Information on climate change in South Africa:
greenhouse gas emissions and mitigation options

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TOPIC 4

What are the options for mitigating climate change in South Africa?

Contents

1. The mitigation scenarios

Mitigation actions in the Long Term Mitigation Scenarios were considered in three categories – energy supply, energy use and non-energy emissions. Each of these includes sub-sectors; Energy modelling considered energy supply (notably electricity generation and liquid fuels), as well as energy use in major economic sectors – industry, transport, commercial, residential and agricultural sectors, while industrial process emissions focused on synfuels production, coal mining, iron and steel, ferro-alloys, aluminium and cement production. Non-energy emissions in agriculture, waste and land use, land use change and forestry (LULUCF) were also modelled (Winkler 2007).

Table 1 below presents a description of the mitigation actions that were modelled in the LTMS process, together with their respective mitigation capacities, mitigation costs and investment requirements, arranged in order of mitigation capacity from the largest GHG emission reduction to the smallest. While the mitigation cost depicts the cost of mitigating one tonne of CO_2-equivalent emissions, the investment cost requirement highlights the undiscounted incremental cost of investment from the baseline scenario.

Table 1: Summary of modelled mitigation actions, GHG emission reduction potentials and costs (Winkler 2007)[1]

Mitigation action	*Model description and parameters*	*GHG emission reduction, Mt CO_2-eq, 2003-2050*	*Mitigation cost (R/t CO_2-eq)*[2]	*Rank costs – lowest cost is no.1*
Escalating CO_2 tax	An escalating CO_2 tax is imposed on all energy-related CO_2 emissions, including process emissions from Sasol plants.	12 287	42	20
Nuclear and renewable electricity, extended	Combines the extended renewables and nuclear scenarios below. At 50% each, this is a zero-carbon electricity case	8 297	52	23
Electric vehicles with nuclear, renewables	Electric vehicles are allowed to take up 10% of passenger kilometre demand between 2008 and 2015 increasing to 60% of demand in 2030 and remains at 60% to 2050	6 255	102	28
Nuclear and renewables	Combines the individual nuclear and renewables cases. i.e. no electricity from fossil fuels by 2050	5 559	64	24
Industrial efficiency	Improved boiler efficiency, HVAC, refrigeration, water heating, lighting & air compressors, motors, compressed air management, building shell design optimising process control, energy management systems & introducing variable-speed drives	4 572	-34	8
Renewables with learning, extended	Same as renewables extended (50%), but assuming that the unit costs of renewable energy technologies decline, as global installed capacity increases	3 990	3	13
Subsidy for renewables	-106 R/GJ, on electricity from power tower, trough, PV, wind, hydro, bagasse, LFG	3 887	125	30
Nuclear, extended	The bound on investment in new capacity for both PBMR and PWR were increased to 2050	3 467	20	17
Renewable electricity, extended	In an extended mitigation action, the bound on commissioning of new Parabolic Trough and Solar Power tower plant is increased to 2.5GW/year by 2050	3 285	92	27

