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LONG TERM MITIGATION SCENARIOS
Strategic options for South Africa

The LTMS: motivation, process and results

In March 2006 the South African Cabinet commissioned a process to examine the options available to ***mitigate***[1] our greenhouse gas emissions, informed by the best available information. The first Phase of this study has been completed. The process was set up as a dialogue between stakeholders from all sectors of South Africa and four research teams, which together made up a **Scenario Building Team**. This document, read with the Technical Summary, is the result of the work of this team. The conclusions reached here are to be presented to South African leadership in each sector for further discussion and refinement, and ultimately will conclude with a final version of this document being presented to Cabinet in early 2008. This document will be published in order to raise general awareness in South Africa.

The LTMS process aims to achieve these outcomes:

Cabinet can approve, on the basis of sound analysis, (a) a pathway for long-term climate policy, and (b) positions for the negotiations under the UN Framework Convention for Climate Change;

South African stakeholders understand, and are focused on and supportive of a range of ambitious but realistic strategies for future climate action;

South African negotiators are well prepared with clear and mandated positions for the negotiations on a future multi-lateral climate regime.

Two fundamental questions arise: *Why should South Africa be concerned with the mitigation of greenhouse gases? What options for mitigation are available, and how much can each reduce emissions, at what cost?* The answers to these questions are found in a complex layer of domestic social and economic realities, international diplomatic outcomes, technological developments, and finally in the ethics of caring for our future generations.

This set of documents is primarily intended to assist South African stakeholders in developing answers to these questions. Looking from a base year of 2003 towards a 2050 horizon, it first explores two possible ***Scenarios***, assessing them against the full range of the possible international climate change ***Contexts***. The assessment suggests that only one of these Scenarios is actually robust. The document then proceeds to explore ***Strategic Options*** for reducing emissions.

LTMS Process
- A) Scenario Document ***(this document)***
- B) Technical Summary
- Technical Report and Appendix
- Technical Inputs:
  - Energy emissions
  - Non-energy emissions
  - Macro-economic analysis
  - Climate impacts

It is hoped that apart from raising the general understanding of a range of mitigation choices available to us as a country, this document will identify the further work that

[1] Mitigation is the reduction of greenhouse gases, the most important of which is CO_2

needs to be done, the parameters for the positions that Government's negotiating teams may adopt, and the pathway for developing a comprehensive Climate Change Policy for South Africa.

The challenge of Climate Change

- ***Climate Change is almost certainly[2] caused by humanity's greenhouse gas emissions.***
- ***The scientific evidence for a rise in global temperature is unequivocal and the economic case for action is compelling.***
- ***To keep temperature increase in a range between 2.0 and 2.4°C, global emissions will need to peak by 2015 and then decline.***
- ***There is a cost to this emission reduction effort, but it is far exceeded by the costs of inaction, as climate impacts require large-scale adaptation.***
- ***This is not just an environmental issue; it goes to the very heart of the international economy's future viability, as well as achieving and sustaining the Millenium Development Goals.***

For South Africa, the implications are important.

- ***South Africans, and particularly our poor communities, are especially vulnerable to many of the projected future climate impacts.***
- ***It is therefore in the interests of South Africa that global emissions decrease to a degree that avoids dangerous climate change.***
- ***South Africa is committed to playing its part in this effort to mitigate emissions.***
- ***South Africa is proactively engaging in the multi-lateral climate negotiations, which will likely agree the future of the climate regime by 2009.***
- ***Developing countries are currently not constrained under the Kyoto Protocol but in the upcoming international negotiations there is increasing pressure on the larger developing country emitters to demonstrate their plans for achieving emissions reductions.***
- ***It is accordingly incumbent on South Africa not only urgently to develop such a plan, but also to prepare the path for its implementation, at an appropriate time in the future, and in so doing to achieve the voluntary/mandatory emissions reductions targets agreed upon. The LTMS information is aimed at helping decision makers to begin this journey.***

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[2] According to the IPCC's Fourth Assessment Report, "most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations". Very likely means that the assessed likelihood, using expert judgement is greater than 90%.

