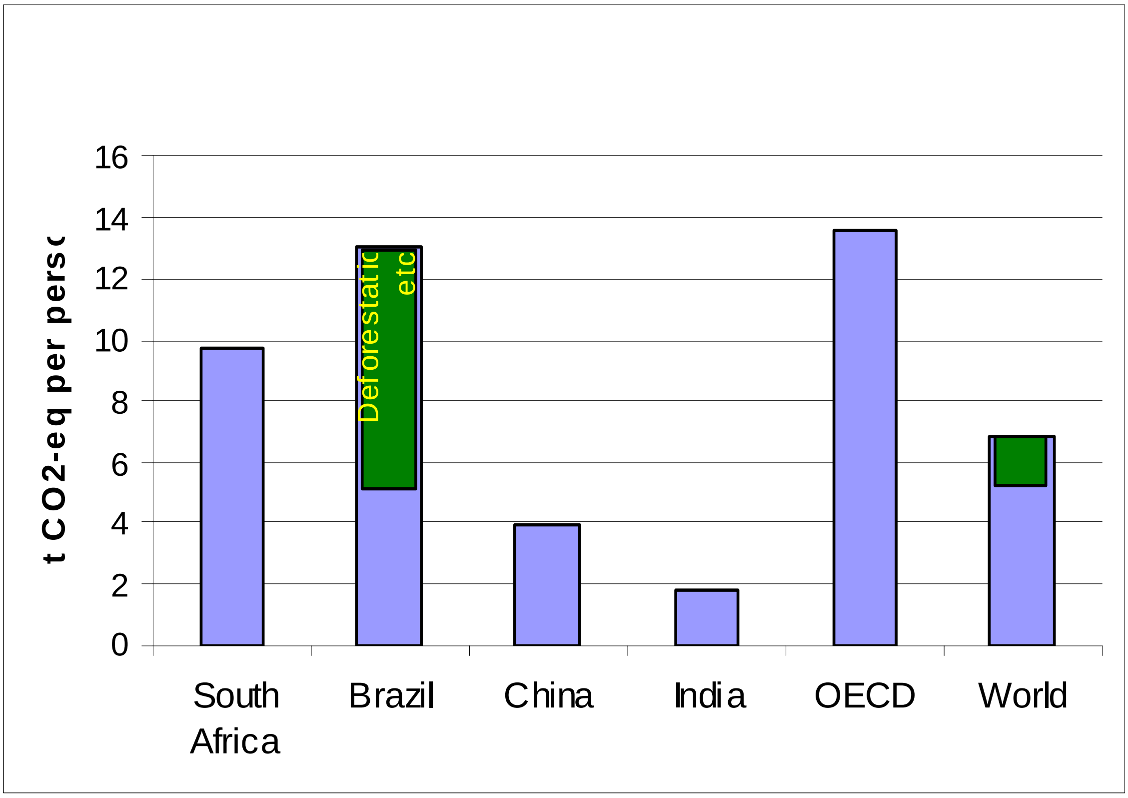
2.1 Emissions per Capita

South Africa is and has been a carbon based economy for many years. This is justified by its large reserves of coal with a predicted reserve of over 160 years left. Also, export of high quality coal and use low quality cheap coal for power generation has meant low prices for electricity for many years. This situation has made it difficult for the creation of open market for electricity generation because prices are not compatible. Furthermore, this has to a large extent discouraged the investment in alternative energy sources for electricity generation. When compared with other developing countries, South Africa has a relatively higher emissions per capita (tons of CO_2 per person) emissions because it's high reliance on coal for electricity generation (>90% contribution by coal towards electricity generation).

However this comparison is subject to criticism for a number of reasons. Countries such as China and India have significantly higher emissions than South Africa. However, because of their big populations, the emissions per capita turn out to be smaller. In addition, it can be argued that the majority of South Africans are still poor and also stay in rural areas. Therefore it is mostly the urban and semi-urban populations that are contributing significantly to greenhouse gas emissions in South Africa. Hence, one would expect a much broader distribution of emissions per capita when considering population types (rural/urban). This is similarly true for developing countries such as Brazil, China and India who have bigger rural populations. Fig.4 shows a comparison of emissions per capita for countries often referred to as BRICS (Brazil, Russia, China, India and

South Africa) for the year 2003. In this figure, data on Russia is not presented for data incompleteness reasons.

Figure 4: Greenhouse gas emissions per capita, 2003.

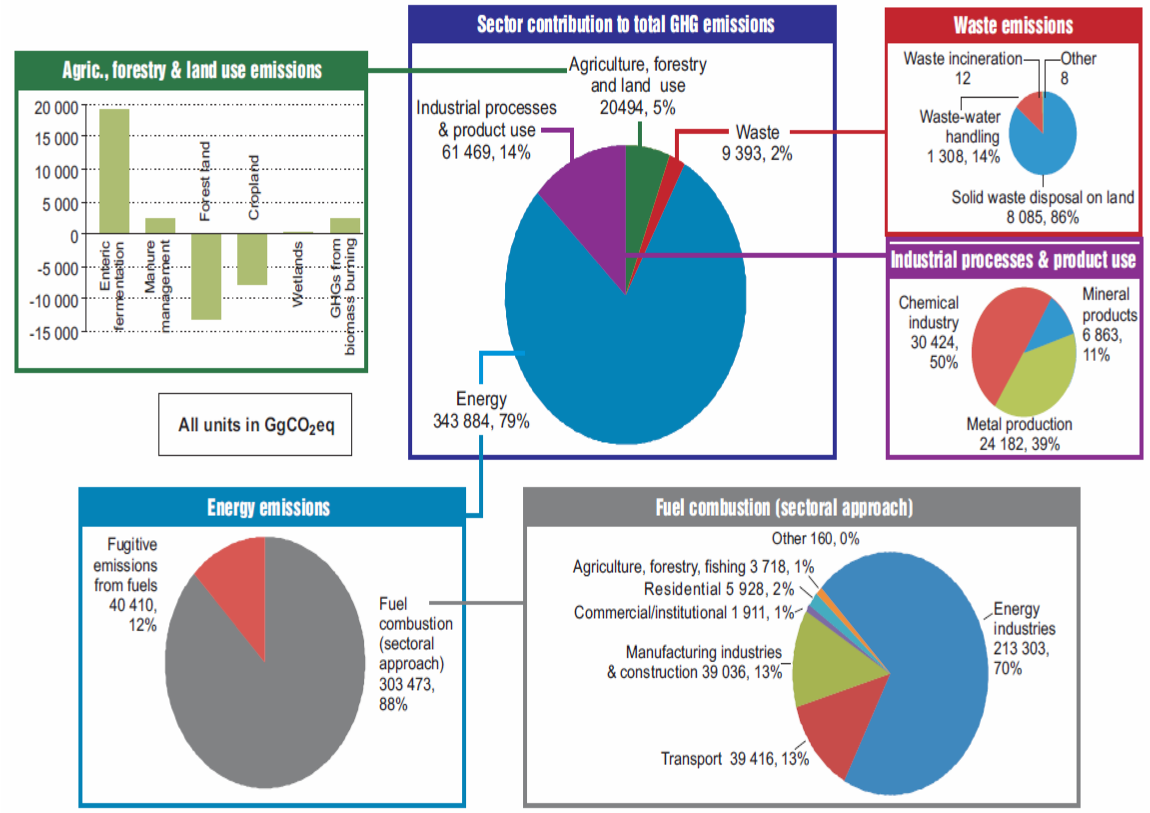


Source: ERC 2007

2.2 Emissions by Energy Sectors

Fairly recently (DEA 2009), South Africa has finalized its third annual Greenhouse Gas Inventory. The Greenhouse Gas Inventory as it is called is an accounting exercise of greenhouse gases from all relevant sectors that contributes to greenhouse gas emission. South Africa has to report its emissions to the United Nations Framework Convention on Climate Change (UNFCCC). Because of this reason, it has to follow guidelines for computing the emissions as provided by the Intergovernmental Panel on Climate Change (IPCC). Under these guidelines, the emissions are divided into four broad sectors namely: Energy sector, Industrial Processes and Product Use (IPPU) sector, Agriculture, Forestry and Land Use (AFOLU) sector and lastly, the Waste sector. Data sources for the emissions range from public statistical sources such Statistics South Africa (StatsSa), Industry, research institutions, Associations, International Organizations such the United Nations as well as other government bodies.

