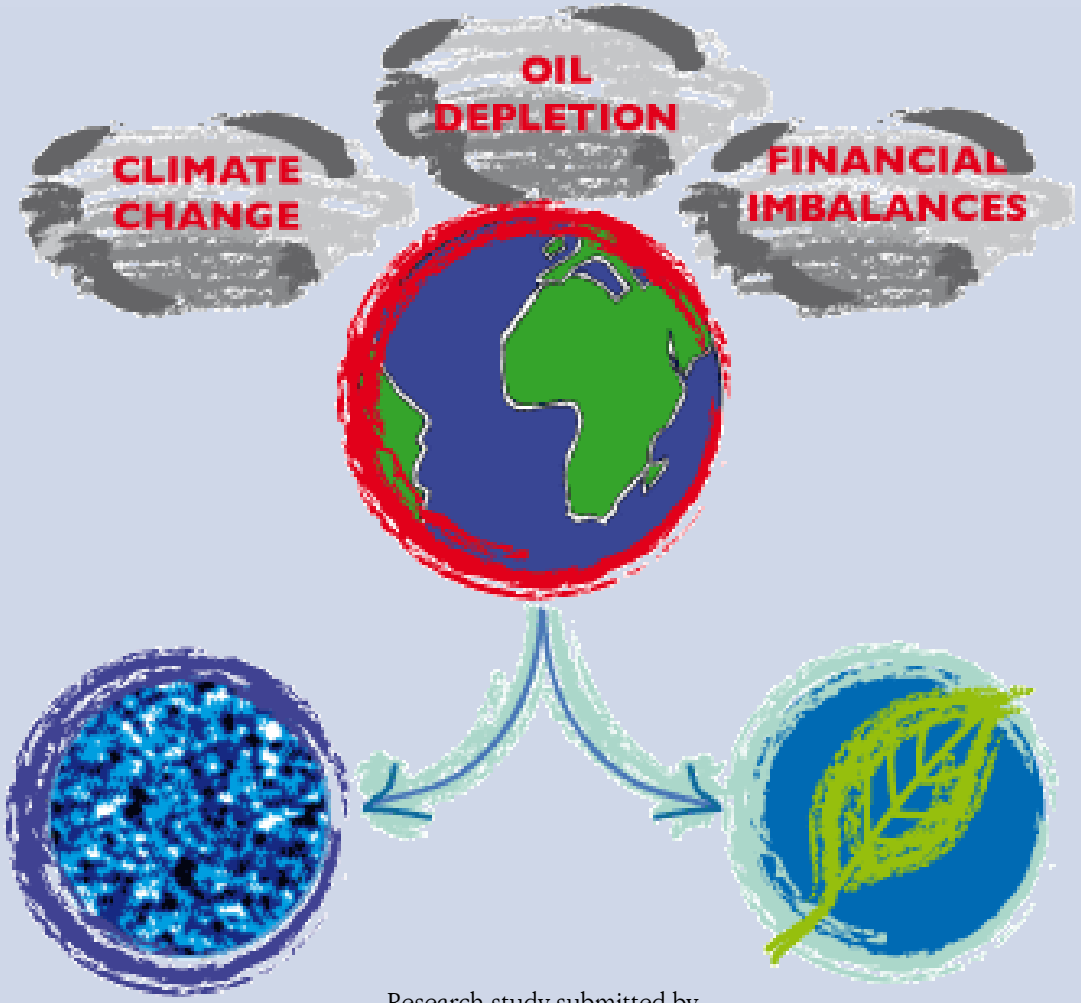
Scenarios 2019

Fragmentation or Renaissance

The inter-connections between oil depletion, climate change and global financial imbalances



Research study submitted by

The Association for the Study of Peak Oil South Africa

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Submission made to The Presidency

by

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The Association for the Study of Peak Oil (ASPO)

The Association for the Study of Peak Oil (ASPO) was established in 2001 by Colin Campbell, an oil geologist with forty years experience in the oil industry both as a geologist and as an executive. Today it is the foremost network of experts studying all aspects of oil depletion in 26 countries around the world, including, Australia, Austria, Canada, China, Denmark, Egypt, Finland, France, Germany, Ireland, Israel, Italy, Japan, Luxemburg, Korea, Mexico, Netherlands, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, Switzerland, United Kingdom and the United States.

Mission

1. To evaluate the world's endowment and definition of oil and gas;
2. To study depletion, taking due account of economics, demand, technology and politics;
3. To raise awareness of the serious consequences for Mankind.

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ASPO South Africa

ASPO South Africa was established in 2006 and constituted as a Section 21 company. It conducts research into all aspects of peak oil and creates awareness of the implications for South Africa.

“ We are entering an era… where we have a brand new set of rules. One of these rules, in my opinion, is that there will be nothing like business as usual... for any country... and the lower you are in the pile, the worse it is going to get. ”

A.S. Bakhtiari, former senior executive of the Iranian National Oil Company.

Contents

Executive Summary

Introduction

- The combined effect of depletion of global oil and natural gas reserves, climate change and global monetary imbalances and financial instability is likely to have significant impacts on the global and South African economies throughout the 21st Century.
- These impacts are likely to include far reaching consequences for energy, food security, settlement patterns and social stability.
- The risk of ignoring these impacts is far greater than the costs of attending to them now.
- But to attend to them coherently we need to critique the assumption of exponential growth which underlies our economic growth strategies, GEAR and ASGISA.
  - If we grow our economy at a constant rate of six per cent per annum, after 11 years its size will have doubled and we will have consumed more energy and other resources than we have in our entire history (assuming no structural change).
- There is an inherent clash between exponential growth and the finiteness of resources.
  - Our quantum of physical resources is limited by the planet's finite size.
  - Our consumption of these resources is accelerating.
- To sustain our societies will require a paradigm shift from exponential growth to sustainable development through the utilisation of renewable resources and a change in consumption patterns.

Key Global Challenges

Peaking of World Oil Production

- Oil is a finite, non-renewable resource that must be discovered before it can be produced.
- Discoveries of oil have been on a declining trend since the 1960's.
- The evidence from real oil wells (eg. in the US South and the North Sea) provide empirical evidence that oil production roughly follows a bell shaped curve, rising to a peak and then falling.
- Approximately two thirds of the oil producing nations have passed their individual peaks.
- While it is uncertain precisely when global oil production will peak, and what the post-peak rate of depletion will be, available evidence suggests that global oil production will probably decline between 2007 and 2019, with significant risk of rapid decline and price spikes.
- Given oil's high energy density, portability and versatility, it appears unlikely that energy substitutes and conservation measures will be sufficient to avert damaging shortages.
- Because oil is an input into most products (including food) and, in the form of fuel, the basis of the modern transport system, shortages of oil will have significant impacts on the following sectors:

- Economy and financial markets – impact would be price spikes, inflation, recession or depression
- Transport and mobility – likely to be greatly reduced for most people
- Agriculture, food and population – declining food production, and rising food prices causing heightened food insecurity.
- Geopolitics and conflict – international competition for dwindling oil supplies could spark wars

To mitigate the effects of oil depletion will require:

- Energy efficient transport systems
- Switching to renewable sources of energy
- Changing consumption patterns – lifestyle changes
- Organic and localised urban agriculture – to enhance food security
- Eco-village type of residential development
- Energy efficient buildings - construction methods and materials.

Climate Change

- The Intergovernmental Panel on Climate Change (IPCC) has identified human activities as the main contributors to climate change, through global warming.
- These activities are:
  - Burning fossil fuels for power generation
  - Transport
  - Industry
  - Changing land use patterns, especially deforestation
  - Agriculture
  - Generation of waste
- Indicators of global warming:
  - Icecaps/glaciers melting
  - Air/sea temperatures rising
  - Increasing frequency and severity of heat waves, droughts, storms
  - Rising sea levels
  - Thermal expansion of oceans

Impacts of climate Change:

- Threat to food and water security
- Spreading epidemic diseases
- Destruction of coastal settlements
- Displacement of peoples

- Africa and South Africa liable to suffer extreme food and water shortages.

To mitigate the effects of climate change will require:

- Reducing fossil fuel consumption
- Sequestering carbon dioxide emissions
- Reducing deforestation; planting more trees
- Enhancing energy, transport and economic efficiency; reducing waste
- Improving agricultural practices (to increase oil conservation)
- Changing lifestyle and behaviour patterns

Global Financial Imbalances

- The global financial system is characterised by severe imbalances between:
  - US debt (debtor nation)
  - Over-savings of (mainly) under-developed economies (creditor nations)
  - Where the creditor nations are funding the debtor nation
- These balances are seen by most economists as unsustainable
- Economists differ as to whether the adjustment will be orderly or disorderly
- The risk of disorderly adjustment is high because of the likelihood of:
  - Highly indebtedUS households reducing their consumption expenditure
  - A sharp fall in the value of the US dollar
  - The imposition by the US of protectionist trade control on imports

Potential outcomes of a disorderly adjustment:

- Drop in global real incomes and output
- Volatility in financial markets
- An oil or climate induced shock could precipitate a recession/ depression

To mitigate the effects of adjusting global financial imbalances will require

- A concerted and co-ordinated multi-lateral policy response involving:
- A package of expenditure reducing/increasing policies
- Expenditure switching via exchange rate adjustments

South Africa's Strengths and Vulnerabilities

- South Africa's response to the global challenges referred to above needs to be based on a thorough consideration of our strengths and weaknesses, which are as follows

Energy security

- Critical strengths: relatively low oil dependence, well established synthetic fuels; abundant solar energy, substantial wind, uranium and coal resources.
- Critical weaknesses: high dependency on imported oil, and liquid fuels for transport; energy intensive industry.

Macro –economy

- Critical strengths: strong growth, low inflation and government debt, funds for infrastructure development.
- Critical weaknesses: relatively large current account deficit, household indebtedness; floating exchange rate and liquid capital market.

Transport

- Critical strengths: existing rail network and potential for bicycles.
- Critical weaknesses: inadequate public transport; high dependence on petroleum fuels.

Food security

- Critical strengths: net food exporter, some subsistence agriculture.
- Critical weaknesses: commercial farming is oil intensive, little organic agriculture, only 13% of land is arable, recurring droughts.

Settlement patterns and geography

- Critical strengths: major ports facilitate cheaper transport and trade for coastal settlements.
- Critical weaknesses: large distance from trading partners; urban areas liquid fuel dependent for transport; large distances between major cities.

Social and political stability

- Critical strengths: successful political transition; 13 years of democracy.
- Critical weaknesses: poverty, unemployment, inequality, prevalence of HIV/Aids and crime.

South African Scenarios to 2019

- The following are two plausible alternative futures that provide reasonable and consistent answers to the "what if?" questions relevant to government and society as a whole.

Scenario One – Fragmentation

- The world and South Africa continue on a Business As Usual path until interrupted by a major shock.
- **Economy**: Inflation spikes driven by rising oil prices; interest rates rise to quell inflation, but depress consumer spending further; the US economy, and the world economy slide into recession; unemployment rises rapidly.

- **Transport**: massive price rises for air flights, road transportation; South Africa's inadequate public transport infrastructure provides no viable alternative; demand for motor cycles and bicycles increase, and also for people to work from home; road maintenance costs soar and road infrastructure deteriorates.
- **Food**: rising prices and fuel shortages place commercial farmers under pressure; food prices rise significantly and severe food shortages increase; government intervenes in the pricing and supply of food.
- **Conflict and security**: competition to control global oil supply results in conflict in Middle East, Central Asia and West Coast of Africa.
- **Governance**: local town administration breaks down, local conflict over scare resources intensifies and the country is increasingly fragmented into small units controlled by uncoordinated militias.
- **Climate and environment**: governments abandon negotiations to lower carbon emissions and CO_2 concentrations increase to dangerous levels setting the course for a 2 degree increase in temperatures and catastrophic, irreversible climatic conditions later in the century.

Scenario Two – Renaissance

- **Leadership from top**: a sustainable development strategy is put inplace, initiated by the Presidency, and communicated effectively to the nation and the world.
- The government takes the lead through:
  - Energy saving quotas for government departments
  - New building regulations to achieve energy efficient building
  - Declareing coal a national asset
- **Economy**: more business conducted by internet/telecommunication as transportation shrinks; incentivisation (subsidies) results in existing industries being re-tooled in favour of technologies using renewable energy sources.
- **Agriculture**: becomes more localised, small-scale, labour-intensive, with bio-diesel as fuel.
- **Population**: South Africa adopts a population policy to further limit population growth.
- **Energy:** South Africans reduce our usage of fossil fuels and compliment existing nuclear power with renewable energy sources; there is also usage of highly energy efficient appliances.
- **Transport:** Transnet develops a sustainable transport system powered by electricity generated from renewable resources; cycling and walking replace cars for short journeys; light electrical rail systems are installed in South African cities.
- **Urban (and rural) planning**: new planning approaches enable the creation self-sustaining urban communities where living and work spaces are integrated, including eco-villages; food supply is re-structured.