Three areas need to coalesce into a coherent vision if SA stakeholders are to succeed in formulating and implementing a plan of action that is economically risk averse and internationally aligned to the world effort on climate change. These are:

Technology: Wider deployment of existing climate-friendly technology, commercialisation of emerging technologies and spending at scale on research and development of new technology
Investment: Determining the sources, mechanisms, and quantum of investment in a low -carbon society
Policy: Providing clear guidance through policy frameworks that send a long, loud and legal message to the markets

South Africa: The response

With the science of Climate Change now unequivocal,[3] the understanding is clear: human-induced emissions of greenhouse gases are driving climate change. The impacts of this climate change will likely be catastrophic if not checked and drastically reduced. South Africa is particularly vulnerable to the predicted Climate Change impacts.

South Africa has ratified the United Nations Framework Convention on Climate Change and its Kyoto Protocol and plays a proactive role in the climate negotiations.

The actions required in South Africa to mitigate emissions will be driven by *policy*, both domestic and international, and by *investment* in new *technologies*, building a new *definition of competitive advantage*. South Africa's challenge is to retain growth and development, while reducing poverty and at the same time retooling its economy in order to reduce its greenhouse gas emissions.

South Africa will also have to ***adapt***[4] to the predicted (and already occurring) impacts of Climate Change. The Stern review[5] has reported that the costs of adaptation for the world, should no mitigation occur (called the costs of inaction), will be in the order of 5 to 20 times the cost of the mitigation actions required. Hence if the world, and correspondingly South Africa, does not mitigate, it will be overtaken by climate impacts and the associated damage costs.

The focus in LTMS is on mitigation, with an updated study on climate change impacts and adaptation reported separately. Determining the options for mitigation, the emissions reductions achieved by these options and the attendant costs of each option, is at the heart of the work done in the LTMS[6].

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[3] There is always uncertainty about the future, however the uncertainty has been quantified, with narrower and narrower error margins. The consensus among scientists is overwhelming. *Observed* data shows unequivocally that the climate is already warming. Best estimates for projected climate change are, for a low emissions scenario is an increase of 1.8°C and the best estimate for the high scenario is 4.0°C. The *likely* ranges are 1.1°C to 2.9°C (lower) and 2.4°C to 6.4°C (higher); likely being specified by the IPCC as greater than 66% probability of occurrence.

[4] Adaptation is the act of responding to the impacts of climate change

[5] The Stern Review (2006) on the economics of climate change, see www.hm-treasury.gov.uk, go to Indepdendent Reviews, and Stern Review.

[6] Our study on Impacts revealed that our state of knowledge currently does not enable us to model the comparative "costs of inaction", which would have been ideal.

Climate Change is becoming a defining fact of economic development. Whilst it is an environmental challenge on one level, in fact it is likely to become a major economic imperative of the next three decades at least.
However the major difficulty lies in the sheer scale of the real and potential mitigation solutions required.
Hence it is now incumbent on policy makers, civil society, as well as investors of capital to face the size of this challenge by planning with climate change implications foremost in their minds.