Figure 5: Greenhouse Gas Inventory for South Africa for the base year 2000



Source: DEA 2009

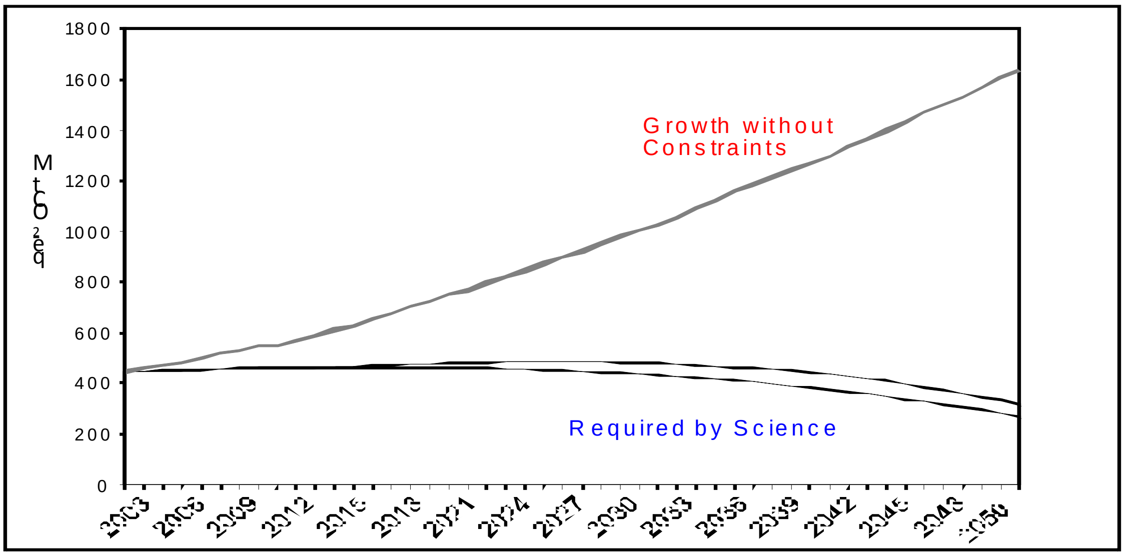
The year 2000 was used as a baseline for the computation of the emissions. Therefore even though the inventory was compiled in 2008 and finalized in 2009, its results reflect emissions from the year 2000. It is also recognized that a lot has changed since 2000 and therefore current emissions may well be more significant than those presented for the year 2000. Fig.5 shows a summary of the results for the year 2000 GHG inventory. The results show that the energy sector dominates the contribution to GHG emissions by 79% followed by IPPU (14%), AFOLU (5%) and lastly Waste (2%). Within the energy sector, fuel combustion mostly from electricity generation is the significant contributor at 88%. Within the IPPU sector, the chemical industry contributes 50% whilst metal production contributes (39%) and mineral production (11%). Within the AFOLU sector, emissions (mostly from enteric fermentation) from animal population are the major contributor, whilst the forests have shown absorption (sequestration) of carbon emissions. In the waste sector, solid waste disposal contributes the most emissions (86%) followed by waste water treatment (14%).

2.3 Projected future emissions

Given that the GHG inventory is outdated and that it give an indication of what current and future GHG emissions are likely to be, a more robust future emissions projections system is needed. Hence, the South African Government responded by commissioning a Long Term Mitigation Scenarios (LTMS) project to provide insight into what future GHG emissions are likely to be. In order to do these, it chose a time horizon of almost 50 years (2003-2050). Then using general drivers such gross domestic product (GDP) and population growth, it was possible to project emissions in 2003 and projecting them to 2050. According to this projection exercise, in 2003 the emissions were equivalent to 440 $MtCO_2$-eq. Buy, by 2050 the emission would have risen to just above 1600 $MtCO_2$-eq, thus a four-fold increase in absolute emissions. This projection scenario is called Growth Without Constraints (GWC). GWC implies that our economic activity would simply grow without consideration of the urgent need to reduce GHG emissions. However, since we are part of the world, we have a responsibility to reduce GHG emissions to avoid the possible impacts of climate change. This must be borne in mind considering that Sub-Saharan Africa is the most vulnerable region to Climate Change.

Therefore, the question is how much can South Africa contribute towards mitigating climate change to avoid the impacts of climate change? Simply put, what is "Required By Science" in terms climate change to avoid the impacts of climate change. To answer this, the South African government developed emissions projection scenario called "Required By Science" RBS. The RBS scenario showed that emission needs to peak between 2000 and 2015 and decline by 2025. This is so in order to avoid global temperature rise beyond a range of between 2-2.4^{o}C as recommended by the IPCC report on Mitigation (IPPC 2007a). Fig.6 shows a plot of the GWC and the RBS scenarios for the time horizon (2003-2050). The space between these two scenarios presents the effort needed to mitigate GHG emission such that increases in temperatures beyond the scale described above are avoided. Therefore the next section discusses the options (technology and other control measures) available to reducing the gap between GWC and RBS scenarios.

Figure 6: Projection of South Africa's Greenhouse gas emissions for a 50 year time horizon (2000-2050) under 'growth without constraints' and what is required by science to avoid the impacts of climate change.



Source: ERC 2007

3 Mitigating Climate Change: Options for Government

As can be observed from fig 6 in the previous section, the gap in emissions between Growth Without Constraints (GWC) and Required By Science (RBS) scenarios increases to just above 1600 MtCO_2-eq by 2050. Therefore the GHG emissions by 2050 will be four times the level of current emissions (~ 440 MtCO_2-eq). This implies that a significant effort is needed to reduce these emissions. It also means that there is no single solution (mostly technological) that can realize such desired emissions reduction. Hence, a portfolio of technologies combined with other control measures presents a realistic approach to deal with the challenge of emissions reductions. Secondly how and when these technologies and measures are introduced is also essential to understand. The reason for this is that some technologies may be in conceptual stage, others in developmental stage, or may not even reached economies of scale which means they are likely to be extremely expensive and therefore not feasible to implement immediately. Other measures such as introducing a carbon tax may need to be investigated thoroughly as they impact negatively on the economy.

With this in mind, the government evaluated solutions to reduce emissions as well as the best possible approaches to package them such that they are implemented taking into account the issues discussed above. Thus, three packages (also called strategic options) were developed. For each strategic option, a combination of technologies and measures were investigated and its overall impact towards reducing emissions studied. Each Strategic option is discussed in detail below:

Strategic option 1: Start Now

This strategic option evaluates the kind of actions that can be undertaken immediately without major effort and also saving money in the process. It considers for options namely:

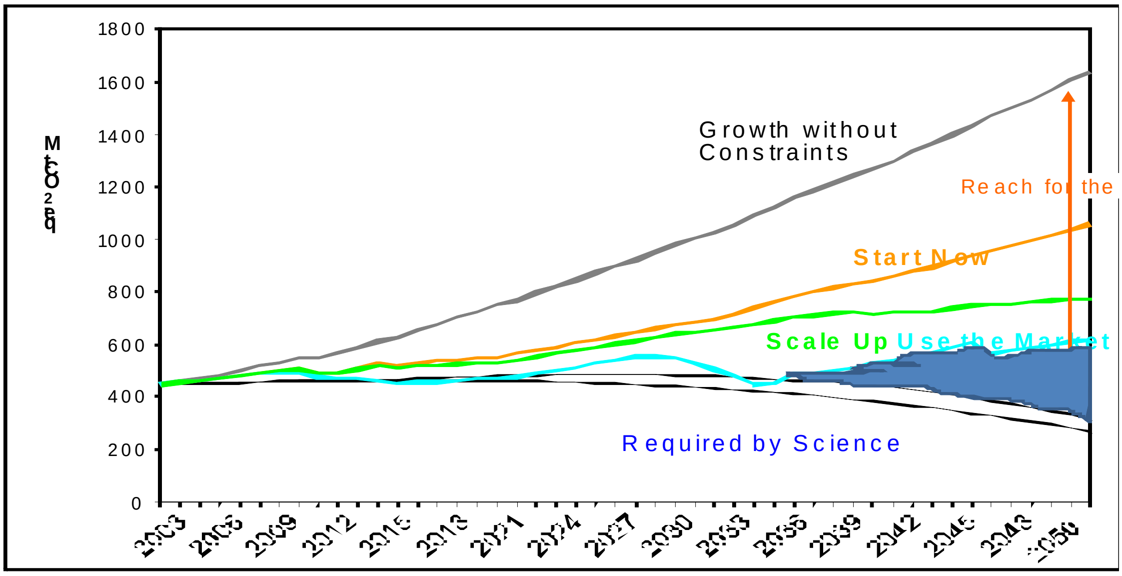
- Improvement in industrial energy efficiency,
- Introduction of nuclear (27% contribution towards electricity generation) and renewable energies (27% contribution towards electricity generation and mostly from solar and Wind).
- Shift towards public transport as well as
- Improved vehicle energy efficiency