Risks and Risk Management

- National, provincial and local governments have a critical role in enabling the renaissance scenario; in particular these tiers of government will have to achieve the following outcomes:

National government

- Formulation and buy-in to a national sustainable development strategy and its implementation
- Achieving important aspects of the strategy globally, and in Africa
- Regulation of liquid fuel pricing (Sasol)
- Implementing a national population control plan
- National regulations for energy efficient housing and PPPs for food security
- Reforestation programme (Safcol)
- National waste disposal regulations
- National sustainable transport plan
- Financial regulation of banks and home owners equity requirements
- Promotion of clean industries

Provincial government

- Steady State Development Strategies as new economic growth paths for identified provincial economic clusters

Local government

- Complete plans and implement:
  - Energy efficient local transportation systems
  - Waste recycling and landfill gas capture systems
- Implement and enforce new energy efficient housing building regulations.
- Implement efficient water usage systems.
- Facilitate local, affordable, food production.

Risks

- There are however risks that undermine the achievement of the above.
- These risks are mainly internal to the various tiers of government and are:
  - Political risks
  - Resource (operational) risks
- To address these risks the state needs to identify key risk managers to drive the necessary processes to conclusion. Two key drivers are:
  - The President (at the level of the Presidency and national and provincial governments)
  - The Executive Mayors (at the level of local governments)

Section 1

Introduction

The early 21st Century is already proving to be a time of great change, and in the next 12 years the pace of this change is likely to accelerate dramatically. In this paper we identify three major global challenges, namely: (1) depletion of global oil and natural gas reserves; (2) climate change; and (3) global monetary imbalances and financial instability. This paper aims to draw the implications of these forces for the global and South African economies, as well as related national and local issues such as energy and food security, settlement patterns and social stability. Finally, the paper sets out alternatives in the light of oil depletion, climate change and financial imbalances, and poses risk assessment questions around these alternatives.

The methodological approach adopted in this paper is an integrated, systemic analysis of a range of strategic trends and risks. After identifying and describing the nature of these threats and opportunities, the paper elucidates their implications. This leads to a first scenario, termed "fragmentation", which it is argued will be a likely result of continuing business-as-usual policies. However, a second scenario is then developed (termed "renaissance"), based on a comprehensive programme of mitigation and adaptation responses to the looming challenges. This paper argues that not only are the government and people of South Africa at a major historical cross-roads similar in some respects to that facing our society in the early 1990s in the build-up to the political transition, but so is our global society. This time, what is required is an economic transition – or more specifically a 'sustainability revolution'.

The purpose of developing scenarios is to identify emerging challenges and to foster adaptability to change. Scenarios are used to help review and assess strategy. They are not forecasts, projections or predictions of what is to come. Nor are they preferred views of the future. Rather, they are plausible alternative futures: they provide reasonable and consistent answers to the "what if?" questions relevant to government and society as a whole. The scenarios we have developed are intended also to offer us choices. Ultimately, as human beings, with stewardship over the planet and over the future lives of our children and their children as well as over the destinies of countless other species and life forms, we hold enormous responsibility. It is therefore incmbent upon us to make wise choices even if they are difficult to make in the short term. Scenarios also address a broad range of strategic and planning needs across the whole spectrum of relevant time horizons and contexts which we hope, in the limited space available, we have highlighted.

Viewing our possible future economic development trajectories through the prism of key non-renewable resources highlights some of the major vulnerabilities of our current path. By understanding clearly the nature of these vulnerabilities we are able to be alert to the kinds of actions we need to take. To comprehend the nature of the issues we face with respect to non-renewable resources we need to examine what we understand by "growth". Exponential mathematics is a useful starting point to demonstrate that there are physical limits to economic growth.

Exponential growth

Exponential growth refers to a situation where there is a constant rate of compounded growth. For example, our current economic strategy is aimed at achieving six per cent growth over a sustained period of time,

to inter alia create employment, address and alleviate our increase in population, levels of poverty and a range of other factors. The formula T=ln(2) x 100/r can be used to calculate the doubling time of anything that is growing at a constant rate, where T is the doubling time and r is the rate of growth. This calculation is often used with respect to calculating financial returns, but rarely to calculate the rate at which we are depleting resources. Six per cent growth means doubling the size of our economy (GDP) in the next 11 years. In order to double what we produce we will need to double what goes into what we produce, including raw materials and, crucially, energy.[1] Moreover, every time we double, that is, when we go from 1 to 2, from 2 to 4, from 4 to 8, from 8 to 16 and so forth, the last doubling cycle is greater than the sum of all the previous cycles. Thus, in the next 11 years (assuming a constant six per cent growth rate) we will consume more than we have in our entire history (Ratcliffe, 2007).

Consider the following situation. Bacteria grow by doubling. One bacterium divides to become two, the two divide to become 4, which become 8, 16 and so on. Suppose we had bacteria that doubled in number this way every minute. Suppose we put one of these bacteria into an empty bottle at eleven in the morning, and then observe that the bottle is full at twelve noon. This is a case of ordinary steady growth; it has a doubling time of one minute, and it takes place in the finite environment of one bottle. We will notice that at 11:59, one minute before 12, the bottle is half full, because they double in number every minute. [2]

If we were an average bacterium in that bottle at what time would we first realise that we were running out of space? Well let's just look at the last minutes in the bottle. At 12 noon it is full, one minute before it's half full, 2 minutes before it's 1/4full, then 1/8th, then 1/16th. At five minutes before 12 when the bottle is only three per cent full and is 97 per cent open space, is it likely that there would be anticipation of a problem? [3]

We use this example to illustrate how quickly very large numbers are generated even with modest rates of growth. The phenomenal growth in the consumption of non-renewable resources is an important part of understanding

1 *For simplicity, we abstract here from changes in the structure of the econo between manufactures and services.*

2 *Example taken from Bartlett A, "Arithmetic, population and energy."*

3 *Adapted from Bartlett A, "Arithmetic, population and energy."*

Table 1: The history of global oil production showing quantities, doubling periods and rates of growth

Source: Adapted from figures supplied by Campbell C. taken from Oil and Gas Journal

Year	Daily prodn (mb)	World prodn (Gb/year)	Cumulative from 1930(Gb)	Years btwn dblg cycles	Grth rate btwn dblg cycles	Previous cycles combined
1934	4.52	1.65	7.41	4	17.33%	
1938	5.34	1.95	14.82	7	9.90%	11.12
1945	7.01	2.56	30.53	8	8.66%	26.38
1953	13.01	4.75	60.14	9	7.70%	56.45
1962	23.78	8.68	120.39	9	7.70%	116.65
1971	47.29	17.26	236.88	9	7.70%	235.09
1983	50.25	18.34	476.65	12	5.78%	473.41
2005	71.78	26.20	957.87	22	3.15%	952.35

our developing energy crisis. On our current path we will reach the limits of this exponential growth sooner than is commonly acknowledged.[4]

The clash between growth and finiteness of resources

By understanding this simple mathematics we can appreciate the following words of Lester Brown, President of the Earth Policy Institute:

> "Our global economy is outgrowing the capacity of the earth to support it, moving our early twenty-first century civilization ever closer to decline and possible collapse. In our preoccupation with quarterly earnings reports and year-to-year economic growth, we have lost sight of how large the human enterprise has become relative to the earth's resources… we are consuming renewable resources faster than they can regenerate. Forests are shrinking, grasslands are deteriorating, water tables are falling, fisheries are collapsing, and soils are eroding. We are using up oil at a pace that leaves little time to plan beyond peak oil. And we are discharging greenhouse gases into the atmosphere faster than nature can absorb them, setting the stage for a rise in the earth's temperature well above any since agriculture began. Our twenty-first century civilization is not the first to move onto an economic path that was environmentally unsustainable." (Brown, 2006: 3).

Brown notes, too, that

> "if economic progress is to be sustained, we need to replace the fossil-fuel based, automobile-centered, throwaway economy with a new economic model. Instead of being based on fossil fuels, the new economy will need to be powered by abundant sources of renewable energy: wind, solar, geothermal, hydropower, and biofuels… We have the technologies to build a new economy—including, for example, gas-electric hybrid cars, advanced-design wind turbines, highly efficient refrigerators, and water-efficient irrigation systems… With each wind farm, rooftop solar panel, paper recycling facility, bicycle path, and reforestation program, we move closer to an economy that can sustain economic progress. If, instead, we continue on the current economic path, the question is not whether environmental deterioration will lead to economic decline, but when. No economy, however technologically advanced, can survive the collapse of its environmental support systems." (Brown, 2006: 4).

> "We recently entered a new century, but we are also entering a new world, one where the collisions between our demands and the earth's capacity to satisfy them are becoming daily events… If we do not act quickly to reverse the trends, seemingly isolated environmental events will come more and more frequently… Resources that accumulated over eons of geological time are being consumed in a single human lifespan and that we are crossing natural thresholds that we cannot see and violating deadlines that we do not recognize. These deadlines, determined by nature, are

4 *In Appendix A, we extrapolate the recent growth in consumption of key resources by the world and by major countries until 2020. This serves to illustrate the power of exponential growth to lead rapidly to enormous scales of resource use. We do not, however, regard these projections as likely to materialise given critical energy constraints, which we describe in section 2.*

not politically negotiable. Nature has many thresholds that we discover only when it is too late." (Brown, 2006: 4-5).

The recent study by Jared Diamond (2005), *Collapse*, documents evidence that in earlier civilizations the leading indicators of economic decline were environmental, not economic. The trees went first, then the soil and rainfall, and finally the civilization itself. To archaeologists, the sequence is all too familiar. Demand has exceeded the sustainable yield of natural systems at the local level countless times in the past. Now, for the first time, it is doing so at the global level.

In developing scenarios looking forward to 2019, we will look firstly at a scenario where we fail to heed the warnings we are receiving on an almost daily basis, and continue as we are. In other words, at this juncture we take no action and conduct business as usual until we hit environmental limits. Our second scenario will examine the likely outcomes where pro-active actions are taken now. Following this we will identify costs and risks associated with these actions, as well as ways to manage these risks and costs. This will lay the basis for further investigation of potential solutions with rewarding results.

Key global challenges

Section 2

Peaking world oil production

In the 1950s, a petroleum geologist named M. King Hubbert theorised that conventional oil production in any given region would roughly follow a bell-shaped curve, rising to a peak when approximately half of the total oil had been extracted, and thereafter gradually falling toward zero as extraction became progressively more difficult and costly. This production curve would mirror a similar pattern of oil discoveries, although after a substantial time lag. Hubbert applied a logistic probability distribution function to historical data on reserves and production in order to forecast the timing of peak production in a region.

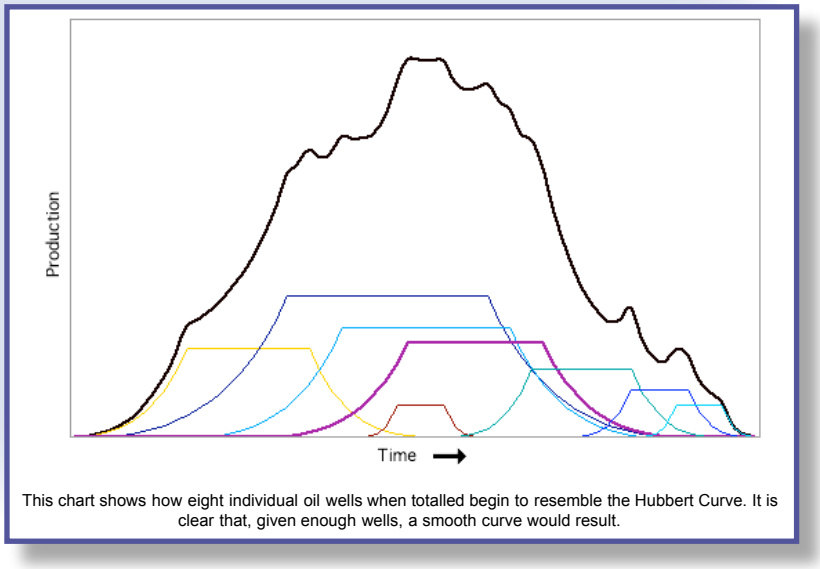
Hubbert's model successfully and accurately predicted that oil production in the lower 48 United States would peak between 1966 and 1972 (Heinberg, 2003: 88), based on the pattern of oil discoveries there which had peaked in the 1930s. The actual production peak for conventional oil (which excludes tar sands, oil shales, and heavy oils) occurred in 1970, after which date production has followed a declining trend.[5] Hubbert hypothesised that world oil supply would follow a similar bell-shaped curve, mirroring the pattern of (earlier) oil discoveries. His theory has been the subject of intense debate, particularly in recent years. The debate now centres on when the inevitable peak in world oil production will occur, not on whether it will occur (see Hirsch, 2005). Nobody can credibly deny that production of a finite resource must eventually decline toward zero.

Economists, amongst others, correctly point out that higher oil prices tend to stimulate increased exploration activity. However, more exploration does not necessarily translate into more discoveries: it depends on the extent to which undiscovered oil fields still exist. At some point, no matter how high the price of oil rises, it cannot overcome the physical limitations of a finite resource.

There is growing evidence that we are nearing the world Hubbert peak:

- Globally, new oil discoveries peaked in the 1960s and have been on a declining trend ever since (see Figure 2). This is despite spectacular improvements in exploration and recovery technology over the past few decades and the incentives provided by high oil prices in the 1970s and in recent years.
- About half of global oil reserves are contained in the largest 100 fields, almost all of which were discovered more than 25 years ago. Production from many of these super-giant and giant fields is in decline.
- Since 1981, more oil has been consumed annually than has been discovered each year (see Figure 2). In the

Figure 1: Diagram illustrating the principle of Hubbert's Peak showing the aggregated production curves for 8 oil wells.