1 Negative value of investment cost implies an investment saving compared to the baseline.

2 Average of incremental costs of mitigation action vs. Base case, at 10% discount rate.

Mitigation action	*Model description and parameters*	*GHG emission reduction, Mt CO_2-eq, 2003-2050*	*Mitigation cost (R/t CO_2-eq)[2]*	*Rank costs – lowest cost is no.1*
Renewables with learning	Same as renewables (27%), but assuming that the unit costs of renewable energy technologies decline, as global installed capacity increases	2 757	-143	7
Renewable energy for electricity generation	15% of electricity dispatched from domestic renewable resources by 2020, and 27% by 2030, from local hydro, wind, solar thermal, landfill gas, PV, bagasse / pulp & paper.	2 010	52	22
Nuclear electricity	27% of electricity dispatched by 2030 is from nuclear, either PBMRs or conventional nuclear PWRs – model optimised for cost etc.	1 660	18	16
Synfuels CCS 23 Mt	Carbon capture and storage on coal-to-liquid plant, with maximum storage of 23 Mt CO_2 per year, equivalent to concentrated emissions of existing plant	851	105	29
Improved vehicle efficiency	Improve energy efficiency of private cars and light commercial vehicles by 0.9%-1.2% per year (0.5% in base case).	758	-269	3
Biofuel subsidy	A subsidy of R1.06 per litre on biofuels applied as an incentive for biofuel take-up	573	697	35
Passenger modal shift	Passengers shift from private car to public transport and from domestic air to intercity rail/bus.–moving from 51.8% of passenger kms in 2003 to 75% by 2050	469	-1 131	2
Land use: fire control and savannah thickening	50% reduction in fire episodes in savannah from 2004	455	-15	10
Electric vehicles in GWC grid	Electric up to 60% of the private passenger car market, operating in an unchanged grid, i.e. largely coal-fired	450	607	34
CCS 20 Mt	A cap on CCS use is increased annually starting with 1 Mt in 2015, and reaching a peak of 20 Mt in 2024.	449	72	26
Waste management	Waste Minimisation and composting	432	14	15
Residential efficiency	Penetration of SWHs, passive solar design, efficient lighting, appliance labelling & STDs, geyser insulation, LPG for cooking, ‘Basa Njengo Magogo’ coal fire-lighting method	430	-198	6
Commercial efficiency	In new buildings: SWH, efficient water heating, efficient HVAC, efficient lighting, variable speed drives, efficient motors, efficient refrigeration, building energy management systems, and efficient building shell design. In existing buildings, retrofit equipment and energy management systems	381	-203	5
Hybrids	20% of private cars are hybrids by 2030 (ramped up from 0% in 2001 to 7% in 2015).	381	1 987	36
Agriculture: enteric fermentation	Cattle herd reduced by 30% between 2006 and 2011; 45% of free-range herd transferred to feedlots from 2006; high-protein, high digestibility feed supplementation	313	50	21
SWH subsidy	The cost of SWHs in the residential sector was reduced. The cost after subsidy in 2001 is R534.7 mil /PJ/a, which reduces further to R336.77 mil /PJ/a in 2050	307	-208	4
CCS 2 Mt	A cap is placed on the amount of CO_2 which can be stored annually by CCS to 2Mt.	306	67	25
Land use: afforestation	Rate of commercial afforestation will increase between 2008 to 2030 so that an additional 760 000 ha of commercial forests are planted by 2030	202	39	19
Cleaner coal for electricity generation	27% of electricity dispatched by supercritical coal and /or IGCC coal technologies by 2030; first plant could be commissioned by 2015.	167	-4.8	11

Mitigation action	Model description and parameters	GHG emission reduction, Mt CO_2-eq, 2003-2050	Mitigation cost (R/t CO_2-eq)[2]	Rank costs – lowest cost is no.1
Biofuels	Biofuels blends increased to 8% ethanol with petrol and 2% biodiesel with diesel in 2013. Thereafter the percentage of ethanol in petrol is taken up to an assumed maximum of 20% and biodiesel to a maximum of 5% in 2030.	154	524	33
Synfuels methane capture	Capture CH_4 emissions from existing CTL plants from 2010	146	8	14
Agriculture: reduced tillage	Reduced tillage is adopted from 2007 on either 30% or 80% (more costly) of cropland	100	24	18
Synfuels CCS 2 Mt	Carbon capture and storage on coal-to-liquid plant, with maximum storage of 23 Mt CO_2 per year, equivalent to the largest planned storage at the time.	78	476	32
Coal mine methane reduction (50%)	Capture 25% or 50% (at higher cost) of methane emissions from coal mines, starting in 2020, and reaching goal by 2030	61	346	31
Agriculture: manure management	Percentage of feedlot manure from beef, poultry and pigs which is scraped and dried (does not undergo anaerobic decompositions) raised to 80% by 2010	47	-19	9
Aluminium: PFC capture3	Capture of PFCs from existing aluminium plant, starting in 2011, and reaching 100% by 2020	29	0.2	12
Limit on less efficient vehicles	SUVs limited to 2% of private passenger kms by 2030	18	-4 404	1