An economic assessment of these options shows that a saving of R34 per ton of CO_2 is obtained by implementing industrial energy efficiency. Similarly, an implementation of modal shift towards public transport saves the economy R1132 per ton of CO_2 whilst improvement in vehicle efficiency realizes a saving of R269 per ton. However, the actual carbon emissions realized under modal shift and vehicle efficiency improvement are significantly low. Implementation of renewable energies costs the economy an amount of R52 per ton of CO_2 and the implementation of nuclear energy costs the economy R18 per ton of CO_2.

Strategic Option 2: Scale-Up

Scale-Up involves the extension of some interventions described under "Start Now". It includes the extension of nuclear (R20 per ton of CO_2) and renewables (R92 per ton of CO_2) to 50% each, thus avoiding the use of dirty coal for electricity generation by 2050. By then, cleaner coal will still be in use, most noticeable for coal-to-liquids (CTL) processes. In order to achieve cleaner coal, Carbon Capture and Storage (CCS) (R54 per ton of CO_2) option is also included under "Scale-up", thus ensuring that the carbon emissions released from CTL are stored in geological formations. The assumption is that CCS is a fully developed technology by 2050. Industrial energy efficiency is also extended (-R34 per Mt of CO_2). In addition to modal shift from "Start Now" the "Scale-Up" introduces the use of electric vehicles (R607 per Mt of CO_2). Under "Scale-Up" only the industrial efficiency option results in savings.

Figure 7: An assessment of South Africa's strategic options and their influence on greenhouse gas emissions



Source: ERC 2007

Strategic Option 3: Use the Markets

"Use The Markets" explores the application of economic instruments to reduce carbon emissions. Two types of economic instruments are explored here, namely carbon tax and subsidies. The carbon tax is applied across all energy sectors. The subsidies are applied to stimulate the penetration of renewables, renewable technologies such as solar water heaters (SWH) as well as biofuels. The carbon tax costs the economy R42 per Mt of CO_2. The subsidy for renewables cost the economy about R125 per ton of CO_2 whilst a biofuels subsidy is expensive at 697 per ton of CO_2. SWH subsidy saves the economy an amount of R208 per ton of CO_2. This saving is attributed to the fact that SWH's are fairly established technologies. Even though the implementation of a carbon tax costs the economy, it is an option that realizes the most emissions reduction (up to 600 Mt of CO_2 by 2050). Even if these three strategic options are implemented, a small gap (see shaded area on fig.7) still remains.

4 Mitigating Climate Change: Options for Industry

Following the results described in the previous section, government has a far more insight into focus areas for mitigating carbon emissions. Most focus areas as observed from the GHG inventory involves the consumption of energy sources and the Industry sector is no exception. Furthermore, in mitigating climate change, governments apply top-down approaches often having economic-wide implications. These approaches include economic instruments such as carbon tax, emissions trading and energy efficiency targets or alternative energy sources mainly renewable (solar, wind) in nature. In addition, government can also explore with legal instruments such as compulsory emissions reporting for significant emitting industries, thus requiring that they submit emissions reduction strategies (ERS's). This call upon industries to be proactive in emissions reductions by assessing leverage points or simply put, places to intervene.

Hence, this section attempts to highlight such leverage points (options) and begins to unpack the possible emissions reduction savings that can be accrued from them. Also, spin-off in the long run can be realized which makes it even more sound to implement such options. First we discuss the industrial sector and then lastly the commercial sector.

4.1 Industrial Sector

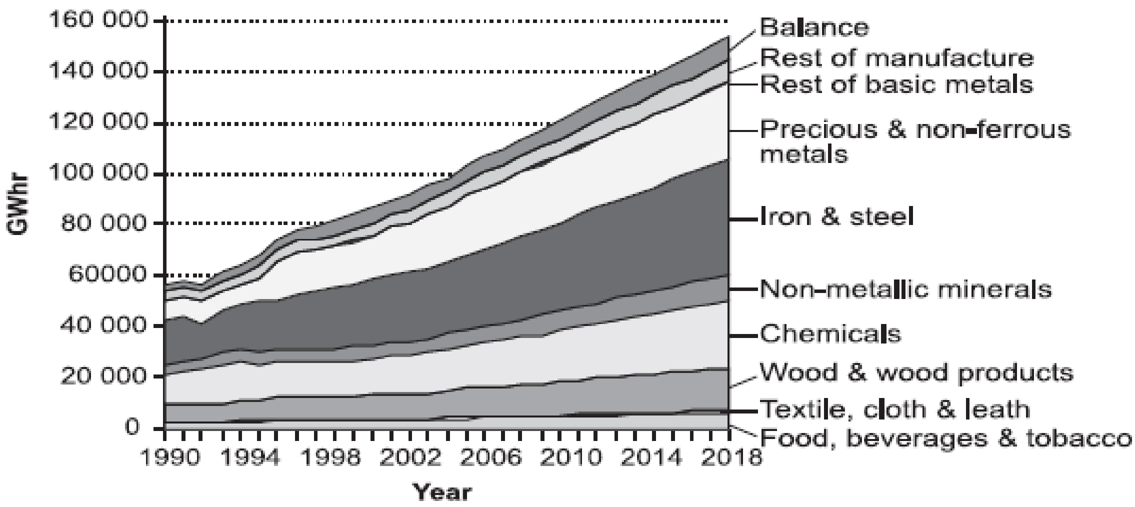
In the past couple of years, there has been a series of excellent studies conducted to analyze energy savings that could be realized in the industrial sector (Howells 2004, Winkler 2006). Hence, the outcomes of this study merely draw from the findings of these studies. Before we can analyze accrues emissions savings, we need to understand the uses of electricity by industry sector. Table 1 gives a fair reflection of the end-uses of electricity by industrial sector. From this table, it is obvious that industry focus areas when looking at improving efficiencies are those listed in the first column. Fig.8 provides insight into future energy demand which is also crucial to understand what future carbon emissions reductions can be realized by implementing energy efficiency.

Table 1: Percentage of end-use of electricity by the industrial sector

	Food & bever-ages	Text-iles	Wood & wood prod-ucts	Chemi-cals	Iron & steel	Non-ferrous metals	Rest of basic metals	Rest of manu-facture	Non-metallic minerals
Indirect uses – boiler fuel	2	1	3	1	0	0	0	1	0
Process heating	4	5	6	3	39	1	17	10	8
Process cooling & refrigeration	24	7	0	6	1	0	0	5	0
Compressed air	8	10	38	10	8	0	11	9	14
Other machine drive	44	50	38	53	40	2	56	47	72
Electro-chemical processes	0	0	0	18	2	95	17	11	0
Other process use	0	1	1	0	1	0	0	1	0
Facility HVAC	8	15	4	4	3	1	0	8	3
FAcility lighting	3	10	7	3	4	1	0	7	3
Facility support	2	2	1	1	1	0	0	2	0
Onsite transportation	0	0	0	0	0	0	0	0	0

Source: Haw & Hughes 2007

Figure 8: Electricity forecast for the industrial sector



Source: Howells 2004

In addressing the inefficiencies related to the energy consumption areas (focus areas) listed in the first column of table 1, certain measures needs to be implemented. This study lists a handful of critical measures that can be implemented by industry. Because it is critical for industry to understand the economics of implementing such measures, the study reports on payback periods as well as the proportion of fuel saved:

- *Variable speed drives*: such drives reduce inefficient power consumption in electrical motors with varying loads. Typical associated paybacks are 3.6 years. It is said that a conservative estimate of 2.2% savings in industrial electricity can be saved (Winkler 2006)