This chart shows how eight individual oil wells when totalled begin to resemble the Hubbert Curve. It is clear that, given enough wells, a smooth curve would result.

5 *Overall US production never regained its 1970 peak rate despite more recent discoveries in Alaska's Prudhoe Bay and the Gulf of Mexico.*

past few years, about five or six barrels have been used for each new one found.

- Thirty-three of the 48 significant oil-producing nations have already passed their individual production peaks (Hirsch, 2005).

The nature of the peak

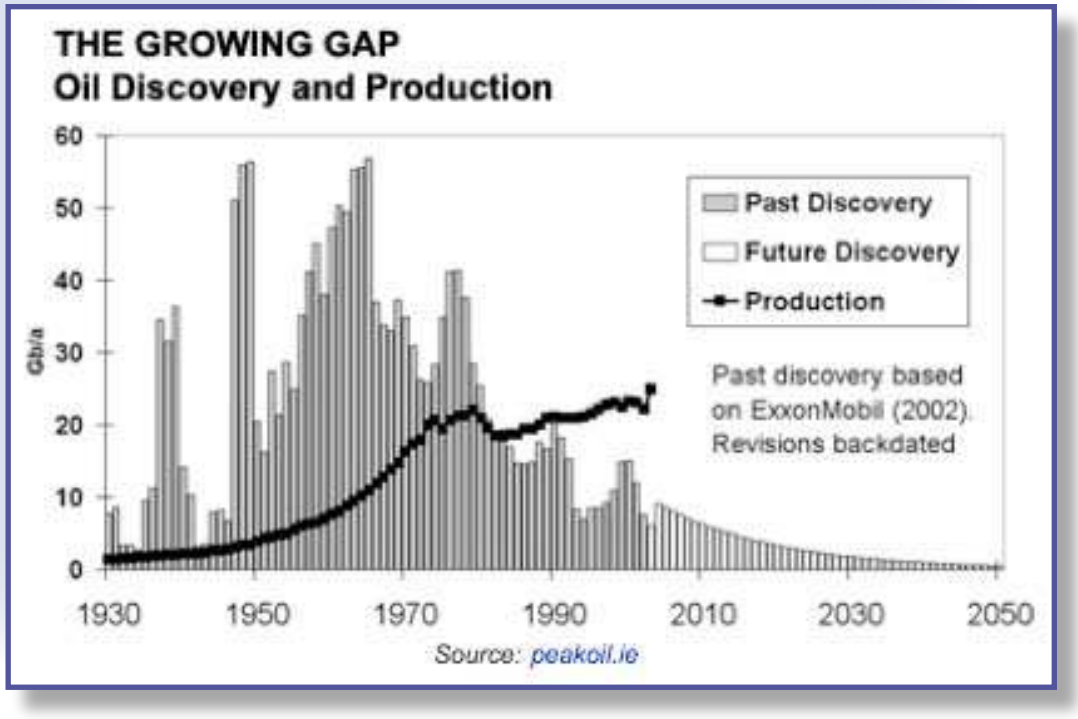
In the US, the oil production curve has been largely unimpeded by political influences and determined chiefly by geological and economic factors. This resulted in a 'classic' Hubbert curve profile, with a well-defined, absolute peak being reached in 1970 and a fairly symmetrical shape (in the lower 48 states). In other countries, however, notably some members of the Organisation of Petroleum Exporting Countries (OPEC) and Russia, production has been more volatile, having been influenced by political decisions or economic turmoil, respectively. Such factors have resulted in two or more local peaks in the production curve of some oil producers.

For the world as a whole, production will not necessarily (or even likely) reach a well-defined, sharp peak. Many experts are predicting a 'bumpy plateau' lasting for several years (Heinberg, 2004: 34-37). The plateau is due partly to the smoothing effect of aggregating national or regional production profiles which peak at different times, while the bumps are expected to result from supply disruptions and subsequent recoveries resulting from political and economic upheavals. However, geologically and mathematically it is clear that production must at some date reach a global maximum (even if it is a plateau lasting several months or years).

The timing of the peak

Predictions about the timing of the world peak vary amongst individual oil geologists and energy agencies. As can be seen in Table 2, a significant number of experts expect oil to peak within the next decade. For instance, the latest projection by veteran oil geologist Colin Campbell, founder of ASPO, is that 'regular conventional' oil production peaked in 2005, and that all petroleum liquids (including heavy, deep-water and polar oil, and natural gas liquids) will peak around 2010 (see Figure 3). In contrast,

Figure 2: Conventional oil discovery and production



forecasts by Cambridge Economic Research Associates (CERA) and the US Geological Survey (USGS) are more optimistic. However, these predictions are based on arguably unrealistic assessments of future oil discoveries discoveries and an unsound methodology (Campbell, 2005: 39-41). Actual discoveries over the past few years have been considerably below the USGS's F95 high probability forecast, which predicts a world peak in 2016. Thus all of the most credible estimated dates of the world peak lie within the next decade, and many within the next five years.

According to Colin Campbell, approximately 90 per cent of crude oil production to date has been regular conventional oil. ASPO's forecast includes so-called 'unconventional' sources of petroleum (heavy oil, oil sands and shale oil, deep water and polar oil, and natural gas liquids), but does not anticipate that these will extend the date of the peak by more than a few years, although they will lessen the steepness of the descent. This is because each of the unconventional sources of petroleum has significant disadvantages and/or limitations: each source has a lower net energy return than regular oil; the costs of extraction are significantly higher; extraction is in most cases technically more difficult; and in some cases the environmental consequences are extremely negative.

Matthew Simmons (2005), a prominent energy investment banker and former advisor to the Bush Administration, has argued that Saudi Arabia is much closer to peaking than is commonly thought, and that when Saudi production peaks, the world will peak. Over the past year the Saudi oil production has dropped from approximately 9.5 million barrels per day (mbpd) to around 8.6 mbpd. According to the Saudis, this decline has resulted from deliberate cuts as part of OPEC agreements. But there is speculation that their largest field, Ghawar, could be in a state of collapse – as is Mexico's Cantarell field, the fourth largest field in the world.

It is important to note that depletion alone will not determine the date of

Table 2: Predicted Dates of World Oil Peak

Source	Affiliation	Date	Notes
Kenneth Deffeyes	Princeton University (retired)	2005	Regular oil
Richard Duncan	Institute for Energy and Man	2006	Regular oil
Ali Samsam Bakhtiari	Iranian National Oil Company (retired)	2006-2007	Regular oil
Chris Skrebowski	Oil Depletion Analysis Centre, UK	2007-2008	Regular oil
Colin Campbell	ASPO-Ireland	2005	Regular oil
		2010	All petroleum liquids
David Goodstein	Cal Tech University	Before 2010	Regular oil
Michael Smith	Oil geologist & analyst	2011	Regular oil
		2013	All liquid fuels including biofuels
	Cambridge Economic Research Associates	After 2020	
	US Geological Survey	2016	F95 (high probability) scenario
		2037	F50 (median) scenario

Sources: ASPO (2007); CERA (2005); Deffeyes (2005); Duncan (2003); Goodstein (2005); Hirsch (2005); Smith (2007).

the peak. Geopolitical events (such as wars in oil producing countries), extreme weather conditions (e.g. hurricanes in the Gulf of Mexico) and economic factors (e.g. an international recession) could all play a role by influencing either supply or demand for oil.

Ultimately, as Heinberg (2003: 202) points out, the timing of the peak in world oil production may only be apparent several years after the fact. This is partly because there is likely to be considerable supply volatility in the years immediately before and after the peak as a result of economic and political disruptions. Even if the peak occurs after 2012, there may be a further run-up in oil prices before then. According to Leggett (2006), there is a very high probability that new oil production coming on-stream will be insufficient to match the combination of rising demand and depletion of existing oil reserves between 2008 and 2012, resulting in excess demand for oil (even though supply may not yet have peaked).

The post-peak depletion rate: slow or rapid descent?

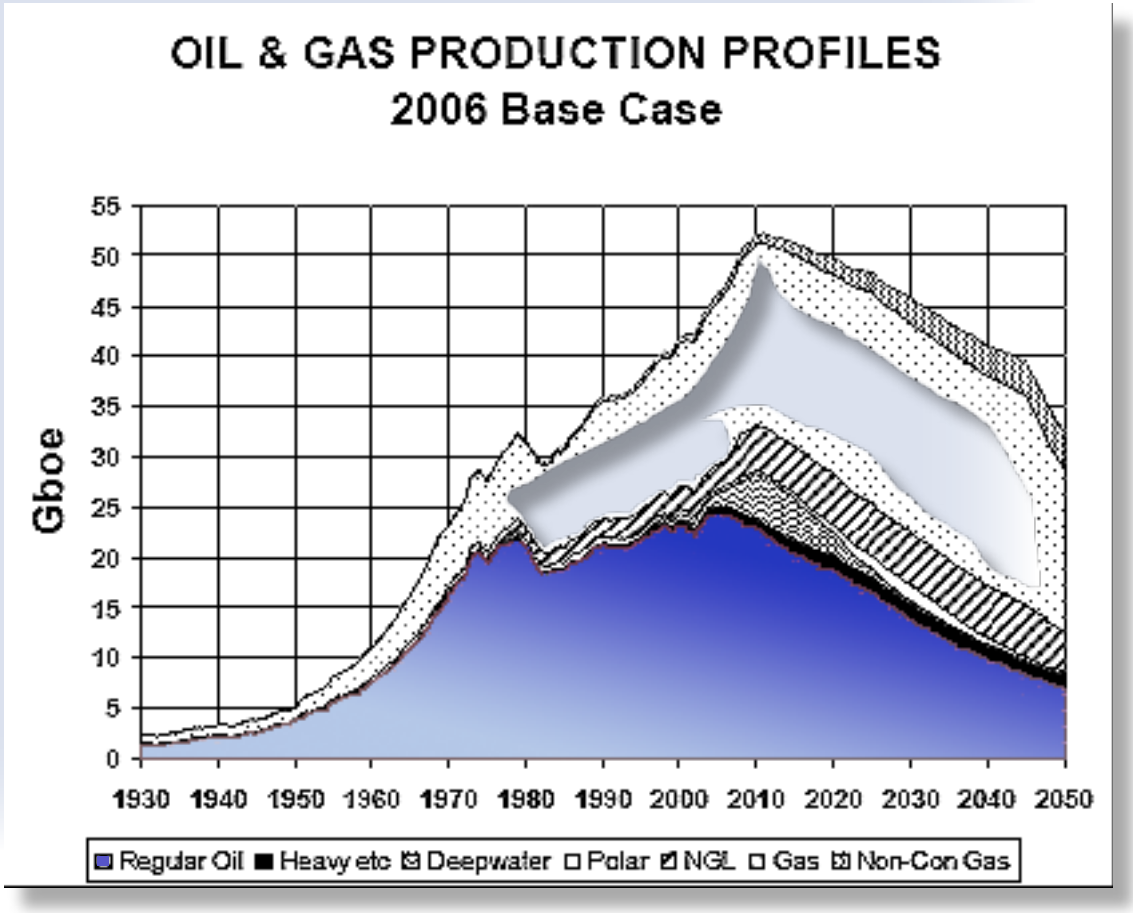
The scale and severity of the oil peak's effects will depend to a large degree on the trajectory of the post-peak decline in oil production. The slower and steadier the decline, the easier it will be for societies and economies to adjust in a more orderly and planned fashion. A faster decline will raise the probability of severe shortages and price spikes.

Estimates of the world depletion rate vary from one expert to the next, from approximately two per cent to approximately eight per cent per annum (Heinberg, 2006). Colin Campbell, chairman of ASPO International, estimates a world depletion rate (of all petroleum liquids) of approximately 2,6 per cent per annum.

However, political and economic forces are likely to play a significant

Figure 3: ASPO's world oil and gas production profiles – history and projections

Source: ASPO Ireland (2007)



part in the evolution of oil supply in addition to geological constraints. There are several reasons why the post-peak descent might be rapid, or involve 'cliffs'.

- Post peak depletion rates in many countries that are already in decline have been quite rapid, e.g. Egypt, UK and Norway. In many cases, it was not clear that production was near its peak even a year before the event (Hirsch, 2005).
- High oil prices over the past few years have encouraged many producers to pump at the maximum rate, thereby extending the production plateau but also raising the likelihood of a steep cliff on the far side of the curve.
- Several of the world's largest oil fields are either already in, or are probably near, a state of collapse.
  - Production from Mexico's Cantarell field, the fourth largest in the world, is collapsing. Production fell by about 15% in 2006, and is expected to fall by a similar percentage in 2007 (ASPO-USA, 2007).
  - There is speculation that Saudi Arabia's Ghawar field, the biggest in the world, is in a state of collapse. Saudi oil production has declined by about one million barrels per day (bpd) over the past year. Ostensibly this is due to voluntary production cuts under OPEC agreements, but this may be a political cover for a peak that analysts like Matthew Simmons and Ali Samsam Bakhtiari have been warning of for several years. Since the Saudi's keep their reserve and production data as State secrets, it is impossible to know for sure at this stage.
  - The Burgan field in Kuwait, second largest in the world, is of a similar vintage to Ghawar and may also be on the verge of collapse.
  - North Sea oil fields are contracting at between six and 10 per cent per year.
- Production from some new giant oil fields is being delayed, partly as a result of rising costs and also because of shortages of skilled personnel. Production from Kashagan field in Kazakhstan, the largest field discovered since 1990, has been delayed by several years. Russia's Sakhalin II field is also experiencing delays.
- Some oil exporting countries – notably Russia and Venezuela – are nationalising their oil industries and shutting out multinational oil companies. This may constrain the future flow of oil exports as these countries conserve oil for their own use.