Apart from the GWC, one other envelope scenario called the '*Required by Science*' scenario (RBS) was outlined. This scenario is different from all other scenarios in that it is driven by a climate target. RBS asks what would happen if South Africa reduced its emissions by 30% to 40% from 2003 levels by 2050.

2. Three modelled strategic options

To bring South Africa's emissions closer to what is required by science three strategic options were modelled in the LTMS. Each option was arrived at by strategically combining various mitigation actions such that the final package of actions is large enough to reveal a distinct emission reduction pathway (Scenario Building Team 2007). These options are described below while their properties are summarised in Table 2.

Table 2: Mitigation costs and emission reduction potentials of combined strategic actions

Mitigation action	Mitigation cost (R/t CO_2-eq)	GHG emission reduction (Mt CO_2-eq, 2003-2050)	Mitigation costs as share of GDP
	Average of incremental costs of mitigation action vs. base case, at 10% discount rate	Positive numbers are reductions of emissions by sources or removals of emissions by sinks	%, negative numbers mean negative costs
Start Now	-R13	11 079	-0.5%
Scale Up	R39	13 761	0.8%
Use the Market	R10	17 434	0.1%

3 Investment for aluminium is only required once in 2006.

2.1 Start now

The first option, called *Start now*, is composed of all those mitigation actions in Table 8 that are not labelled as extended, excluding the CO_2 tax and subsidies which are modelled as part of the 'Use the Market' scenario below. All mitigation actions that have upfront costs, but where the savings over time more than outweigh the initial costs – also known as net-negative cost mitigation actions – are part of this strategic option.

Table 2 shows that this option saves money over time, even if implemented up to 2050. The biggest mitigation actions of *Start now* – in terms of emission reductions – are industrial efficiency, more renewables and nuclear sources for electricity generation, passenger modal shift and improved vehicle efficiency. Effectively the *Start now* scenario reduces the gap between GWC and RBS by 43% in 2050 (Scenario Building Team 2007).

2.2 Scale up

The second strategic option is called the *Scale Up* scenario, and it is an extension of the *Start now* package. Basically all the extendable mitigation actions in *Start now* are replaced in *Scale up* by their extended counterparts as shown in Table 8.

In terms of mitigation, the biggest actions in this scenario are energy efficiency, extended renewables, extended nuclear, synfuels with CCS and electric vehicles. Emissions follow the *Start now* profile fairly closely at first, and continue to rise; but in the last decade they level out (plateau). Under *Scale up*, the emissions gap is closed by two-thirds (64%) in 2050 (Scenario Building Team 2007).

2.3 Use the market

The last modelled strategic option is termed the *Use the market* scenario. This option focuses on the use of economic instruments, and it includes an escalating CO_2 tax on the whole energy sector, which generates revenue that could be used to provide incentives for renewable electricity, solar water heating and biofuels (Scenario Building Team 2007).

The tax causes electricity supply to move away from coal to nuclear and renewables. No new coal plants are built in this scenario and existing coal power supply declines rapidly from 2025, so that by 2040 only 4GW of coal capacity is left. A total of 14 new conventional nuclear plants are built, adding 25GW of new capacity by 2050. The renewables plants come in smaller units, but add a total of 118GW by 2050. No new coal-to-liquid plant is built, but five additional oil refineries are built (Scenario Building Team 2007).

3. Reaching for the goal: Strategic options beyond the modelled

FigureFigure 1 shows emission pathways of all the modelled scenarios, and illustrates how far each strategic option closes the gap between GWC and RBS.