- *Efficient motors*: efficient motors can reduce power consumption. However they may require modifications because running speeds are generally higher than for inefficient motors. The major disadvantage with efficient motors is their high upfront costs. Hence their typical payback period is seven years whilst achieving a 2.3% saving in industrial energy consumption (ERI 2000a).
- *Compressed air management*: this measure is easily achieved and often realizes significant savings are low cost. According to recent studies, typical payback period is equivalent to 0.9 years and a conservative figure of 3.2% in industrial electricity savings can be achieved (ERI 2000a).
- *Efficient lighting*: the measure refers to more use of natural lighting and shifting to more efficient light bulbs and appropriate task lighting. Typical paybacks are 3.6 years and the industrial energy consumption savings to be accrued from this measure is at 1.9% (ERI 2000a).
- *Heating, ventilation and cooling*: These measures are meant for maintaining good air quality and temperature. With improved maintenance and installation of appropriate equipment and fluid mechanics design, it is possible to realize savings in electricity consumption of up to 0.6% with a payback period of up to 2.2 years (ERI 2000b).
- *Thermal saving*: this measure refers to more efficient use and production of heat mainly from steam systems. In steam systems, condensate recovery and improved maintenance are seen as key in improving efficiency. Here, typical payback period is about 0.8 years and achieving a 1.4% savings in industrial energy efficiency. With regard to coal and oil use in steam generation, savings in fuel use can reach 10% (oil) and 15% (coal) (ERI 2000b).

4.2 Commercial sector

The commercial sector is an agglomeration of the economic sectors defined under Standard Industrial Classification (SIC) codes 6, 8, 9. Table 2 shows the breakdown of commercial sub-sectors. All public sector activities are included under SIC 9.

Table 2: Commercial sub-sectors by SIC code

SIC	Description
6	**Trade, catering and accommodation**
61	Wholesale trade
62	Retail trade
631	Accommodation
632	Catering
8	**Finance, property and business services**
81	Financial institutions
82	Insurance institutions
83	Auxiliary activities
84	Real estate
85	Renting of equipment
86	Computer activities
87	Research and Development
88	Other business activities
9	**Community, social and personal services**
91	Public administration
92	Education
93	Medical and health services
94-99	Other services

Essentially, there are six key energy service demands for the commercial sector, namely: cooling; lighting; refrigeration; space heating; water heating and other (cooking, personal computers, printers etc). Table 3 lists some of the measures that can be implemented in the commercial sector.

Table 3: Measures for reducing energy demand in the commercial sector[a]

Measures	**Energy savings (%)/m^2**	**Payback Period**	**Barrier**
New building thermal design: Optimal insulation; glazing; correct orientation; and building shape	40% in final HVAC demand	5 years	Lack of training of architects and consulting engineers in efficient building energy practice
HVAC retrofit: Switch-off air-con when there are no occupants; prevent mix of cold and hot air; ventilation by outside air an d night cooling; use of evaporative cooling; computerized energy management systems	35%	3 years	Lack of awareness by building owners, Energy services are not seen as part of the commercial activity
Variable speed drives (VSDs) for fans	15	NA[b]	Lack of awareness Only variable volume air handling units can be operated with VSDs

Efficient lighting systems: Introduce more switches, photo-electric sensors and occupancy sensors; reducing lighting levels in naturally high illuminated areas; introduce skylights and other building design features.	20	3 years	High capital costs, Lack of training of architects and consulting engineers in efficient building energy practice
Heat pumps for water heating	67	NA	High capital costs and operational problems
Solar water heating	90% water demand supplied by solar	NA	High capital costs[c] and operational problems
Fuel switching	Not modelled even though it has a huge potential	NA	NA

[a] Source: Winkler et al 2006

[b] Not available

[c] a 1000 litre solar water heater system costs roughly R35000 including installation costs

5 Carbon Accounting Framework

5.1 Identification and calculation of emissions

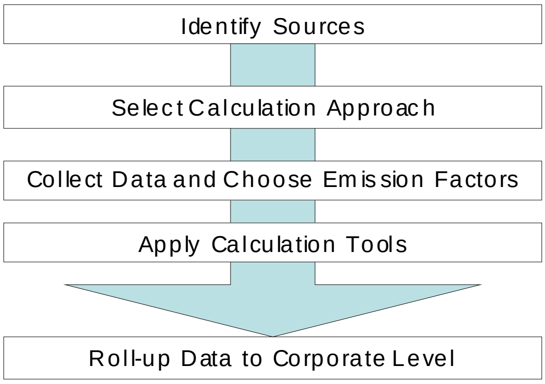
Identification and calculation of carbon emissions from an enterprise follows five key steps as given on fig.9. The first step is to identify emissions. Identification of emissions must be focused within the boundaries of an enterprise. Typically emissions can be identified from the following category sources:

1. *Stationery Combustion*: combustion of fuels in stationary equipment such as furnaces, burners, heaters, boilers, incinerators, flares, etc.
2. *Mobile combustion*: combustion of fuels in transportation devices such as vehicles, trucks, trains, buses, airplanes, boats, ships, etc.
3. *Process emissions*: emissions from physical or chemical processes such as carbon dioxide (CO_2) from culcination step in cement production, CO_2 from catalytic cracking in petrochemical processing, etc.
4. *Fugitive emissions*: leaks from joints and seals, packaging, gaskets, wastewater treatment pits, coal piles, etc.

Every enterprise has activities that generate emission directly/indirectly from one or more of the source categories described above. The approach to decide on direct/indirect emissions is thoroughly discussed under section 6.2.

The second step is to select a calculation approach. The approach to be followed largely depends on the nature of the source category identified. Calculation approaches are available from a number of public sources such as the IPCC[2] guidelines (IPCC 2006). Other useful calculation tools are available from the World Resource Institute (WRI) at www.ghgprotocol.org. Once a calculation method has been chosen and an emission factor identified (see fig 9's step three), it is possible to apply calculation tools (step four) to calculate emissions for categories identified. The last step (step five) involves the summation of emissions from all source categories to provide a corporate emissions profile.

Figure 9: Steps in identifying and calculating GHG emissions



Source: WRI 2004

5.2 Emissions accounting

The first step in every enterprises effort to reduce greenhouse gas emissions is to do a carbon accounting exercise. In this way, the enterprise is able to assess its overall emissions and most importantly identification of areas for significant improvement. Generally, an enterprise is a dynamic organization dealing with suppliers and customers. Secondly, it also receives services such as electricity which acts as an input to its activities (e.g. to power machines). This dynamic nature raises a question as to which activities; an enterprise should focus on when conducting its carbon accounting. In addressing this question, the paper introduces the concept of "scope" to assess an enterprise activities and their impact on greenhouse gas emissions.

Essentially, there are three "scopes" used to conduct carbon accounting as listed below;

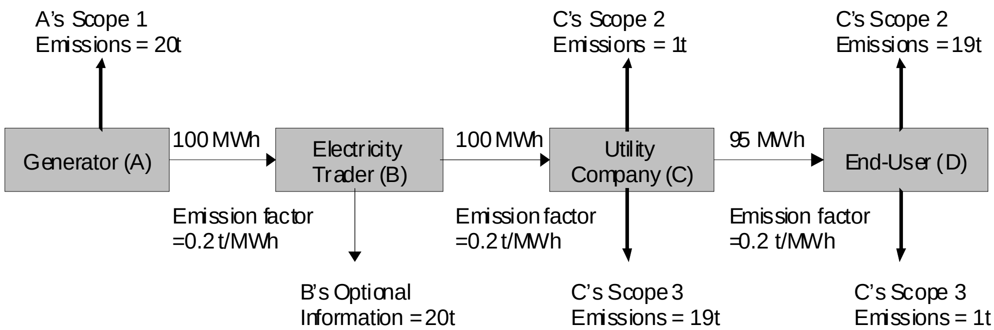
- Scope 1 emissions: emissions emitted directly by the enterprise activities in one or more of the four categories mentioned in section 6.1.
- Scope 2 emissions: these are emissions that are emitted indirectly from the consumption of electricity, heat or steam. Is it worth to note that almost all businesses generate indirect emissions through purchase of electricity for use in their processes or services.