Furthermore, the existence of numerous self-reinforcing feedback loops increases the likelihood that oil production will decline rapidly rather than slowly.

- There will likely be an increasing prevalence of wars and conflict in oil producing regions as competition for dwindling oil supplies increases, and as the revenue stakes are raised (already extensive conflict limits production in Iraq and Nigeria).
- As oil peaks, and the price of oil rises, the costs of extracting the remaining oil – mostly in less accessible areas like deep water – will rise significantly. This reflects the low net energy return of

unconventional oil reserves. Already, rising costs are hampering or halting new oil and gas investment projects in many areas. In addition, more volatile oil prices will cause greater uncertainty for oil investors and may further dampen oil exploration and new investment.

- Oil producing nations may voluntarily cut back on supply to conserve oil and to wait for the prices to rise to boost revenues.
- The infrastructure supporting the production, refining and distribution of oil is ageing rapidly. However, the incentives to replace such long-lived capital diminish when oil production is in decline. This may lead to shortages induced by faulty infrastructure rather than a lack of crude oil itself.
- The oil industry is experiencing an increasingly acute shortage of adequate skills, which is likely to hamper further exploration and production, especially in less accessible oil provinces.

Energy substitutes, conservation and technological progress

Before considering the possible social and economic implications of peak oil, it is necessary to consider the potential of alternative energy sources, energy conservation measures and technological development to mitigate the impending shortfall in oil supply.

From the outset it must be stated that energy conservation and energy efficiency are the greatest pool of future energy supplies. It will take strong political will and leadership to embark on a nationwide energy conservation programme, which would have to be led from the top. For example, reducing national road speed limits to 100km per hour will yield a 10 per cent saving on transport fuels. At a global and national level, however, energy efficiency is unlikely to be sufficient on its own; new energy supplies will be needed.

Non-renewable energy sources are by definition not a long-term, sustainable proposition. Their use is constrained by natural depletion; coal, gas and uranium extraction will – like oil production, over time reach peaks and then decline. Many governments, including South Africa are considering further investments in these non-renewable energy sources. In doing so, the authorities need to take the full life cycle environmental costs into account and no project should be considered unless it is environmentally clean, that is it has a minimum carbon foot print. Further any project based on non-renewable energy sources should be considered as a bridging project only until sufficient renewable projects are available.

There are a number of very successful renewable interventions worldwide, namely photovoltaic panels for electricity, wind turbines, solar heating, landfill methane extraction, micro-hydro turbines, wave power and biofuels. Each one of them can play a positive roll in reducing energy demand from non-renewable energy sources.

However, unless there is strong government intervention it will take many years to bring sufficient new renewable production capacity on stream. This would most probably be too late and of insufficient quantity to offset the rate of oil depletion and climate change. The costs of such investments will also rise as oil production declines. Thus investments

in renewable energy should begin immediately.

Perhaps most seriously, large-scale replacement of oil with non-clean coal projects will most likely result in catastrophic consequences for climate change and the environment.

Nuclear waste similarly poses great risks for the environment and human health. Radioactive waste is containable and managable in the short term, although as yet no permanent solution has been found for its safe disposal. There should be concerns about SA's capacity to safely operate and decomission nuclear power plants if a societal collapse, of which there is a significant risk, occurs. In addition, there is a question as to whether there are sufficient quantities of uranium to sustain nuclear power over a significant timeline. South Africa is in the fortunate position of possessing significant uranium reserves. At a global level, however, Meyer (2006) argues that there are likely to be critical shortages of uranium by 2013, or even before, possibly forcing up to 25 per cent of the world's nuclear power plants to be shut down within the next decade. Meyer (2006) and the Energy Watch Group (2006) note that uranium production peaked in 1981 while demand from the nuclear power industry has continued to grow. The shortfall has up till now been made up by drawing down stockpiles, but these have dwindled and will be exhausted within a decade.[6]

While some renewable energy sources hold great promise for the future, there are three main problems from the point of view of oil depletion: (1) with the exception of biofuels, they cannot readily be substituted for liquid petroleum fuels (but some biofuels require substantial fossil fuel inputs and compete with food production); (2) they currently contribute a miniscule fraction of the world's energy supply, so that a large amount of time and resources will be required to scale them up sufficiently to replace depleting fossil fuels; and (3) they currently require fossil fuels for manufacture, distribution and maintenance.

Currently, no energy source is fully substitutable for oil, given its high degree of versatility both as a fuel (especially for transport) and as an input into the petrochemical industry, as well as its high energy density. Consequently, a transportation network of automobiles, aeroplanes and ships on anything like the present scale is simply not feasible with existing energy technologies.

If existing energy substitutes and conservation options will not be adequate to offset declining oil supply, can we rely on technological developments to take us painlessly past the oil era? Clearly, technological improvements are an unpredictable wildcard. It is conceivable that major strides will be made within a short time period when the incentives are adequately strong (e.g. when the price of fossil fuels is sufficiently high or renewables are sufficiently subsidised). But relying on possible short-term technological fixes on a large scale seems imprudent at best and wishful thinking at worst. It should also be noted that any transition to new technology will likely need to be created and driven by current oil-based technology until a sufficiently large base is installed. In an unstable oil environment on the downside of the Hubbert curve, this will be difficult; the sooner research and development initiatives are undertaken, the better. But this should not distract attention from the implementation of viable, existing renewable energy technology.

6 *See Appendix B for a chart of historical and projected uranium production and demand.*

Global implications of peak oil

Humanity has never before confronted the situation whereby supply of its primary energy source declines on a global scale. Therefore it is impossible to predict with certainty what impact the peaking of world oil production will have on societies and economies. However, on the basis of past experience (including episodes of local energy depletion and previous international oil shocks) and reasoned argument, we can sketch plausible outcomes.

Economy and financial markets

Global demand for oil has been growing for decades as a result of both population expansion and economic growth (at an average rate of approximately 1.5 per cent per annum over the past 30 years). Supply has for the most part risen to meet this demand, aside from two interruptions in the 1970s and a brief one in 1990. The oil shocks of 1973/4 and 1979/80 resulted in rising inflation together with severe recessions and higher unemployment (i.e. stagflation) in the industrialised economies. However, these shocks had political origins and lasted for a few years at most. Peak Oil, being imposed by Nature, will have both short-term and long-term impacts on the economy.

The severity of the short-term economic impact of an oil shock depends on several factors, including the magnitude and rate of the price increase, and whether it is sustained or transient. Rapid, large and sustained price shocks have historically had the biggest impact. After oil output peaks, a gap will open up between demand (desired oil) – which is highly inelastic in the short run – and supply (available oil). As discussed earlier, a conservative estimate of the post-peak depletion rate is about three percent per annum. Considering that oil prices trebled in 1979/80 after a mere five percent reduction in output (Iran's contribution), the potential for runaway oil prices becomes evident.

Another important factor is the monetary policy response of central banks. If central banks allow higher energy prices to work through the economic system, then the increasing scarcity of fossil fuels will manifest appropriately in altered relative prices and act as a stimulus to both energy conservation and investment in substitutes. In the short- to medium-term this new investment could help to offset declines in demand and investment in other sectors. However, most central banks are primed to respond aggressively to signs of rising inflation, especially if oil prices rise rapidly. In this case the likelihood of a recession is increased. Consumers will already be curbing spending as a result of higher energy prices (and second-round price increases for energy-intensive goods and services), and if this demand destruction is exacerbated by higher interest rates, which also depress investment, the economic situation could deteriorate significantly.

Leggett (2005) argues that the crucial timing may not be the actual date of the oil peak, but rather when a critical mass of investors recognises that Peak Oil is unavoidable and imminent. Given the sensitivity of oil prices to news of even small interruptions to supply, this realisation is likely to spark wide-spread panic and hoarding behaviour among investors, leading to a dramatic price spike. Such a spike could have devastating effects on financial markets as investor confidence in the growth economy dissolves.

Indeed, the integrity of the world financial system is deeply dependent on continuous economic growth. This is because new money is created as debt, on which interest payments are required. The only way that the interest can be repaid in future is if more new money is issued, which itself increases the stock of debt. The collateral for this debt is continuous economic growth, which is itself dependent on growing supplies of energy. Should growth fail for an extended period, the financial system may implode, compounding the economic adversity.

In the medium term, an economic recession and/or investor confidence crash would reduce global demand for oil and – somewhat perversely – result in the oil price falling again. This in turn could stimulate a partial economic recovery, only for another price spike to be triggered and the cycle to repeat itself.

In the long term, the world faces a virtually endless sequence of supply-side oil shocks on the down-slope of the Hubbert curve. Thus we can reasonably expect a rising oil price trend due to cumulative shocks along with greater volatility as a result of economic and political fallout. Certainly, efforts will be made to conserve oil (and energy more generally), and there will be heightened efforts to find substitutes for depleting oil. However, it will take many years – if not decades – to replace the vast infrastructure that currently relies on oil. The problem is that economic conditions will be far less conducive to such investment after Peak Oil as a result of less energy being available, rising costs, and the business environment being characterised by greater volatility and uncertainty.

If no mitigating action is taken, or it is begun too late, the combination of repeated supply-side oil shocks and a major stock market crash could prompt a prolonged economic depression. The US Department of Energy commissioned a report on peak oil by Robert Hirsch et al (2005: 4), who concluded that:

> "The peaking of world oil production presents the US and the world with an unprecedented risk management problem. As peaking is approached, liquid fuel prices and price volatility will increase dramatically, and, without timely mitigation, the economic, social, and political costs will be unprecedented. Viable mitigation options exist on both the supply and demand sides, but to have substantial impact, they must be initiated more than a decade in advance of peaking."

Transport and mobility

The rapid process of globalisation over the past two decades has been driven by a number of factors, including neoliberal ideology favouring free trade and technological progress (especially with regard to telecommunications). Globalisation has been underpinned by the availability of abundant, cheap oil to fuel the world's transportation systems. With declining supplies of oil, we can expect a partial reverse of the globalisation process in favour of localisation of production and consumption (especially of material goods). More specifically, all sectors that rely heavily on oil-fuelled transport will be adversely affected. Chief amongst these is

the aviation industry, a large fraction of whose operating costs are fuel. As a result of reduced international and national mobility, the tourism sector will probably shrink significantly.

Agriculture, food and population

Oil and natural gas are essential inputs into modern industrial agriculture, both for the production of fertilisers and pesticides, and for the operation of farm machinery (e.g. tractors and harvesters). Furthermore, oil-based transport is used to deliver food products to consumers.

The so-called 'Green Revolution' in agriculture, which took place from the 1960s, involved the extension of Western farming methods (including fertilizer and pesticide use) and crop varieties to developing countries, massively boosting agricultural yields and thereby supporting rapid growth in their populations. Globally, the use of fossil fuels enabled the human population to grow from less than one billion in 1800 to approximately 6.4 billion today. The world population is currently growing by some 80 million people per annum, which implies a growing demand for food.

After oil output has peaked, the world faces the prospect of declining food production and therefore rising world food prices. Some authors suggest that without fossil fuels, the sustainable world population is probably in the region of about two billion (see Heinberg, 2003: 177). Others, however, are optimistic about a larger world population being sustainable. The impact on agriculture of fossil fuel depletion will be exacerbated by soil degradation, depletion of water resources and climate change. Together, these factors pose a significant threat to food security.

Another concern is the growing competition between food and fuel. Rising oil prices have prompted governments in several countries (including notably the US and Europe, as well as South Africa) to promote biofuel industries. Together, market forces and government support are making it increasingly profitable for (e.g. maize) farmers to supply their produce for the production of ethanol rather than for food. Growing international production of ethanol from maize and sugar is already pushing up the world prices of these staples, threatening the food security of certain food-importing nations and especially poor, landless consumers.

Geopolitics and conflict

As oil production begins to wane after the peak, international competition for remaining supplies will intensify. Given how critical oil is for economic and military power, there is a strong likelihood of further regional military conflicts over energy resources, especially in the Middle East and Caspian region, but also in other significant oil-producing regions such as West Africa and Latin America.

In some cases (Iraq and Nigeria, for example) local conflicts are already deepening, and may possibly descend into civil wars. In addition, the probability of occurrence of war between a powerful consuming nation and a weaker producing state will probably increase (see Heinberg, 2004). Some commentators (e.g. Heinberg, 2006) have argued that such intervention could seed terrorist activity in the future.

Regional conflicts could result in a new military rivalry among the US, EU, China and Russia.

This could be a reason for the US policy of positioning and utilising its military forces in order to ensure or control the flow of oil, especially in the Middle East. Russia is now the world's leading oil producer and boasts the world's largest natural gas reserves. Already this resurgent nation has begun to use its energy resources as a political weapon in Europe. China has a voracious appetite for energy, and has been concluding bilateral trade and investment agreements with several oil producing countries (e.g. Angola and Canada).

Escalating geopolitical tensions, outright conflict over energy resources, and terrorism could erode economic confidence, hampering investment and making the transition to alternative energy sources and infrastructure that much harder.