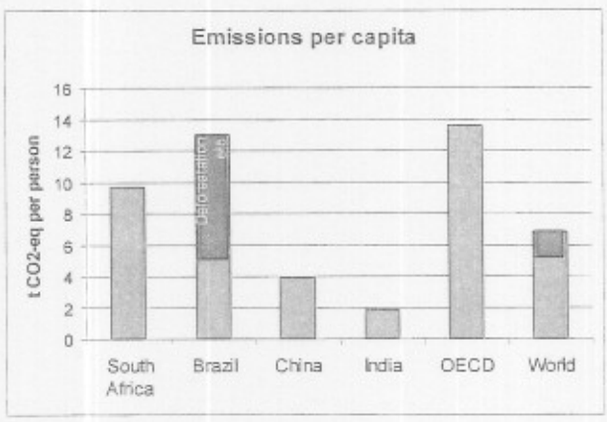
Emissions

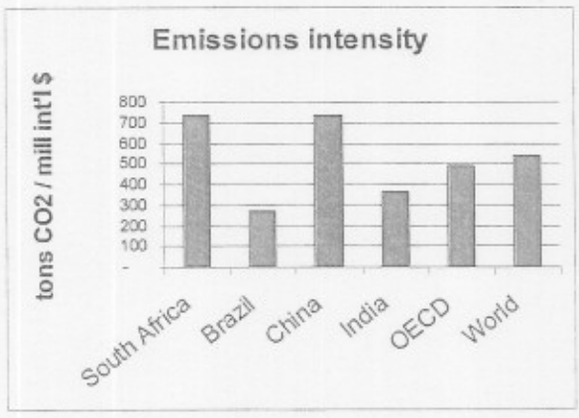
The World in 2004 produced about 49 000 Megatons CO_2-equiv[7], mainly from energy generation and deforestation. In comparison South Africa produces about 440 Mt, or about 1% of the global figure.

On any basis, South Africa's emissions are large relative to its population and economy. South Africa has a coal-based energy economy, which has historically had relatively low energy prices supporting energy-intensive industries such as minerals beneficiation. As the table shows, our emissions intensity is high compared to major developing and developed countries. Our emissions per capita are high compared to China and India, the latter two also being coal-based energy economies, and also compared to Brazil – until one includes emissions due to changes in land use, notably deforestation.[8]

	Annual GHG emissions, 2000	*Cumulative CO_2 emissions, 1950-2000*
	Mt CO2-eq	*Mt CO_2*
	Six gases[1], energy & LULUCF	*CO_2 only, energy & LULUCF*
South Africa	415	10,250
Brazil	2,213	68,389
China	4,920	110,675
India	1,814	17,581
OECD	15,423	467,564
World	41,240	1,113,122

Notes: [9]
1 Gases for annual emissions include CO_2 (energy), CO_2 (land use change), CH_4, N_20, PFCs, HFCs, SF_6.
2 International dollars on a power purchasing parity basis.





[7] "Megatons". Emissions from the other GHGs are converted to CO2-equivalents by Global Warming Potentials, 21 per ton of methane, 310 per ton of nitrous oxide. Units of million tons are preferred; inventories tend to report in Gg. 1 Mt = 1000 Gg.
[8] In the climate negotiations, the sources of emissions are referred to as 'LULUCF' – land use, land use change and forestry.
[9] Data source for table and graphs: Climate Analysis Indicator Tool (WRI, 2003; http://cait.wri.org). Note SA's emissions in the table are not the 440 Mt CO_2-eq in this study – which is for a different base year and based on bottom-up analysis.

South Africa is therefore in a difficult position in relation to some proposed climate regimes. Some countries argue – on the basis of equity – for allocation of emission allowances on a per capita basis. South Africa already exceeds the global average. Other proposals for developing countries are based on emissions intensity. Again, given our high relative emissions intensity, this is not likely to be a favourable approach for South Africa.

The multi-lateral negotiations

Thus far, South Africa has been exempt from taking mandatory action to reduce our high level of relative emissions. In the United Nations Framework Convention on Climate Change (UNFCCC) the principle of equity and "common but differentiated responsibility" was agreed, by which the developed nations would take the lead in mitigating greenhouse gases. South Africa has a loose commitment to mitigate under the Convention, but no legally binding, quantified target. Under the Kyoto Protocol, carbon constraints, or caps, were only placed on industrialised countries. South Africa along with others such as Brazil, China and India are allowed to continue to grow without a cap on emissions but contributing through the Clean Development Mechanism in the first commitment period (2012). This provides credit for early action. However, once developed nations take the lead with more ambitious emissions reductions, they expect at least some developing countries to take a fair share of our common (albeit still differentiated) responsibility. What happens beyond 2012 is currently the subject of negotiations. Agreement on a post-2012 regime is likely in 2009. Therefore, there is **urgency** to translate LTMS into policy and negotiation positions.