[2] IPCC: Intergovernmental Panel on Climate Change

- Scope 3 emissions: this optional step involves the identification of other indirect emissions from an enterprise's upstream and downstream activities as well as activities emission associated with outsourced/contract manufacturing, leases, or franchises not included in scope 1 or scope 2. Scope 3 is optional, but it also provides the opportunity to be innovative and proactive in greenhouse has emissions management

To illustrate the application of the "Scope" approach, this paper provides an example (see fig.10) of four enterprises and how their emission are dealt with in this approach to avoid double accounting. Enterprise (A) generates electricity must directly account for scope 1 emissions. Enterprise B's role is to transmit high voltage electricity to major distributors. Thus, in the case of enterprise (B), there potentially no direct emissions related to the sale of emissions. (B) can choose to treat emissions from (A) as its indirect emissions (scope 3) but this is not compulsory since those emissions occur outside its boundaries. (C) distributes bulk electricity its electricity to end-users and in that process they consume 5MWh for their own operations. Therefore emissions related to consumption of electricity are treated as scope 2 emissions. As an option, (C) can choose to treat the emissions associated with distributing 95MWh to its end-users as scope 3 emissions. (D) which is the end-user consumes 95MWh of electricity and therefore account for 19t of indirect emissions accounted for as scope 2 emissions. Optionally (D) can account for emissions related to (C's) consumption of electricity equivalent to 5MWh.

Figure 10: Carbon accounting from the generation, sale and purchase of electricity



Source: WRI 2004

Performing such an exercise in dealing with GHG emissions helps the enterprise to priorities emissions and develops well informed emission reduction strategies.

6 Market Based Instruments for influencing emissions

The market based instruments for influencing emissions are taxes, subsidies, and transferable permits. Taxes and subsidies operate in the same way through modifications of relative prices. For controlling emissions, taxation can be levied on the inputs as well as on emissions, where as subsidies have to be levied on reduced emission quantities only. The short run effects of both these instruments are the same, though they have different distributional implications. Depending on the initial situation and the design of the instrument, subsidies and taxes have different effect (Droge and Schroder, 2005). By levying a tax on emission, the private prices are brought in line with the social prices. The level of tax on each emission unit should be equal to monetary value of the marginal damage at efficient level of pollution. Abating emission now leads to avoidance of tax or gain of subsidy. It is profitable for firms to abate pollution as long as the abatement cost is less than the tax levied or abatement subsidy. For tax or subsidy to be cost efficient, the rate should be uniform over all emitters.

The transferable permit schemes works in the following way- the total level of emissions is decided by the government, initial allocations of permits for emission quantities are done for the various firms, and then these permits are allowed to be freely traded between the firms. The initial permit allocations may be through auctions, or simple distribution of permits to the firms on the basis of any criteria chosen by the government. As compared to taxes and subsidies, transferable permits also work on the bases of quantity rather than prices. Thus a market for property rights is created. Thus on the basis of emission levels of the firms, the firms will decide the value of permits to themselves. Some firms will have surplus permits while others will be needing permits. Thus a market is created and the price of the permits will be dependent on their demand and supply quantities. Firms which will have very high abatement costs will demand more permits while firms having low abatement costs will prefer abatement through internal measures instead of buying permits in case they are highly priced. It the potential difference in the reduction cost between the parties that creates market opportunities (UNEP et al., 2002). In equilibrium, marginal abatement costs would be equal among all firms, which ensured that like taxes and subsidies, tradable permits are also least cost instruments. Its distributional implications depend on what is the initial level of allocations.

Table 4: Comparison between Various Instruments

Command and Control	Emission Tax and Subsidy	Cap and Trade
For equalizing marginal abatement cost across all firms, their marginal cost abatement function needs to be known for ensuring the cost efficiency of command and control instruments. Since this is almost impossible within the given resources, these instruments are usually cost inefficient.	Achieves the target at least cost. Can secure equal marginal cost across emission sources.	Cost effective only if the market is sufficiently liquid and effective.
It can guarantee a definite level of emissions which would be inefficient to achieve.	If abatement cost function is not known, then the level of abatement achieved by tax or subsidy is not known. So these are not dependable. Hence these, place an upper bound on marginal abatement cost, but uncertain impact on pollution levels.	On the other hand, transferable permits ensure that the level of emissions and abatement are known with certainty, but the price of emission permits can not be decided with certainty. So these guarantee emission levels, but at uncertain marginal abatement cost.
For achieving cost effectiveness the amount of information required is very high.	For achieving cost effectiveness only the aggregate abatement cost function knowledge is required.	
No continuous incentive for technology innovation. Incentives only if it is expected that the controls in future would be tighter.	Provide a continuous incentive to invest in innovations for controlling pollution.	These can also provide incentive for technology development if the total aggregate cap on emissions is planned to be decreased in the future.
No revenue for the government in this case.	Tax revenue can be used for reducing other more distorting taxes. On the other hand, subsidies can itself become a burden on the exchequer.	Revenue can be generated by auctioning the permits.
	Taxes are less exposed to regulatory capture. Taxes may be plagued by heavy lobbying and pressure tactics by the industries.	Lobbying can take place if the permits are grandfathered.
Does not increase the output restricting behavior of the monopoly polluter as might be the case with taxes.	Can lead to output restricting behavior by a monopoly polluter.	If the number of participating firms in the market is less, then some firms can exert monopoly power.
		Sufficient volume of tradable permits is required for a successfully functional market.

Source: Authors

There are seven major provisions in Kyoto Protocol (Hahn and Stavins, 1999)-

1. Relative to the 1990 levels, the industrialized nations (the Annex B parties) agree to reduce their greenhouse gas emissions by about five percent on average between 2008 and 2012. Different national targets for reduction are set however.
2. Trading of emission rights between the Annex B parties is allowed. This can be between national governments as well as project by project bilateral exchange of 'emission reduction units (ERU)' within 'joint implementation (JI)'.
3. The annex B countries can invest in non-Annex B countries through the 'clean development mechanism (CDM)' and gain credits- 'certified emission reductions (CER)'.
4. Banking emissions for subsequent period is allowed, though the targets for subsequent periods are not specified.
5. Nations have complete sovereignty for deciding the domestic policy instruments to achieve their targets.
6. Some provisions are provided for counting of 'sinks'- principally through human induced afforestation, reforestation and retarded deforestation.
7. Finally, the Kyoto Protocol agreement comes into force only when it is ratified by 55 nations including Annex B nations.

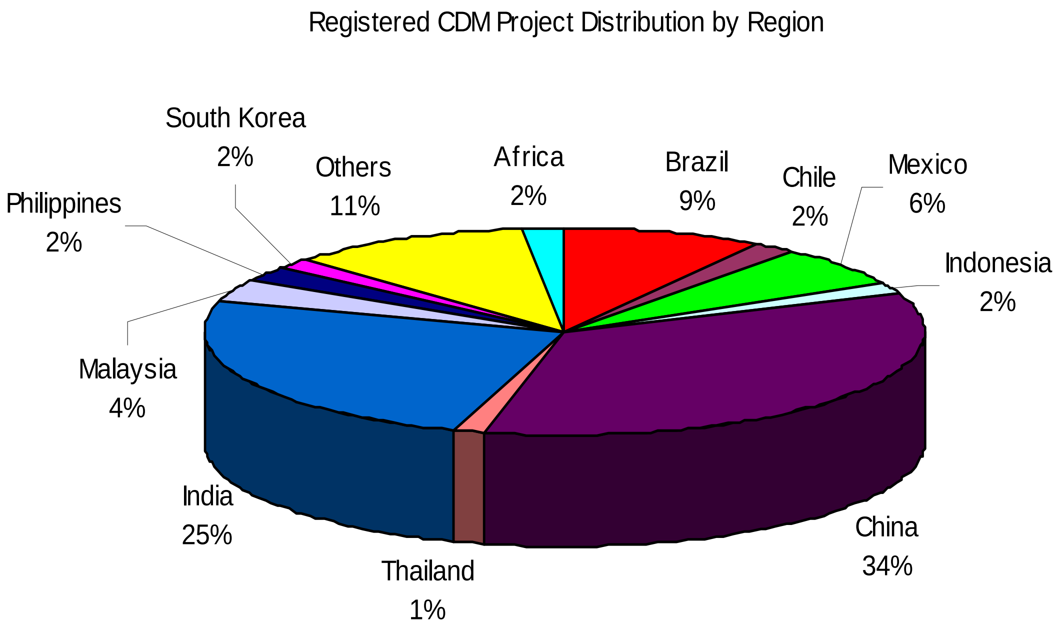
The Cap and Trade arrangement has been made for achieving the ultimate objective of greenhouse gas mitigation at the least cost. Trading will take place on the account of differences in marginal costs and can ensure that abatement takes place where the marginal costs of abatement are minimum. But there can be trading also if though the marginal cost is the same, but still one firm simply does not want to invest in abatement technologies and hence wants to buy carbon credits. Similarly, even if the marginal cost is different, the firm with higher marginal abatement cost still might not want to trade as it is more interested in reducing the emissions by itself. These actions could be on account of high uncertainty over future carbon prices in the market. Various modeling approaches have been used for analyzing the implications global climate policy architecture and the carbon price trajectories. The country level studies are also diverse in terms of their aggregation details, behavioural and data assumptions, and endogenisation of economic effects, resulting in different abatemet costs for developing economies (Shukla, 1995).