Conclusions on peak oil

In summary, we can state what we know for *certain* about the depletion of oil:

- Oil must be discovered before it can be produced.
- Oil must be extracted, refined and transported before it can be used.
- On the human time scale, oil is a finite, non-renewable resource.
- The more oil we use now the less we have for the future.
- Exponential growth goes hand in hand with depletion of non-renewable resources.
- Exponential growth in human populations and consumption of physical resources, including non-renewables like oil, is not sustainable indefinitely on a finite planet.
- Production of oil will at some point reach a peak and then begin to decline.
- Petroleum products have the highest energy density of any known portable energy carrier.
- Replacing the current oil-based infrastructure requires time, finanical resources and energy.
- The longer we take to change our consumption patterns the more constrained our options will be for doing this in an orderly manner.

Existing research has demonstrated a compelling argument about the life cycle curve of oil production:

- The life-cycle curve of oil production is roughly a bell curve – this is empirically verifiable (e.g. US-48, North Sea, etc.).
- The longer that production is maintained at or above current rates, the faster it will fall on the far side of the Hubbert curve.
- Improvements in extraction technology increase the rate of depletion.

The following is uncertain:

- Precisely when the oil production peak will occur.
- What the post-peak rate of depletion will be.

- Whether sufficient substitutes for oil will be developed, produced and installed in time to avert damaging shortages.
- The scope for conservation and efficiency to offset the decline.
- Precisely how people, countries, and markets will react when the decline sets in.

Based on available evidence, it appears to us likely that:

- Oil production will not increase substantially beyond its current level.
- Between 2007 and 2019, oil output will begin an inexorable decline.
- There is a significant risk of a rapid decline (cliff) in global production at some point.
- Without proactive mitigation well before the peak, shortages will occur causing the price to spike.

Climate change

The Intergovernmental Panel on Climate Change (IPPC), a United Nations body which comprises over 100 member nations, has issued three reports this year summarising (1) the scientific consensus on the physical science basis of climate change (IPCC, 2007a), (2) the impacts of, and adaptation and vulnerability to, climate change (IPCC, 2007b), and (3) mitigation responses (IPCC, 2007c). These reports are based on a comprehensive review of scientific studies on the nature, causes and implications of climate change and reflect the current consensus amongst scientists and representatives of IPCC member countries.

This consensus (IPCC, 2007a: 3) identifies human activities as being contributors to global warming with "very high confidence" (i.e. with greater than 90 per cent probability). Such activities include the burning of fossil fuels for power generation, transport and industry; changing land use patterns (including the destruction of natural forests); agriculture; and the generation of waste. The IPPC (2007a) points to increasingly clear evidence that global warming and climate change are under way: icecaps and glaciers are melting (e.g. the Artic sea ice has shrunk considerably and in summer no longer covers the North Pole), and air and sea temperatures are rising. The effects of global warming on the Earth's climate are already evident, manifesting in increasing prevalence and severity of extreme weather conditions, such as heat waves, droughts, floods and storms. In addition, there is already evidence of rising sea levels owing to the melting of icecaps and glaciers as well as thermal expansion of the oceans.

Impacts

Global impacts

The Stern Review (2007: iii) states that "[t]he scientific evidence points to increasing risks of serious, irreversible impacts from climate change associated with business-as-usual (BAU) paths for emissions." According to the IPCC (2007b), climate change poses threats to food and water security in many areas, increases the risk of epidemic diseases spreading, will destroy some coastal settlements, and will result in massive displacement of peoples as some regions become uninhabitable. Ecosystems will suffer, with "around 15-40% of species potentially facing

extinction after only 2oC of warming" (Stern Review, 2007: vi).

Agriculture is one of the sectors most vulnerable to climate change. Although some regions (especially cooler areas such as northern Canada, Europe and Asia) may actually benefit from climate change in terms of agricultural productivity, Brown (2006) states that on balance climate change is expected to reduce crop yields on a global scale. Indeed, some crops – including maize – are highly vulnerable to small changes in average temperatures. Less stable and more extreme weather means greater susceptibility to droughts and floods, as well as greater uncertainty inhibiting agricultural investment. Furthermore, the melting of glaciers threatens stable water supplies for agriculture (as well as industry and private consumption) in some areas. In addition, rising sea levels may compromise agricultural production in some critical regions, such as low-lying southern Bangladesh, which produces about half of that country's rice (Brown, 2001: 36). Some regions are already experiencing worsening droughts, such as Southern Africa, the Sahel in North Africa, northwest China and Australia.

Global warming also threatens ocean fish stocks. Coral reefs, which support an abundance of fish species, are increasingly dying as a result of bleaching caused by rising surface sea temperatures (IPCC, 2007b: 6). Potentially even more concerning is the discovery that carbon dioxide is dissolving in the oceans at an increasing rate, thereby raising their acidity level. This may threaten the existence of zooplankton, the basis of the entire marine food chain (Leggett, 2005: 121).

Overall, therefore, climate change increases vulnerability and threatens water and food security in many regions. This in turn raises the risk of large-scale migration and conflict.

Furthermore, the Stern Review (2007: ii) concludes that [o]ur actions over the coming few decades could create risks of major disruption to economic and social activity, later in this century and in the next, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century." The Review (2007: x) anticipates that business-as-usual climate change might lead to a reduction in per capita consumption of up to 20%.

A specific – and arguably more immediate – economic implication of climate change is increasing financial risk. According to Leggett (2005: 106), the global insurance industry maintains a reserve for natural catastrophes in the region of $300 billion annually, which "could in principle be wiped out overnight." Should this happen due to a natural catastrophe the resultant knock-on effect to the global financial system could have severe implications for the global economy. Losses to the insurance industry from natural disasters, many related to global warming, have been growing by about 10 per cent per annum since the 1970s. Mounting losses – or a particularly severe catastrophe – could bankrupt the insurance industry and lead to systemic capital market collapse. The two biggest reinsurance companies in the world, Swiss Re and Deutsche Re, are keenly aware of the threat posed by climate change.

Africa and South Africa

The IPCC (2007b: 8) states that "Africa is one of the most vulnerable continents to climate variability and change because of multiple stresses

and low adaptive capacity." Food and water shortages are expected to be especially acute in Africa. The IPCC (2007b: 8) estimates that by 2020, "between 75 and 250 million people are projected to be exposed to an increase of water stress due to climate change" and "[i]n some countries, yields from rain-fed agriculture could be reduced by up to 50%". Increasing scarcity of food and water are likely to lead to higher rates of migration and conflict.

Southern Africa has been singled out as one of the areas most vulnerable to climate change, even by African standards. On average, temperatures are expected to rise, crop yields to decline, and rainfall to decline in the western parts and become more erratic (i.e. more droughts and floods) in the east. In a country that is already water stressed, the impact on water and food security could be extremely severe in the coming years and decades.

Mitigation

The Stern Review (2007: i) concludes that "[t]he benefits of strong, early action on climate change outweigh the costs… Mitigation – taking strong action to reduce emissions – must be viewed as an investment, a cost incurred now and in the coming few decades to avoid the risks of very severe consequences in the future." The IPPC (2007c) and the Stern Review (2007) identify a range of mitigation measures that national governments could adopt to curtail the extent of climate change and its possible future impacts. These include:

- reducing the consumption of fossil fuels;
- capturing and storing carbon dioxide emissions (sequestering carbon);
- reducing deforestation and planting more trees;
- enhancing energy, transport and economic efficiency and reducing waste;
- improved agricultural practices to increase soil carbon storage;
- developing renewable energy sources (e.g. solar, wind and wave power); and
- changing lifestyles and behaviour patterns.

The Stern Review (2007) states that the average expected annual cost of stabilising the atmospheric carbon dioxide concentration in the 500-550 parts per million range (which is seen as a key threshold) is about 1 per cent of world GDP by 2050. Should the world's major economic powers (including the US, Europe, Japan, China and India) embark on a concerted effort to reduce their carbon footprints by for example reducing fossil fuel consumption, the most serious potential consequences of climate change could be averted. Unfortunately, progress to date has been highly inadequate, with the top two greenhouse gas emitters (the US and China) not being signatories to the Kyoto Protocol. Moreover, the effects of climate change are already being felt, and will continue to increase in the future irrespective of mitigation actions, owing to momentum in the warming process.

Peak oil and climate change

There are strong linkages between peak oil and climate change. Most obviously, the burning of oil (as well as coal and gas) reserves have been identified as a major contributor to global warming. But does fossil fuel depletion – and specifically the impending peak in oil production – imply that concerns about future carbon emissions are unwarranted? We argue that they are not, and that the two challenges must be viewed and tackled in conjunction.

The IPCC (2007a) has several long-term carbon emission scenarios, based on varying assumptions about future rates of economic and population growth, technology and the energy mix. Most of these scenarios assume continued fossil fuel consumption and rising carbon emissions at some level or other. The IPCC's (2007c) report on mitigation also includes scenarios where deliberate attempts are made to reduce carbon emissions. However, none of the IPCC projections take peak oil, gas and/or coal into account.

If indeed the peak of oil (and gas) production turns out to occur in just a few years' time, this might seem to imply that greenhouse gas emissions will decrease irrespective of mitigation policies such as voluntary emission reductions or those agreed to under the Kyoto Protocol. On the other hand, however, oil depletion raises the spectre of a substitution of coal for oil and gas, especially in the US, China and India, each of which has substantial coal reserves. Increasing reliance on coal, which produces more CO2 per energy unit than oil or gas, may mean increasing net emissions in the future and even faster planetary warming, unless 'clean coal' technologies – which are expensive – are used. [7]

This raises another question: can we afford to burn all the remaining fossil fuels? In the view of Jeremy Leggett (2005: 117), a specialist on both oil and climate change, "we have plenty [fossil fuels left] to tip us into global economic ruin as a result of climatic meltdown." Consequently, Leggett argues, "we cannot afford to burn all the oil [that remains], much of the gas must remain below ground, and the great majority of the coal shouldn't even be considered" (p. 128). In reality, the countries of the world are likely to continue their use of fossil fuels for decades to come, even if it is at a diminishing rate. Either way, as mentioned above, further global warming and resultant changes in the climate will continue to occur as a result of past emissions, since there are lags in the process.

Peak oil and climate change must be understood and tackled together. Some (albeit partial, unsustainable) remedies for oil depletion, such as the more intensive use of coal, will exacerbate the global warming problem. On the other hand, the development of clean, renewable energy sources (such as solar and wind power) will help human societies to cope with both challenges. It is possible that effective mitigation of global warming will require faster reductions in the use of oil than will be imposed by

7 *However, doubt has recently been cast on the prevalent assumption that the world has hundreds of years of coal reserves left. The Energy Watch Group (2007) produced a report recently, in which they estimate that global coal production might reach a peak within 10 to 15 years. If this turns out to be an accurate prediction, it could have extremely significant consequences for future CO2 emissions as well as economic and social conditions.*

natural depletion. However, given the current state of international climate change negotiations and the limited mitigation targets agreed under the Kyoto Protocol (e.g. the fact that the US, Australia, China and India are not signatories to the protocol), and the likely imminence of peak oil, the latter issue will have to be addressed directly. Otherwise, the economic and financial destabilisation likely to be caused by the oil peak could seriously hamper future climate mitigation efforts.

Carbon sequestration

South Africa is one of the largest CO2 polluters per capita in the world as a result of our coal based energy economy. Our large industrial complexes like Sasol emit about 57 Mt/a of CO2 per annum whereas Eskom power stations emit approximately 160 Mt/a of CO2. In terms of the Kyoto Protocol it was accepted that countries should reduce their emissions of green house gasses to 5% below their 1990 levels.

As a developing country South Africa is not bound by the protocol but nevertheless has accepted the general principals thereof.

Carbon sequestration, or the removal of carbon dioxide from the atmosphere by a variety of means to help mitigate global warming has become an important carbon offset mechanism under the protocol. Significant carbon credits can be earned by sequestering a country's carbon dioxide emissions.

It is only a matter of time when the world investment community will be voting with their funds and withdrawing funds from countries that are not reducing their carbon footprint and becoming energy efficient. The carbon emissions of a single company could have an impact on the investment profile of the entire country.

South Africa should be embarking on an urgent programme of carbon sequestration research for its major polluters and no new coal projects should be commenced unless there is a proven plan to capture the CO2 and other noxious gasses, i.e. all new coal projects should be clean coal projects.

Global financial imbalances

A seemingly insatiable, uncompromising consumption of natural resources will ultimately be limited by the fact that natural resources are of a finite quantity. At some point we will use up the supply of oil that we require for our ever-increasing, exponentially growing consumption. At some point the continuing emission of greenhouse gases, with concomitant global warming, will change climate patterns resulting in rising sea levels, droughts, floods, etc. The ecosystem has a finite limit to absorbing the impact of global warming after which irreversible climate change will set in. The previous sections of this paper have described some likely impacts of both oil depletion and climate change on global, regional and local economies.

In addition to these threats, the global financial system, which enables the functioning of global, regional and local economies, is itself subject to severe imbalances which could trigger off an economic recession that would add to the economic and social impacts of oil depletion and global warming. While the majority view appears to be that global financial imbalances are unsustainable in the long term, there are differing views

about how the economic adjustments – and therefore the impacts – will take place. One school of thought views adjustment as likely to take place through a severe economic depression; another sees adjustment as a market managed process with minimal, negative impact.