Pressing for total exemption from any mitigation effort is not an option. This is because the full extent of the impacts South Africa will progressively experience over this century will depend on the agreement reached by the international community to constrain its emissions (and its success in adhering to this constraint). The closer this agreement is to the constraint "required by science", the more South Africa will be protected from serious to catastrophic climate impacts. Hence these impacts in South Africa are not a direct consequence of South African emissions. We are reliant on the commitment of others, and hence must match them with a commitment of our own.

The question is hence: in the negotiations ahead, what position should SA take? This can only be based on a full knowledge of how much different mitigation options (wedges) reduce emissions and how much they might cost. What are these actions? How can they be packaged so that emissions peak fairly soon and at what level? When do they need to decline, and how fast?

Wedges are important:
Wedges refer to "triangles" showing emissions reductions over time. Emission reductions are the difference between emissions in the reference case (GWC) and the mitigation case. If the reductions increase over time, the graphs have the shape of a wedge. In the LTMS, the terms mitigation actions and the resultant wedges are used somewhat interchangeably

The Scenario Building Team of the LTMS through its research has explored these questions, and some significant results have emerged. These results are packaged in the following sections.

The LTMS Scenarios and Strategies were achieved with rigour, both from the perspective of the process followed and the data used. The process combined 4 eminent research groups with a technical team of sector based individual experts, forming a Scenario Building Team. A bank of data has been produced through modelling, captured in the LTMS Technical Report (the summary of which is attached). Cost and emissions levels for a number of actions are captured. This work covered energy and non-energy emissions in SA. The data has been fed into economy-wide modelling, giving further results for effect on GDP, job creation and wealth distribution.

SCENARIO 1

What if South Africa did not mitigate its emissions before 2050?

The "Growth without Constraints" story

If in 2050 (and beyond) South Africa was not subject to any climate change constraint, if there were no climate impacts highly damaging to the economy, if there was no significant oil constraint, and if we made our choices to energise our economy purely on least-cost grounds, without internalising external costs, what would our economy and its greenhouse gas emissions look like? Growth without Constraints is the story of this, the first Scenario. All other Scenarios and Strategic Options are assesses against Growth without Constraints – it is our reference case. [10]

This Scenario is rigorously modelled, and data is accurate. The Scenario Building Team agreed on key drivers, constraints and assumptions to use in the modelling (details in Technical Report). Drivers are for example population growth and GDP projections. Prices of oil and other fuels, as well as exchange rates are factored in. Assumptions on economic growth are consistent with the growth targets in the Accelerated and Shared Growth Initiative for SA (ASGISA), ranging between 3 and 6% GDP growth per year. These and other assumptions were fed into the model, which selected the least-cost sources of energy to fuel the economy over the period 2003 through to 2050. It also assumes that current trends in land use, agriculture and waste sectors continue.

In this Scenario, SA's emissions in the base year, 2003, stand at 440 megatons of CO_2-eq. By 2050, our emissions have quadrupled to around 1600 Mt.

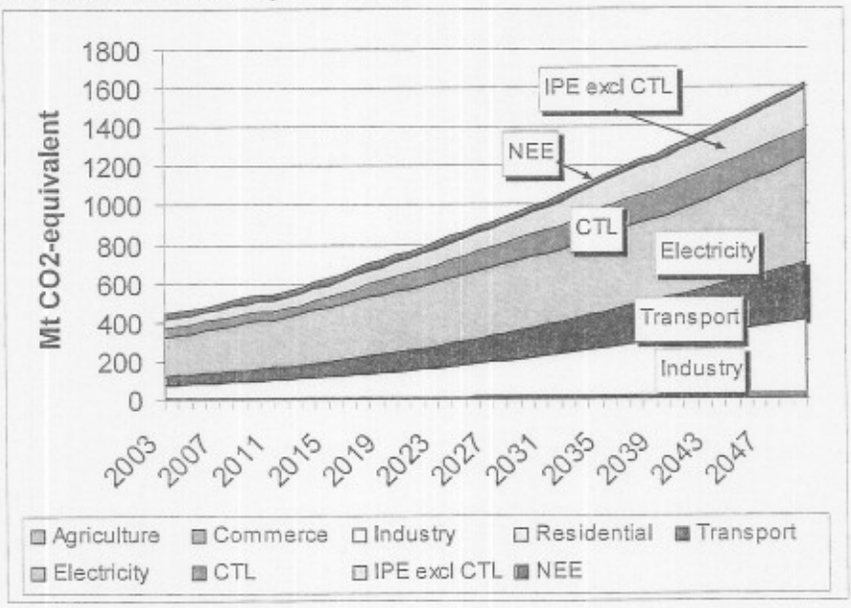
Here are the characteristics of the Scenario:

- **Demand side: Energy efficiency**
  In this Scenario, overall fuel consumption grows more than five-fold, mainly in the industry and transport sectors (see the Technical Report for details). There is no incentive for – and therefore no uptake of - energy efficiency, despite the potential net savings over time, showing the typical market pattern not to take up no-cost strategies.
- **Supply side: Coal**
  New coal plants are supercritical (23 GW, or 7 new plants, by 2050) or integrated gasification combined cycle (68GW, or 21 new plants, by 2050). IGCC becomes attractive as it is only slightly more expensive but significantly more efficient than supercritical coal. Since no carbon constraints are imposed, no electricity plants have carbon capture and storage (CCS).
- **Supply side: Nuclear**
  A total of 9 new conventional nuclear plants, adding 15 GW of new capacity are built, mostly between 2023 and 2040. Twelve modules of PBMR are built for domestic use.
- **Supply side: Renewables**
  Very few renewables enter the electricity mix in this Scenario. No electricity is generated from solar thermal or wind, with the only significant addition being 70 MW of landfill gas.
- **Liquid fuel**
  Liquid fuel supply is dominated by oil and synfuel (coal-to-liquids, CTL) refineries. Five new oil refineries add 1.5 million barrels / day by 2050. Five additional CTL plants are built over the period, each with a capacity of 80 000 bbl-eq /day, i.e. each half a Secunda. The costs of bringing forward water supply options are a potential constraint, with the costs of securing a reliable supply potentially prohibitive under current economic conditions. In this Scenario, CTL plants are built without carbon capture and storage (CCS).
- **Human behaviour**

[10] The reference case was modelled in great detail. Figures quoted are arrived at through this modelling process.

Patterns of human consumption and social behaviour do not change markedly in the period, compared to 2003 patterns.

The emission profile that emerges from the **Growth without Constraints** story is one in which emissions continue to be dominated by energy. Electricity generation accounts for 45% of greenhouse gas emissions in 2003 declining to 33% in 2050. The declining share is due to emissions growth in liquid fuels, with five new coal-to-liquid plants. Industrial process emissions (non-energy) increase more than four times in **Growth without Constraints**. The largest share in this category is from synfuels. Emissions in the other non-energy sectors – notably waste, agriculture and forestry, increase much less rapidly than for energy. The diagram shows model results for the rise in overall emissions and the respective shares of each major sector:



This Scenario tells a story of an economy and society based very much on the patterns and dynamics that dominate South Africa today. Mining has declined and the composition of GDP moved even further into tertiary sectors. The Scenario assumes that any constraints (e.g. on local water availability) have been overcome. It further assumes that industrial policy continues with its current, energy-intensive focus. In the absence of these constraints, at least notionally, the economy by 2050 is still performing well, and by all accounts South Africa is seen here as a successful country having achieved its goals. However, its emissions have quadrupled in the process.

SCENARIO 2

What if full-scale Mitigation was undertaken by South Africa? The "Required by Science" story

If by 2050, South Africa had all the resources and technology readily at its disposal to contribute significantly to the global mitigation effort that is required to stabilise the climate, what would have to be achieved? What would the implications be if South Africa charted this course from 2007 onwards?