6.1 GAINING FROM CLEAN DEVELOPMENT MECHANISM

CDM, discussed in Article 12 of the Kyoto Protocol, is one of the three flexible Kyoto mechanisms. Under this mechanism, Annex-I parties which have caps for GHG emissions assist non- Annex I parties which don't have emission caps to implement emission reducing project activities. Credits are issued based on emission reduction by project activities. A CDM credit is known as certified emission reduction (CER).

Between 18th November 2004 and 1st October 2009, 1834 CDM projects have been registered by the CDM Executive Board (EB). Most of these projects have been hosted by China and India, as shown in the following figure.

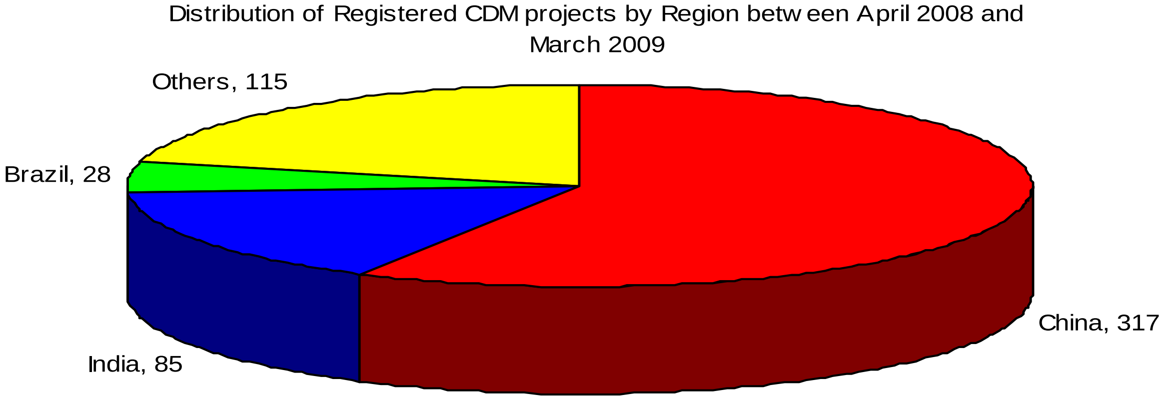
Figure 11: Registered project activities by host party (total 1834 till Oct 1, 2009)



Source: Derived from UNEP Riso Centre Database (http://cdmpipeline.org/cdm-projects-region.htm)

If one analyses the distribution of CDM projects for the year April 2008 to March 2009, then around 58% of the projects have been hosted by China, 15% by India, 5% by Brazil and 22% by others. More than one-third of the total number of projects, 545 in all, has been registered between April 1, 2008 and March 31, 2009, implying a high increase in rate of CDM project registrations in the last year.

Figure 12: Distribution of Registered CDM projects between April 2008 and March 2009

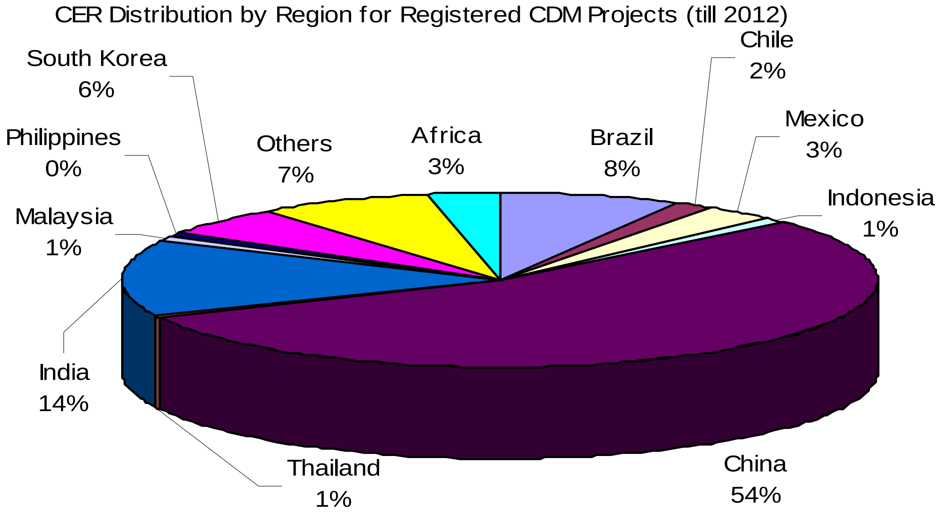


Source: www.cdm.unfccc.int

It can be observed from the comparative graphs that bulk of the Chinese CDM projects have been registered in the last financial year 2008-2009, which exhibits the huge impetus given by the Chinese government for increasing revenue and development gains arising from CDM activity, whereas India and other countries have not shown progress on this front.

The distribution of total CERs till 2012 from registered projects show that around 54% CERs are being issued to China (against 34% registered projects), 14% to India (against 25% registered projects), and 8% to Brazil (against 9% registered projects). South- east Asian economies like Malaysia, Indonesia and Thailand are also increasing their presence in the CDM project activities. South Korea also holds 6% of these CERs against the 2% registered projects. This also shows that the size of projects registered in China and South Korea is much larger compared to India as well as other countries.

Figure 13: Total CERs from registered projects by host party (total 16853 million till 2012)



Source: Derived from UNEP Riso Centre Database (http://cdmpipeline.org/cdm-projects-region.htm)

CDM Activity in South Africa

South Africa is a non-Annex I country and has tremendous potential to gain from CDM activity. However, very few projects hosted by South Africa have been registered. The following table shows all the CDM projects which have been registered in South Africa[3] till October 1, 2009-

Table 5: A sample of registered CDM projects till October 1, 2009 (total 16 projects)

CDM EB Ref	Project Activity	Type of project	Date of registration/ start of crediting period	Av annual CERs (tCO2/y)	Total CERs till 2012 (tCO2)
0079	Kuyasa low-cost urban housing energy upgrade project	Energy efficiency	27 Aug 2005/ 1 Sep 2005	6580	46060
0177	Lawley Fuel Switch Project	Fuel switch to natural gas	6 Mar 2006 / 1 Jan 2005	19159	153272
0446	PetroSA Biogas to Energy Project	Biogas	29 Sep 2006/ 1 Apr 2006	29934	171635
0358	Rosslyn Brewery Fuel-Switching Project	Fuel switch to natural gas	29 Sep 2006/ 1 June 2007	101413	598462
0545	Durban Landfill-gas-to-electricity project – Mariannhill and La Mercy Landfills	Methane recovery & utilization	15 Dec 2006 / 1 July 2006	68838	481833
0795	Tugela Mill Fuel Switching Project	Fuel switch (Biomass)	12 Feb 2007/ 15 Jan 2007	55912	335472
0925	EnviroServ Chloorkop Landfill Gas Recovery Project.	Methane recovery & utilization	27 Apr 2007/ 1 July 2007	188390	1015295
0752	Omnia Fertilizer Limited Nitrous Oxide (N2O) Reduction Project	N2O decomposition	3 May 2007/ 1 Apr 2007	473338	2366396
0966	Mondi Richards Bay Biomass Project	Biomass	20 May 2007/ 1 Oct 2005	184633	1402438
0961	Sasol Nitrous Oxide Abatement Project	N2O decomposition	25 May 2007/ 25 May 2007	960322	5761932