These imbalances consist in the rising indebtedness of the largest developed economy in the world, the US (the debtor economy), and the over-savings of still severely under-developed economies like China and India and other developing economies (the creditor economies). Most economists agree that this imbalance is unsustainable because:

- There is a limit to how far the creditor economies will fund the debtor economy – at some point they will want to invest domestic savings in local infrastructure, production and consumption.
- There is a limit to the extent to which consumers in the debtor economy will be able to continue their high rates of consumption in the face of high indebtedness, extremely low savings and falling house prices.

Nature and causes of the imbalances

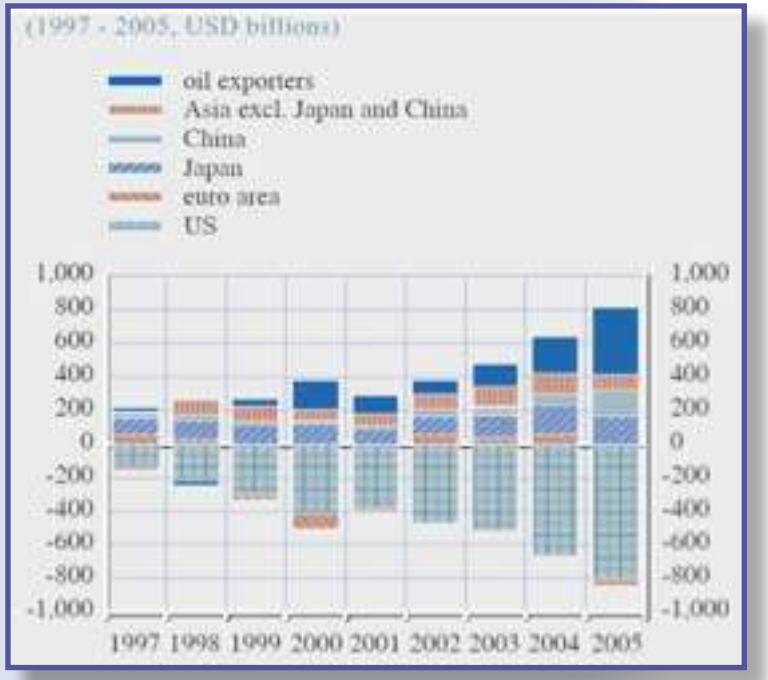
Llewellyn (2006: 15) succinctly summarises the nature of global financial imbalances: "The world economy currently has massive net savings in some parts of the world economy which are financing a single enormous deficit in the US." The US current account deficit has been growing since the early 1990s, and exceeded $800 billion (6.4 per cent of GDP) in 2005 (Llewellyn, 2006). Approximately two-thirds of this deficit has over the past few years effectively been financed through loans provided by the world's central banks at low interest rates (Roubini & Setser, 2005: 2). China, Japan, other emerging Asian economies are increasing their holdings of dollars and US Treasury securities so that they can continue to export large volumes of goods to the US.[8] Meanwhile, OPEC countries are stockpiling dollars – and to a lesser extent euros – received from their oil export revenues. Europe is providing another source of finance for the US deficit, helping to prop up the value of the dollar.

Put another way, there is an unprecedented transfer of real resources from net savers (mainly China, Japan, other Asian economies and certain members of OPEC) to the US in exchange for an accumulation of dollar denominated financial assets. The growth of these imbalances over recent years is reflected in Figure 4 alongside.

As Llewellyn (2006) points out, global financial imbalances are determined ultimately by domestic imbalances

Figure 4: Global trade imbalances

Source: Llewellyn (2006)



8 *The system whereby certain Asian countries peg their currencies to the US dollar has been referred to as 'Bretton Woods II' (Roubini & Setser, 2005: 2), referring to similarities with the Bretton Woods system of fixed exchange rates thaat operated between 1945 and 1971.*

in the countries involved, as reflected in their balance of payments positions and net savings. There are several views as to the main origins of the current global imbalances (Llewellyn, 2006: 16-17):

(1) "the attractiveness of the US economy to foreign investors", leading to large capital inflows;

(2) US net dis-saving or 'profligacy' (near-zero household savings and a large Federal budget deficit, itself reflecting inter alia substantial tax cuts in 2003 as well as financing of the wars in Afghanistan and Iraq);

(3) excess savings in certain Asian countries (notably China and Japan) and some oil exporting countries;

(4) deliberate under-valuing of exchange rates that are fixed to the dollar (in some of the countries mentioned in (3) above);

(5) "the creation of excess liquidity mainly by the US through its expansionary monetary policy and sharp lowering of interest rates by the Fed in 2003"; and

(6) a sustained rise in the price of oil since 2003.

Certain commentators emphasize one or more of the above factors (e.g. the US's deficits) as being of paramount importance, while others hold a differing view (e.g. the role of net savers). It seems plausible that all of the above factors have contributed to the imbalances, and therefore that the 'blame' for the imbalances cannot be levelled at any one country or group of nations in isolation.

As with the causes of the imbalances, there is substantial disagreement over whether or not they are sustainable. A bullish view, held inter alia by Federal Reserve Governor Ben Bernanke (2005), is that the US is efficiently performing the role of the world's financial intermediary for a global savings glut, and that the highly globalised financial system has allowed a diversification and attenuation of risk. A bearish view, enunciated for instance by Roubini and Setser (2005) and Obstfeld and Rogoff (2005), is that the US 'twin' deficits are not sustainable in the long term and that globalised financial markets raise the risk of contagion in the event of instability in one country or region. Llewellyn's (2006: 22) assessment of the debate is that "we do not know whether the imbalances will prove to be sustainable or not although the consensus seems to be that they will not be." To understand why this might be the case, we need to consider the nature of the risks attending these imbalances and the possible paths towards rebalancing.

Risk, adjustment and impact scenarios

There are also varying opinions about whether any adjustment, if or when it were to take place, would result in a 'soft' or 'hard' landing for the US

Table 3: Perspectives on global financial imbalances and their possible consequences

Issue	Optimistic View	Pessimistic View
Sustainability of imbalances	Sustainable indefinitely	Unsustainable in long term
Result of any adjustment for US economy	Soft landing	Hard landing
Result of any adjustment for world economy	US delinked from rest of world	US leads world into recession and financial stability is threatened

economy. In addition, one school of thought argues that any hard landing in the US would spill over to the rest of the world, while another school contends that the rest of the world could be 'delinked' from any downturn in the US economy. These differing perspectives are summarised in Table 3 on the previous page, and spelt out in further detail below.

The view held by former Fed Chairman Alan Greenspan, among others, is that if and when an adjustment does occur, it will be "smooth and benign and without causing serious disruption" (Llewellyn, 2006: 27). In other words, market mechanisms will ensure a relatively painless adjustment. On the other hand, authors such as Roubini and Setser (2005) argue that there is a strong likelihood of a 'disorderly adjustment' and consequently a hard landing for the US economy.

Llewellyn (2006: 27) identifies several possible adjustment routes:

(1) "American households reduce their expenditure substantially and, as a result, imports decline sharply;

(2) the American government cuts the budget deficit;

(3) a sharp rise in growth outside the US so that American exports rise;

(4) the imposition by the US of direct protectionist trade controls on imports;

(5) key countries (notably China, Japan, India and other countries in South East Asia) revalue their pegged exchange rates against the dollar; and/or

(6) a sharp market fall in the US dollar in the foreign-exchange markets."

Routes (2), (3) and (5) would likely be relatively benign in terms of the impact on the world economy. However, given the extremely high rates of growth in countries like China, India and other Asian countries, and the persistent structural obstacles to higher growth in Europe, option (3) seems unlikely. Option (2) also appears unlikely given the protracted nature of the conflicts in Afghanistan and especially Iraq, as well as the effects of an aging 'baby boomer' population and financing of the Medicare system. If anything, the large US budget deficit looks likely to persist. The main obstacle to route (5) is that it involves a prisoner's dilemma: if all these countries were to sell dollars and force its value down, the real value of their accumulated reserves would suffer a capital loss.

Routes (1) and (4), and possibly a sharp drop in the dollar (6), would probably have negative consequences for the world economy. The risk of a sharp drop in US consumer spending is significant. The Federal Reserve Bank (Fed) lowered interest rates dramatically from 2001 in the wake of the 'dot.com' stock market correction, in order to pull the economy out of a recession. The lowest interest rates in decades stimulated a boom in the property market and a large increase in consumer debt. In 2004 to 2006 the Fed raised interest rates from 1% to 5.25%, which has put consumers under pressure. In addition, over the past year evidence has emerged that the housing bubble is in the process of deflating, eroding home-owners wealth.

Evidence has recently emerged about problems in the 'sub-prime' lending market, although there is debate about how serious this issue is. Some commentators warn that the collapse of the US housing market, or significant sections thereof, could trigger a bank (or lender) crisis (as increasingly risky loans are called in) and thereby engender the collapse of several financial

institutions, which in itself could trigger further economic destruction. An alternative view is that over the past two decades the securitisation of mortgage loans, and the selling of securities for different market segments to investors globally, has disaggregated the risk of default. This disaggregation of risk across many global investors, rather than its concentration in a limited number of institutions, has, according to this perspective, greatly mitigated the risk of a banking (or financial institution) collapse as a result of the collapse of a segment of the US housing market. The veracity of the latter argument depends on whether in reality the risks have been disaggregated or whether they ultimately rest on the shoulders of a limited number of financial institutions which are interlinked. If the funding of the US housing market is based on surplus domestic savings from China and Europe then in the event of a collapse of that market it is European and Chinese savers who will suffer the loss rather than financial institutions.

Nonetheless, with the household savings rate near zero, US consumers have little room to manoeuvre, and are gradually being squeezed by high and rising energy costs. Ultimately, they will have to scale back on their consumption of imports.

Should the economic situation in the US deteriorate as a result of the above factors, there is a risk of a loss of confidence in the dollar as international reserve currency. At some point, countries like China, Japan and South Korea may decide that the exposure risks of continuing to support the dollar outweigh the benefits in terms of boosting their exports, in which case they would limit their purchases of US Treasuries (Roubini & Setser, 2005). A similar situation faces the European Central Bank, although in this case political considerations are probably as important as economic ones: Europeans are growing conscious of the risks involved in indirectly financing America's war in Iraq and US citizens' excessive consumption. Moreover, certain significant oil producing nations (including some OPEC nations and Russia) may decide to switch the denomination of their oil exports to Euros. Iran has already begun to sell oil for Euros, and earlier this year China set up its own oil trading bourse. Any significant switch of oil sales from dollar denomination to other currencies would erode a cornerstone of dollar strength.

Accounting for nearly a quarter of global Gross Domestic Product (GDP), the US economy – especially its consumption spending – is a key driver of world growth. Given that the US is the world's foremost importer by far, a substantial decline in the relative value in the dollar, or an increase in trade protectionism by the US, would hurt many exporting countries, especially those in East Asia.

Figure 5: Net lending/ borrowing in the US economy

Source: Llewellyn (2006)

Llewellyn (2006: 27) warns that the "key risk… is that adjustment will be forced in ways that could cause real incomes and output in the world to fall, and cause substantial volatility in financial markets". Llewellyn (2006: 27) further cautions that "experience suggests that the longer the adjustment is delayed, the greater is the probability of a hard landing." This could result from a gradual build-up in pressures until a tipping point is reached. Alternatively, a sudden shock might precipitate an unwinding of the imbalances in a disorderly fashion.

Mitigation

Llewellyn (2006) points out the similarities and differences between the current global imbalances and two similar sets of circumstances which prevailed in the early 1970s and mid 1980s. In the earlier period, severe imbalances culminated in the breakdown of the Bretton Woods system of fixed exchange rates and considerable international financial volatility. However, in the 1980s the major countries of the world initiated a coordinated plan, known as the Plaza Accord, to adjust the imbalances through a managed depreciation of the US dollar. Thus Llewellyn (2006) recommends a similar "concerted and coordinated" policy response to current imbalances, which could mitigate the risk of an economically harmful, disorderly adjustment. Such a response would involve a package of expenditure reducing/increasing policies as well as expenditure switching via exchange rate adjustments.

Global imbalances, peak oil and climate change

We have argued that there are serious risks inherent in the financial imbalances currently characterising the world economy. Two additional shocks could upset the apparent stability of the imbalances. One is the possibility of a climate-related natural disaster, such as another major hurricane hitting the southern or eastern seaboard of the US. Estimates of the costs resulting from the three hurricanes that hit Florida in 2005 run into the tens – if not hundreds – of billions of dollars. As global warming intensifies, the risk of more such events rises.

Secondly, even if the global imbalances prove to be durable for another several years, eventually the effects of peaking oil production will be encountered. That event, and its attendant effect on the oil price and investor confidence, is likely to tip the scales and force a disorderly adjustment. Put another way, the financial risks associated with peak oil are all the more serious in the light of the global imbalances.