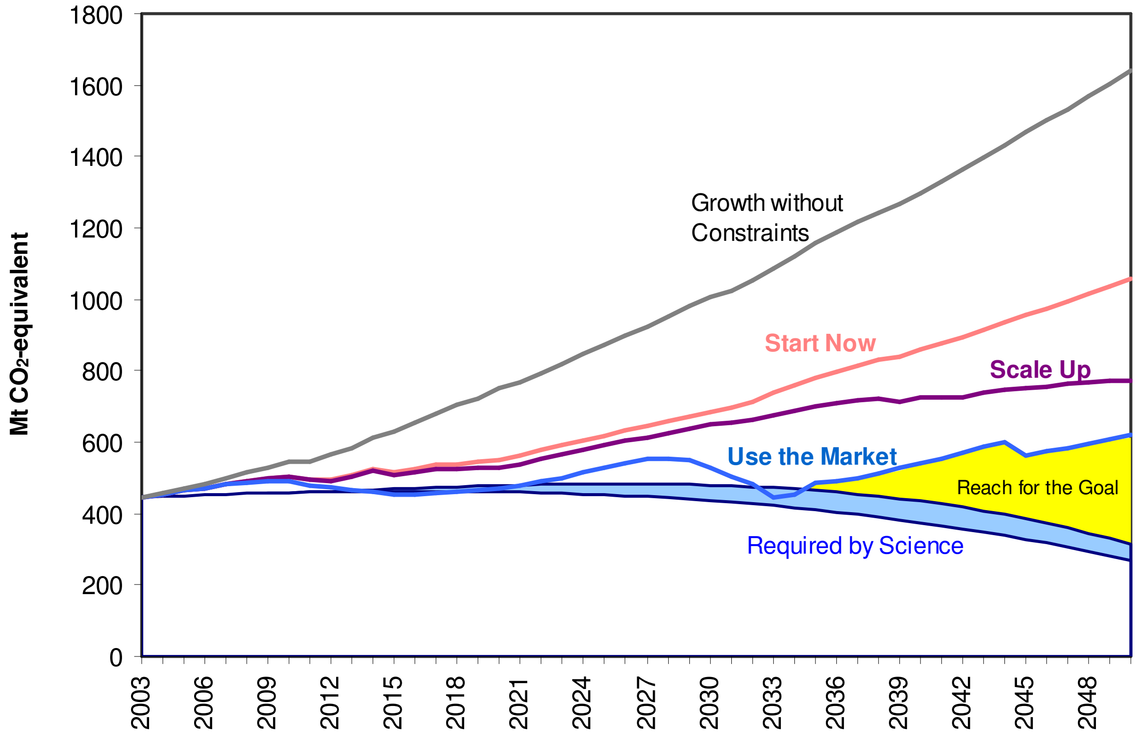

Figure 1: Emission pathways o f GWC, RBS and combined strategic options

While *Scale up* closes the gap between RBS and GWC by about two-thirds (64%) in 2050 and *Use the market* does the job well until around 2035, a 'triangle' of emissions remains between 2035 and 2050. This implies that a new set of options would have to be ready for implementation by this time. It is expected that new technologies will emerge – but what will they look like? Awareness of climate change may induce significant changes in people's patterns of consumption and behaviour – to what extent? The fourth strategic option, *Reaching for the goal*, lays the platform for getting these answers.

While it is acknowledged that the components of the *Reaching for the goal* strategic option cannot be modelled as was done with the other options, it can be imagined what some of its salient characteristics might have to be, by 2050. In the LTMS four actions, all requiring further study, were suggested (Scenario Building Team 2007): 1) New Technology – investigating technologies for the future; 2) Resource identification – searching for lower carbon resources; 3) People-orientated measure – incentivised behaviour; and 4) Transition to a low-carbon economy – redefining SA's competitive advantage

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