[3] Detailed data for South African CDM activity available at www.cdm.unfccc.int

1027	Transalloys Manganese Alloy Smelter Energy Efficiency Project	Energy efficiency	19 Oct 2007/ 1 Oct 2004	55044	483886
1171	Project for the catalytic reduction of N2O emissions with a secondary catalyst inside the ammonia reactor of the No. 9 nitric acid plant at African Explosives Ltd ("AEL"), South Africa	N2O decomposition	5 Nov 2007/ 14 Aug 2007	116683	628687
1364	N2O abatement project at nitric acid plant No. 11 at African Explosives Ltd. (AEL), South Africa	N2O decomposition	8 Feb 2008/ 8 Feb 2008	265242	1299739
1665	Kanhym Farm manure to energy project	Biogas From animal waste	18 July 2008/ 18 July 2008	32666	144442
1921	Durban Landfill-Gas Bisasar Road	Methane recovery & utilization	26 Mar 2009/ 26 Mar 2009	342705	1170000
2549	Alton Landfill Gas to Energy Project	Methane recovery & utilization	24 Aug 2009/ 24 Aug 2009	25883	155086

Source: Derived from http://www.iges.or.jp/en/cdm/index.html

Thus, only 16 CDM projects have been registered in South Africa till October 1, 2009. Out of the 16 projects that were registered for CDM in 2008, only four projects have been issued CERs. They are Lawley Fuel Switch Project, Omnia Fertilizer Limited Nitrous Oxide (N2O) Reduction Project, Sasol Nitrous Oxide Abatement Project and Transalloys Manganese Alloy Smelter Energy Efficiency Project. The issuance rate has been 92%, 114%, 76%, and 115% respectively. A total of 1022602 CERs have been issued till October 1, 2009 to projects hosted by South Africa.

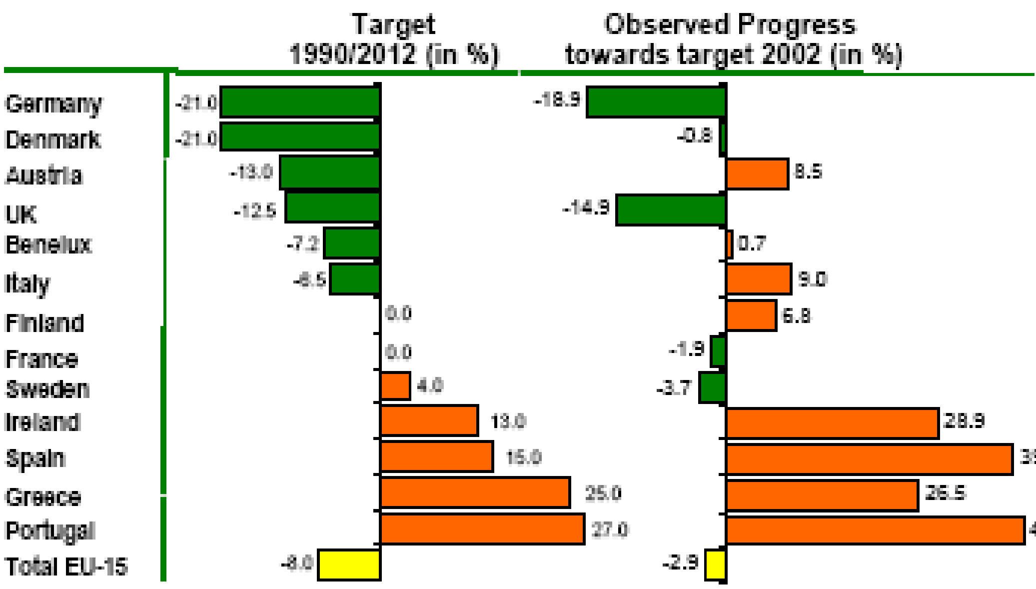
South Africa, being a developing economy, has tremendous potential for gains from CDM. Still, progress on this front has been negligible. It appears that one or more enabling conditions are not present which is impeding CDM progress in South Africa. Three important enabling conditions for ensuring gains from CDM are as follows; (i) appropriate policies, (ii) efficient institutional structures, and (iii) adequate technological capacity. The kind of projects which have already been registered in South Africa by the CDM EB include energy efficiency, fuel switch, biogas, N_2O decomposition, and methane recovery. Possibility of gains from such projects can be found amply in South Africa, given the developing state of economy where chances of gaining from efficiency improvements are significantly high. Thus the government needs to ensure that all the major enabling conditions are met for making CDM a success in South Africa.

6.2 OPPRTUNITIES FROM EMISSION TRADING SCEHEMES: The Case of European Union Emission Trading Scheme

The EU-ETS started its operation from 1st January 2005. This was the beginning of the first phase of the first mandatory international greenhouse gas trading scheme in the world. The EU-ETS regulates around 11,400 installations owned by more than 5000 companies across 25 EU member states. The scheme regulates carbon dioxide emissions from large point sources of key industries sectors including energy, paper, cement and metal, which together emit more than two billion tones of CO_2 every year, covering more than half of EU emissions (Climnet 2009). The first phase can be regarded as a large scale experiment for deriving important policy lessons and learning. The second phase, running from 2008 to 2012, coincides with the first Kyoto commitment period, while the third phase runs from 2013 to 2020.

Initially, only 15 EU states joined the treaty, but later with 10 more states joining by May 2004, the EU-ETS was expanded to 25 countries. The EU-15 nations had agreed to reduce 8% from the 1990 levels by the first commitment period. The accession of the new 10 member states, most of which are economies in transition from Eastern Europe, has eased the burden of reduction as many of these already have much lower emissions than their targets due to their economic restructuring. If any member state is not able to meet its emission target obligation under the EU-ETS, then it has to face a strict penalty.

Figure 14:EU15 Burden Sharing

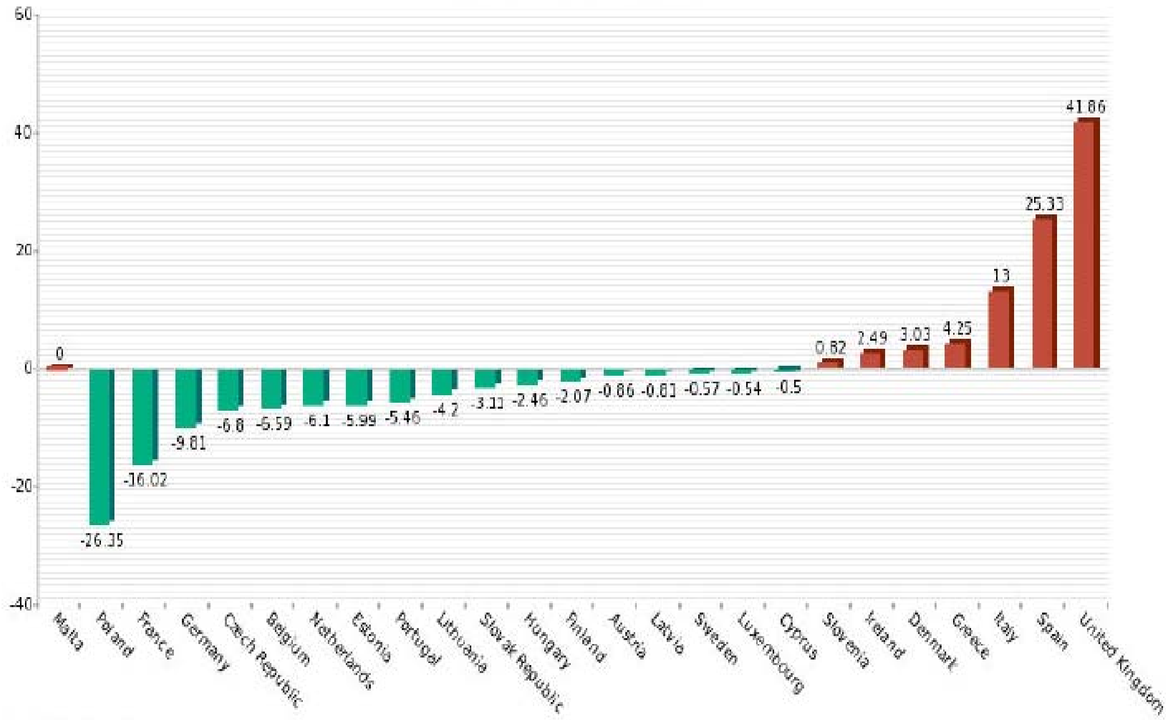


Source: Duerr (2007)

Even after incorporating the currently in practice policy measures in various sectors (like energy efficiency, vehicle emission standards, etc.), GHG emissions over the next 10 years are expected to be 300 MtCO2 above the Kyoto target (Pew Centre on Global Climate Change 2005). This leaves a huge chunk of emissions to be mitigated even after including allowances left with the new member states.