Interconnections, interactions and triggers

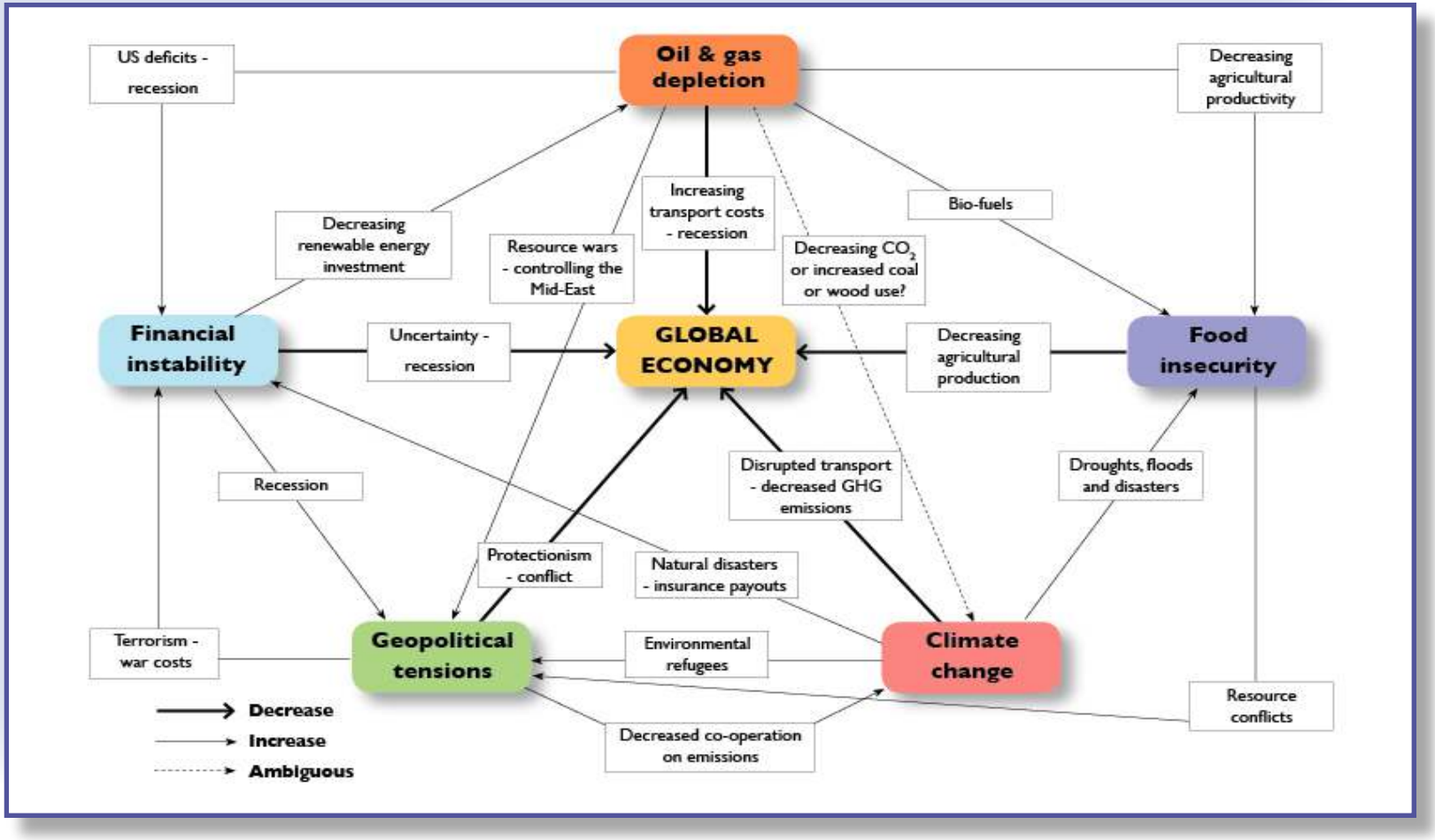
Peak oil, climate change and the global financial system are inextricably linked together and with the global economy, food security and geopolitical (in)stability. Some of the main linkages are summarised in Figure 6. As can be seen, there are several complex feedback loops among the risk factors, which raise the probability and magnitude of adverse outcomes for the global economy. Many of these feedback effects are already in operation. An especially concerning example is the effect that a rapidly growing biofuel industry is having on world food prices. For instance, social protests have recently erupted in Mexico over rising corn prices, driven mainly by the booming US corn-ethanol industry. The pressure of such forces may build up gradually until they

reach 'tipping points' and cause major disruptions.

Additionally, as we have argued, within the next 12 years the world and South African economies could be hit by one of several sudden and severe shocks. Which one will occur first is a matter of speculation. At this stage it appears to be a 'race' between a financial crisis (emanating especially from the United States debt and deficit situation) and an oil price shock. However, there is a chance that a climate-related natural disaster could strike first, such as another major hurricane hitting the southern United States.

Each of the three global risks demand a 'coordinated and concerted' international policy response, which could substantially mitigate the risks we have outlined. If the leading countries of the world fail to take such mitigating actions early enough, the outcome is likely to be highly adverse, especially given the feedback effects between the risks.

Figure 6: Inter-connecting risks to the global economy



South Africa's Strengths and Vulnerabilities

Section 3

South Africa needs to develop an unambiguous, vision-driven policy on oil depletion, climate change and financial imbalances and to push for multi-lateral agreements as envisaged earlier in this paper. Irrespective of whether our country is able to influence the global outcomes, we can and must take responsibility for our own course, and this may serve as an example to others. We need to consider our strengths and vulnerabilities in the face of these largely external challenges and on this basis develop prudent risk mitigation strategies. Table 4 contains a summary of relevant strengths and weaknesses, which are then elaborated upon on page 41.

Energy security

Figure 7 provides a snapshot of South Africa's consumption of energy by type and by economic sector.

South Africa relies on its indigenous coal reserves for nearly three quarters of its total primary energy requirements.[1] In 2004 only 14 per cent of South Africa's energy needs were met by oil (IEA, 2007). Imported oil makes up about 65 per cent of South Africa's annual petroleum consumption. The remainder comes from domestic production of oil (meeting about 5 per cent of domestic needs) and the well-developed synthetic fuels industry (supplying approximately 30 per cent of domestic consumption). South Africa processes imported crude oil into liquid petroleum fuels (petrochemical feedstock for production of plastics and other synthetic materials is derived from coal). About 85 per cent of our oil imports come from Saudi Arabia and Iran, which are at the heart of the politically unstable Middle East. Three quarters of petroleum products are used for road transport (see Figure 8).

Therefore, peak oil represents first and foremost a threat to liquid fuel prices and availability in South Africa. However, as will be discussed below, our country can also expect to experience various indirect effects

1 *Primary energy supply is transformed into 'final energy' categories such as electricity, petroleum, etc.*

Figure 7: Energy production and consumption in 2004

Source: Own calculations based on International Energy Agency (2007)

Note: The left hand column gives the breakdown of final energy consumption by type of energy; the right hand column indicates the percentages of energy consumed in various sectors. Figures in the red dots are the percentage of that type of energy flowing to the sector indicated by the arrow, while figures in the purple dots indicate the percentage of energy consumption in a sector that is derived from where the arrow originates. For example, 83% of 'combustibles and waste' energy flows to the residential sector and the other 17% is consumed by industry; 54% of the energy consumed by the residential sector comes from combustibles and waste, 21% from electricity, etc.

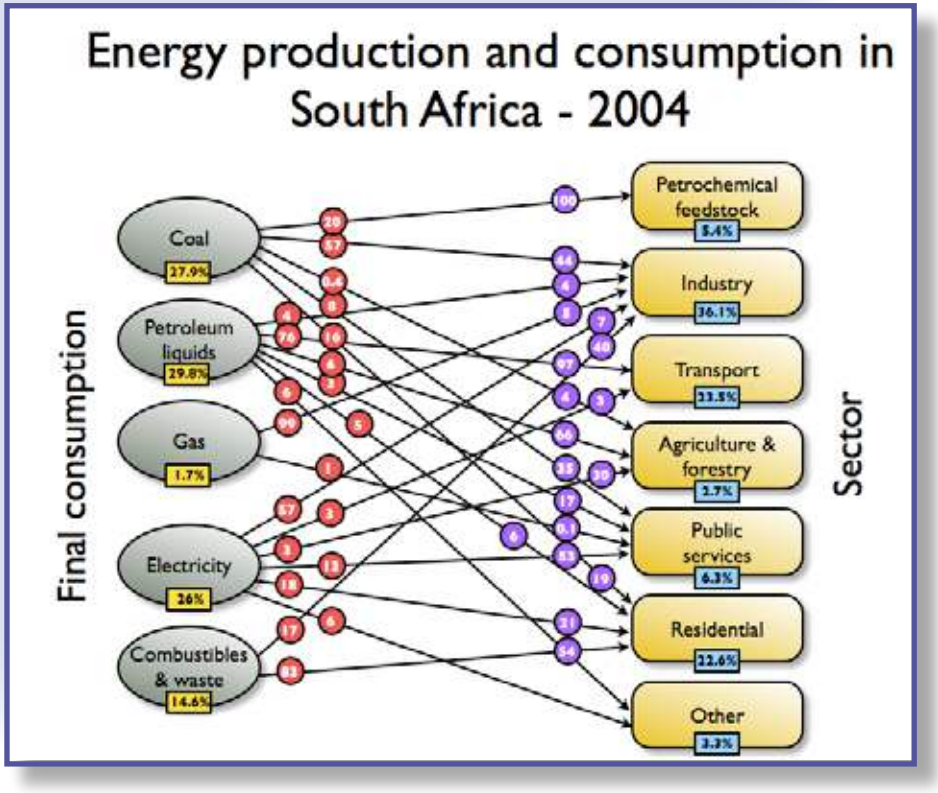


Table 4: South Africa's strengths and vulnerabilities relative to the global risks

Sphere	Strengths	Vulnerabilities
Energy security	• Low oil dependence (14% of primary energy) • Synthetic fuels (35% of liquid fuels) • Abundant solar resources • Large coal reserves • Large uranium reserves • Coastal wind resources	• High oil import dependence on Iran & Saudi Arabia (85% of crude oil imports) • High energy intensity of industry • High petroleum dependency of transport • Import parity pricing for synthetic fuels
Macro-economy	• Relatively strong growth over past few years • Relatively low inflation (5.5%) • Government debt not excessive • Asgisa investment programme could promote sustainability	• Current account deficit over 6% of gdp in 2006 • Floating exchange rate plus a highly liquid financial market • Possbility of rapid capital flight (portfolio disinvestment) • Record household indebtedness (ratio of aggregate national debt to disposable income is 73%)
Transport	• Rail network connects major centres • Potential for greater bicycle use	• High reliance on road freight and passenger transport • Inadequate public transport infrastructure • Extremely high dependence on petroleum fuels (97%)
Food security	• Net food exporter • Some subsistence agriculture	• Small percentage of land area is arable (13%) • Highly oil-intensive commercial farming • Little organic agriculture • Recurring droughts (set to worsen with climate change)
Settlement patterns & geography	• Several major ports to facilitate cheaper transport and trade (for coastal settlements)	• Urban areas highly dependent on liquid fuels for transport • Large distances between major cities • Large distance from trading partner countries
Social & political stability	• Successful political transition in 1994 • 13 Years of democracy • High unemployment in rural areas an opportunity for developing crops to stimulate bio diesel industry provided it is under local control and doesn't compromise food security	• Deep & widespread poverty • High unemployment rate (25% official rate; 38% including discouraged workers) • High and growing inequality • High prevalence of hiv/aids • High levels of crime

of peak oil via its impact on the global political economy. It is important to understand that increasing our reliance on coal as a substitute could only be seen as a short-term measure, both because of climate change and because coal production will itself reach a peak and begin to decline with rising costs, possibly within the next few decades.

Macroeconomy

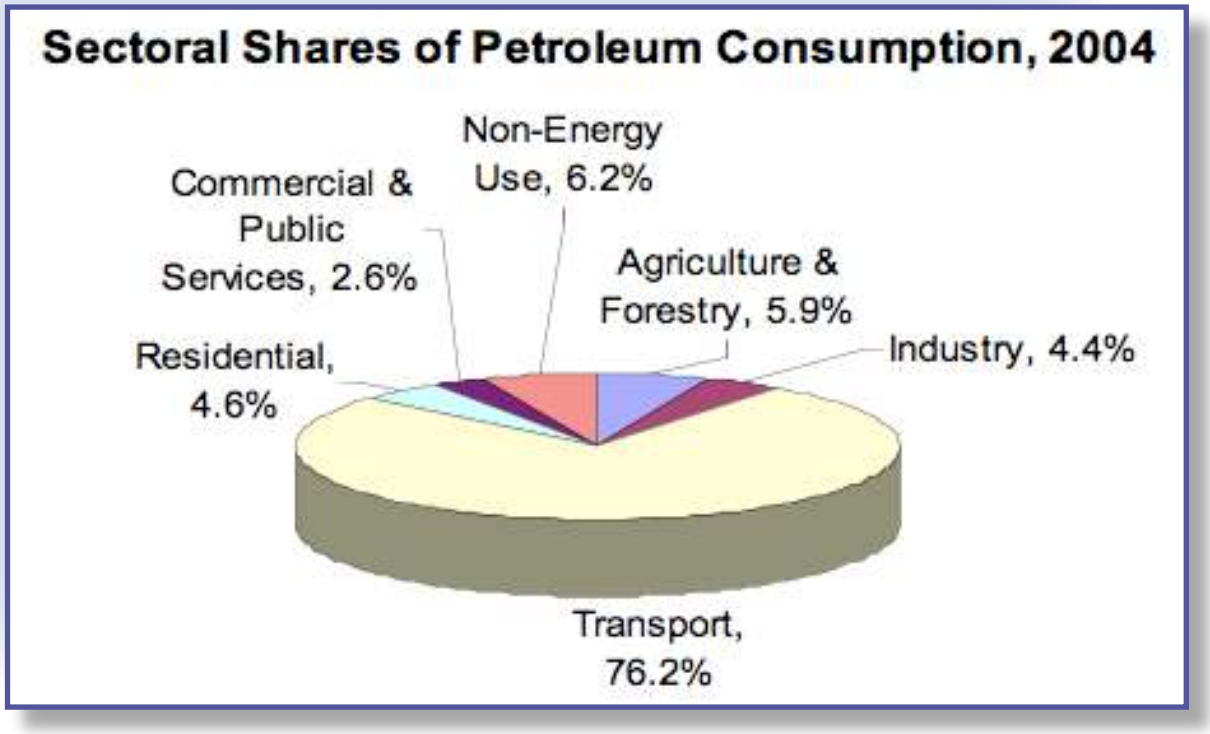
Rising crude oil prices push up domestic petrol and diesel prices. Since most goods in South Africa are distributed by road freight, higher liquid fuel prices raise the overall rate of inflation to a certain degree. When severe enough, this impact of oil price shocks on inflation usually prompts the monetary authorities to raise the interest rate – particularly if it is concerned about second-round inflationary expectations. Higher interest rates in turn have a depressing effect on aggregate demand and economic activity (which are already suffering from the effects of higher prices and therefore reduced purchasing power) and may ultimately result in a recession.