In this Scenario South Africa joins the world community in taking similar action to stabilise GHG concentrations, and negotiates a target as its fair contribution to this shared vision.

Globally, what the IPCC[11] tells us is that reductions by 2100 of between -60% to -80% from 1990 levels must be achieved.[12] The burden sharing between nations of this target is the subject of the international negotiations.

This Scenario could not be modelled in the same way as Growth without Constraints. This is primarily because the Scenario depends for its full realisation on technologies and measures whose parameters are largely unknown. The Required By Science Scenario cannot be met within a modeling framework that is based on known technologies with well-understood parameters, including cost. The LTMS process also did not attempt to quantify the emission reductions or costs of behavioural changes. Hence the SBT could not analyse the costs and other characteristics of this scenario. Hence the Scenario is more like the classic "story of the future" and its components, therefore, are imagined and not arrived at through the rigour of modelling.

In this Scenario, the burden taken up by South Africa is not exact, but is seen rather as a target band ranging between between -30% and -40% from 2003 levels by 2050, assuming a burden-sharing discount, which would in itself be tough to negotiate. The lower end of the **Required By Science** target (-40%) can be thought of as a global or collective bottom line. The upper end of the **Required By Science** target range suggests some differentiation in responsibility, with countries of different capability and different national circumstances doing more or less. This range can be pushed up further, although this is not explored in this Scenario. The results show that even if a larger burden-sharing discount is negotiated, the extent of the emissions reduction challenge does not shift significantly (see diagram below). The degree of the burden sharing discount will be based on a number of factors:

- South Africa's status as a developing country and the imperative to reduce poverty
- The coal-based nature of its energy economy and the degree of effort and cost to make the changes required
- The extent to which the technological and financial resource transfers agreed in the Convention are realized.

It is assumed in this Scenario that South Africa does not have to take the same mitigation actions as the developed countries, but along with other major emitters in the developing world it takes greater responsibility and quantifiable mitigation action commensurate to its level of development and national circumstances.

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[11] The UN based Inter-Governmental Panel on Climate Change, the leading scientific body on Climate Change

[12] At the time the SBT agreed this level for 2050, the IPCC's Fourth Assessment was not yet published. The latest science suggests that, if anything, even greater reductions will be needed for any stabilization levels that avoid serious impacts.

For South Africa, emissions would still rise at first but would have to peak at an appropriate level and at the right time in order to guarantee the required decline to the target range in this Scenario. This implies large emissions reductions achieved through a co-ordinated mitigation programme at the national level with appropriate international assistance. In short, there is a high degree of planning required in this Scenario.

In turn climate security is guaranteed through the joint international action. Developed countries reduce emissions by -80% from 1990 levels by 2050, enabling South Africa to be more ambitious at -30% to -40% than it might otherwise have been. South Africa suffers less dramatic Climate Change impacts and reduced costs for adaptation and direct damage costs.

The characteristics of the Scenario are as follows:

The **Required by Science** story sees a South Africa in 2050 vastly different to the one we know. In both electricity generation and transport new technologies dominate the sectors, with the renewable and nuclear technologies we see in **Growth without Constraints** taken up much earlier and at much larger scale. Large-scale investment in new technologies across the globe has substantially reduced the unit costs of technologies, for example renewables. New technologies, notably hydrogen-based transport, are now the norm, with hydrogen being manufactured through non-carbon means. Although the largest emissions reductions are achieved in the energy and fuel sectors, the final gap is closed by widespread changes in human consumption and behaviour patterns. Many of these are achieved through awareness, as most citizens are acutely concerned with emissions and adopting low emission lifestyles.

In the Strategies sections that follow, we will look in more detail what the likely characteristics of this Scenario may be. To a large degree this Scenario, imagining as it does South Africa as part of a post-carbon world, is difficult to describe in detail. It can be stated with confidence, however, that achieving this emissions target range will be an immense task.