The distribution of allowances is based on National Allocation Plans (NAPs). Each EU member state had to submit a NAP. The NAPs set the overall level of emission reduction effort relative to the emission reduction in other sectors of the economy in line with the country's Kyoto commitment. These allocate allowances to various sectors and installations under EU-ETS. The NAPs are approved by the EU council after review and discussions. The first phase of EU-ETS has a very important learning that most of the NAPs over allocated emission allowances. The following figures show actual and percentage emissions in 2007 as compared to caps. It can be seen that countries like UK and Spain under-allocated allowances and hence over-emitted, while other countries like France and Germany over-allocated allowances, which has been a strong concern for the EU council of ministers.

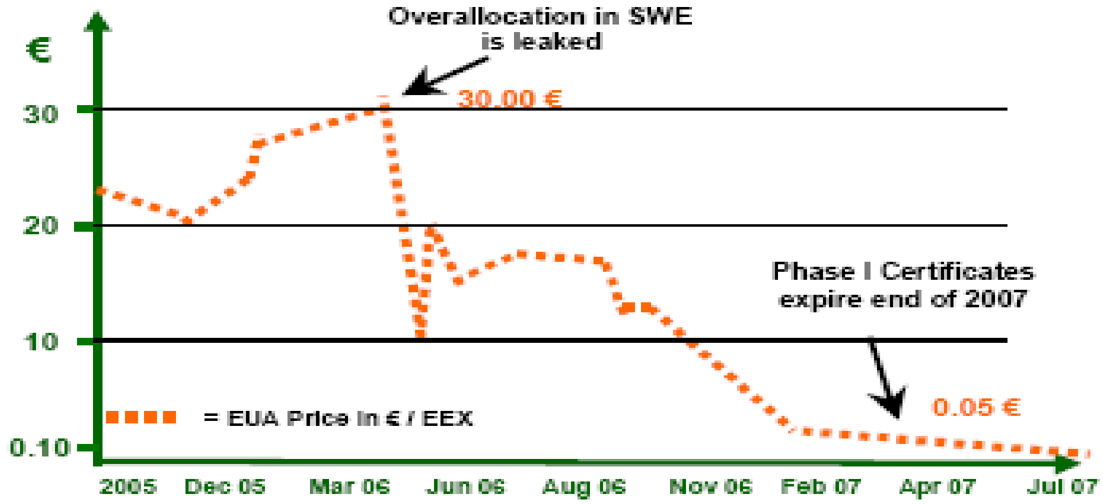
Figure 15: Emission to Cap in 2007 ($MtCO_2$)



Source: Carbon Market Data (2008), www.carbonmarketdata.com

This implied reduced effort for emission mitigation. In 2007, the EU-ETS nations emitted 7.5 Mt less than they were allowed (Carbon Market Data, 2008). This has been taken very seriously by the European Council and the emission targets under NAPs are expected to be much more stringent in the second phase. Other important issues have been linkages with other large emission trading schemes, like Japan and Canada, and import of emission credits from project based mechanisms like CDM. Price fluctuations and instant build up and fall in prices was another important learning. Thus pricing of CO_2 has made it another factor of production and has not started being considered as an important variable in the decision making process of the EU companies, many of which are projecting EU allowance prices and using this information for strategic decision making. The huge fluctuation in prices exhibits the high uncertainty prevalent in the early trading period and the importance of NAPs in influencing the carbon price.

Figure 16: CO_2 price during first trading period (2005-07)



Source: Duerr (2007)

A very important concern for developing economies like India and South Africa which can gain from CDM is the import of project based credits in EU-ETS. Currently there is a limit to import of credits. Still, given the huge size of EU-ETS credit market, the demand for project based credits is huge. As per World Bank estimates, 78 $MtCO_2$ of credits were traded in 2003 mainly through the project based mechanisms. If the average size of a CDM project is around 250,000 tCO_2, then it will take around 1700 projects to meet the demand if the carbon credit demand from EU-ETS as well as other Kyoto compliance nations is considered (Pew Centre on Global Climate Change, 2005). Given the lead time in developing, financing and implementing projects, and the criticism of the way CDM has progressed, this raises many concerns regarding adequate availability of project based credits for being imported into EU-ETS.

One signal which is very strong is that the demand for CDM credits is going to be huge in the future. With even more stringent targets being adopted by EU member states under EU-ETS; this demand is going to further increase. This gives a clear signal to all the countries, like South Africa, which have tremendous potential to gain from CDM financing, to start formulating national policies and building institutions which can facilitate the process of CDM so that these countries can derive maximum benefit out of this Kyoto flexible mechanism.

7 Discussion and Conclusion

Impacts of climate change are imminent and a united global action is urgently needed to avoid what could potential become an environmental crisis that prove extremely difficult to reverse. Now is the time to examine our development path carefully and structure it in a way that decouples it from carbon. South Africa is a developing economy and is still grappling with basic issues relaed to heath, education and water. Climate change impacts are expected to further worsen the water availability and health situation. With all the major regions of the world recognizing the climate change problem and accepting that the responsibility of mitigation would be a common but differentiated one, South Africa also needs to start undertaking actions which lower its carbon emissions and primary energy usage. This country could also be expected to play the role of a leader of the African continent in the future for demonstrating and managing climate change mitigation and adaptation activities.

Being a coal based economy due to abundance of domestic coal reserves, government policy becomes important to ensure that the future development pathway is less energy and carbon intensive. The current paper presents and asseses some of the strategies which can be employed by the South African government for reducing its emissions. The start now option points out those actions which can be undertaken right away without substantial investment. Many of these options can be also viewed as providing co-benefits of various development services required by South Africa. The scaling up option picks up few options which can be scaled up in the future reduce in substantial emission savings. This strategy hinges critically on the development of new technologies including carbon capture and storage, electric vehicles, and less costly renewable energy and nuclear technology. The third strategic option is the use of markets and CDM financing which needs to be tapped for increased investment in emission reduction activities.

The paper also emphasizes and discusses in details the importance of end use energy efficiency for the industrial and commercial sector as well as the potential of gaining from the international carbon market. Industry has a role to play particularly around energy efficiency and process optimization. As Waste Minimization studies have shown in the past, investment in efficiency and optimization has both economic and environmental benefits including improvement in human behavior and work ethics. The industrial and commercial energy efficiency improvements can bring about substantial financial savings to the businesses and reduce carbon emissions as well. Since the initial cost of these efforts can be high, government policy needs to ensure that there are incentives and subsidies for the industrial sector to undertake energy efficiency improvement efforts. There can be capital subsidies for energy efficient machienery and equipment as well as energy efficiency targets for the highly energy intensive industries. Energy efficiency certificates and trading can also be explored.

Finally, carbon market and CDM financing hold tremendous opportunity for South Africa. Till date, negligible gain has been made out of this huge resource. Very few CDM projects have been registered in South Africa and it appears that either the existing information and institutional processes for registering a CDM project are highly tedious or the government policy is not proactively addressing issues related to promoting CDM in South Africa. The government should start with reviewing the CDM project status around the world and identify sectors having highest potential for gaining from CDM activity. After this, strategies for promoting such projects in these specific sectors and incentivising project developers from South Africa need to be devised and implement. The relevant institutional arrangements existing at the national level need to be strengthened and revitalized for tapping the maximum potential of carbon markets. With more emissios trading schemes being initiated and implemented by various countries and regions, like the Japanese ETS, Australian ETS, the Regional Greenhouse Gas Initiative (RGGI) and Western Climate Initiative (WCI) in the US, the importance of offsets is bound to grow increasing the demand for carbon credits from emission reduction activities in the non-Annex 1 economies. Therefore South Africa can decide to view climate change as a potential environmental crisis or better, an opportunity to participate in the global climate change mitigation efforts and also gain from it and move towards a development pathway towards that is truly sustainable.

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