Furthermore, being a small, relatively open economy (exports comprise a quarter of the gross domestic product or GDP), South Africa is vulnerable to global economic shocks. An international recession (in addition to rising transport costs) would impact negatively on our economy by reducing the demand for many of our exports. However, declines in manufactured export revenues may be counterbalanced to some extent by rising receipts in the mining (gold, coal and uranium) and possibly agricultural sectors. (This is provided the country is still able to produce significant quantities for export in the face of climate change and oil depletion). Considering that oil imports are the single largest import item by value, the overall effect of rising oil prices on the balance of payments is likely to be negative. This will put pressure on the rand exchange rate and depreciation would further contribute to rising inflation.

South Africa's stock exchange usually takes its lead from the major world bourses, although the dominance of the commodity sector makes

Figure 8: Sectoral shares of petroleum consumption in South Africa, 2004

Source: International Energy Agency (2007)



its dynamics somewhat different. A major international stock market crash would almost certainly spill over to the JSE to a large extent. This is especially so considering South Africa's status as a relatively risky emerging market and the recent surge in foreign portfolio investment in the local bourse.

In general, those sectors that use oil most intensively will suffer the greatest impact of declining global oil production. In South Africa, the most vulnerable sectors include:

- **Transport**: The bulk of South Africa's oil imports are used by the transportation sector, which is highly dependent on liquid fuels (for 97 per cent of its energy requirements).
- **Retail trade**: The heavy reliance on road freight in South Africa means that a wide range of goods prices are affected by oil prices.
- **Tourism**: South Africa's tourism sector will contract as international transport becomes progressively more expensive – particularly considering South Africa's distance from wealthier nations (US, EU, Japan) whose citizens are generally in a better financial position to travel. Local tourism will also suffer from higher transport prices.
- **Agriculture**: See following section.

Agriculture and food security

Because oil is integral to the way in which the vast majority of our food is produced, the agricultural sector has important vulnerabilities to oil depletion. Large scale farming relies on fuel for its machinery used for ploughing, planting and harvesting. It relies heavily on oil based products for the pesticides that it uses and on natural gas for fertilisers. Oil is needed for the distribution of fresh produce and processed food products throughout the country. In the USA the oil to calorie content of food has risen to 10:1. In other words, for an average food item, there are 10 calories of oil to every 1 calorie of energy ingested by eating it. South Africa's agriculture has adopted a similar model to that of the US.

South Africa is at present a net exporter of agricultural products, including the main staple, maize. However, it does import various agricultural commodities, such as soybeans, as well as most of its fertiliser inputs. Mirroring the global situation, South Africa's agriculture and food security face two main challenges as a result of oil depletion: increasing scarcity and costs of inputs as oil (and gas) prices rise; and competition between drivers and food consumers for maize. The Government has decided to promote a biofuels industry, the main component of which appears to be large-scale production of ethanol from maize (DME, 2006). In the short term, this may lead to an increase in the maize crop as farmers are guaranteed a larger domestic market and indirect subsidy, but in the longer term it may result in the poor being deprived of their staple food. Rising transport costs will further raise the prices of foodstuffs in this country, harming the poor even more.

Cities and urban planning

South Africa's major urban areas are characterised by sprawling suburban areas surrounding concentrated commercial centres. In general, public transport systems are inadequate. Many urban residents rely on private

road transport or taxis, although the majority depend on public transport or walking (Department of Transport, 2003). Diminishing availability and rising prices of petrol and diesel present an enormous structural challenge to cities. Presently, the bulk of food and other commodities are trucked into and within cities; rail freight is currently underutilized. In future, urban areas will have to densify and allow mixed zoning such that a wide variety of activities (e.g. work, schooling, commerce and food production) can take place along localised patterns. Public transport systems, such as light rail, will have to be expanded as well. Peak oil provides an opportunity for South Africa to develop integrated public transport systems at the local and metropolitan levels, based on electrically driven trains and trams, and also bicycles.

Social stability and security

Peak Oil has potentially important security implications at the global, regional and local scales.

South Africa is unlikely to be the site of major international conflict over fossil energy as it does not possess significant oil or gas reserves (although exploration is continuing off the west coast). Although this country ranks seventh in terms of national coal reserves (possessing some 5 per cent of the world total), it seems unlikely that this poses a geo-strategic risk. This is because some of the highest energy-consuming countries (e.g. the US, China and India) possess large domestic coal reserves while others (e.g. Europe) are geographically proximate to countries well endowed with energy resources. On the other hand, South Africa has the world's fourth-largest deposits of uranium, which could conceivably make it a target if nuclear power production takes off globally.

While some of South Africa's immediate neighbours do depend partly on her for energy, it seems implausible that they pose a significant military threat. On the other hand, the relative size and strength of South Africa's economy in the context of Southern Africa means that this country is something of a regional magnet in times of crisis. South Africa is already receiving a flood of refugees from neighbouring countries suffering from the effects of droughts, HIV/AIDS and especially Zimbabwe's economic collapse. Such immigration is likely to increase as the effects of Peak Oil and climate change are increasingly felt by our neighbours. This will place extra strain on already over-stretched social services and aggravate social tensions.

Domestically, rising food and transport costs will affect the poor most, thereby worsening already high levels of inequality and poverty in South Africa. Increasingly, satisfaction of the poor's basic needs will be in jeopardy. HIV/AIDS mortality will be rising and will be compounded by increasing prevalence of joblessness and hunger. This in turn will place added strain on social services. At the same time, the provision of such services will be hampered as economic activity contracts and costs mount. The past few years have already witnessed an increase in social protests over lack of service delivery, so the scene is set for heightened social tensions in the future. The taxi industry in particular, well known for its extreme violence, could react adversely to rising fuel prices. Food protests are a distinct possibility, especially as global and national maize-ethanol production increase.

An opportunity for the development of bio diesel in rural areas is

an opportunity to relieve poverty and create employment through identifying projects that will grow crops suitable for the manufacture of bio diesel. Relatively simple plants can be built to process the fuel as well as by-products such as fire brickets. Cooperative type schemes could be developed to ensure that a critical mass of the fuel is developed and as such each cooperative will become viable to suit and sustain local needs. There needs to be local control over such schemes to ensure that food security is not compromised.

Section 4

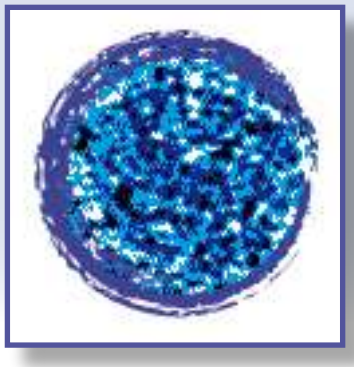
Scenarios for South Africa to 2019

Scenario One: Fragmentation – Attempting Business as Usual

In this scenario, we assume that the world and South Africa continue on a 'business as usual' path until we are interrupted by a major shock. In section 2 we argued that one of several major shocks is likely to hit our economy and society between now and 2019, including peak oil. We also illustrated the complexity of the system of interconnecting risks. This makes the identification of scenarios difficult, as there are so many possibilities. For simplicity, we develop this scenario under the assumption that an oil price shock occurs, either because a tipping point in awareness about peak oil is reached leading to extensive panic and hoarding behaviour, or because the natural depletion of oil after the peak creates a widening gap between demand and supply. We also assume that the shock takes the world and South Africa unawares, i.e. mitigating actions have not been taken in advance. We describe the likely economic and financial effects, with particular impact on the supply, demand and pricing of food and transportation. Further effects can be expected in the areas of security, conflict and governance, and the environment. In this scenario the effects of peak oil are amplified by both financial and climate instability.

Economy

Global oil production has peaked and begun to decline. It becomes apparent that despite their promises, oil producers are not able to meet the demand. In the face of highly inelastic demand, and driven by hoarding behaviour, the oil price spikes to over $150 per barrel. Consumers all over the world are hit by sharp rises in the costs of transport. Soon, the prices of all goods and services that depend on oil-powered transport begin to rise, sending inflation rates to new highs. Central banks react by raising interest rates in a bid to quell the inflation, but instead their actions exacerbate a sharp downturn in consumer spending. Meanwhile, oil companies and producing nations continue to receive massive revenues.



Millions of indebted American consumers are unable to meet their repayment obligations, triggering foreclosures on home loans. Scores of small lenders in the US become insolvent, putting pressure on the major banks, some of whom file for Chapter 11 protection – although the immediate impact of this might be mitigated somewhat by securitisation of these loans if this would spread the risk of defaulting way beyond individual banks and onto the backs of a myriad of international investors.

As it becomes clear that the US economy is sliding into recession, equity investors take fright. The US stock market plunges, as does the over-heated Chinese bourse, triggering similar losses around the world. Trillions of dollars of wealth are wiped out over a few months. Faced with such loss of wealth, consumers restrain their expenditures further, compounding the economic contraction. The value of the US dollar reaches record lows against other major currencies as confidence in the US economy erodes.

Gold is in high demand and its price rises sharply, providing an initial buffer for the Rand by partially

offsetting portfolio capital flight and the much higher oil import bill.

In South Africa, the petrol price rises to R12 per litre and inflation races toward 10%. The Reserve Bank raises the repo rate by three percentage points. Many sectors and businesses begin to realise how dependent on oil they have been and that they have very little flexibility to adapt. Where possible, they pass on higher production costs to consumers, but many are forced to lay off workers. The official unemployment rate rises rapidly, breaching the 30% mark, while the broad rate reaches 50%. At the same time, food prices rise dramatically as a result of higher transport costs. Many members of the middle class have to cut back their expenditure on discretionary items, and some have to sell their houses, contributing to a decline in house prices that was triggered by the stock market crash.

A number of key sectors face mounting difficulties resulting from the high price of fuel, including transportation, tourism, food, construction and import/export.

The global economy slides into recession. After a time, the destruction of demand for oil results in the oil price dropping. This helps some economies to begin to recover, but once again the lowering supply ceiling acts as a constraint and forces the oil price upwards, repeating the economic cycle of contraction. The costs of most goods and services increases and their supply falls. This raises the costs of taking mitigating and adaptive actions. The world economy, and especially international trade, continues to contract.

Transport

The global airline industry is in serious trouble as its operating costs rise dramatically. Many large airlines worldwide need to be saved from bankruptcy through state intervention. Many privately owned airlines struggle to stay aloft as high fuel prices cripple their profitability. International tourism declines markedly, hitting South Africa's balance of payments hard.

Domestically, road transportation companies are forced to increase their tariffs, and the cost of moving goods rises sharply. With its dependency on road transportation for the movement of people, goods and services, South Africa is confronted with the limitations of its transportation infrastructure. There is increasing criticism of Transnet and the Department of Transport for not having invested more heavily in public transport over the past 10 years. The rail network has for many years been downgraded and has lacked ongoing maintenance and investment. Its commuter services are limited and do not offer a viable service to those who need it. The costs of upgrading and expanding public transport have risen dramatically. South African Airways incurs ever greater losses, much to the annoyance of both government and taxpayers. Airline tickets rise to their highest levels since the airline was founded. Many people's mobility is constrained by the high price of fuel. People plan their travel and holidays much closer to home while overseas travel becomes a privilege only affordable by the wealthy.

International geopolitical developments reduce the supply of oil coming to South Africa, resulting in shortages, especially in smaller cities and the

interior. Alternatives to liquid fuels are extremely limited and cannot be scaled up to meet the shortfall. There is no option but for consumers to downscale their consumption of petrol and diesel. Car pooling becomes commonplace. Many private car owners are forced to use public transport, which becomes heavily over-subscribed. Many commuters opt to work from home whenever possible, and businesses have to allow more flexible working hours. The national government is forced to take emergency measures to limit fuel consumption, especially by the rich. National road speed limits are reduced and fuel rationing is introduced.

The demand for motor cycles and smaller cars increases in relative terms, but overall the automotive industry is hard hit as consumers postpone new vehicle purchases indefinitely. Cycling becomes increasingly commonplace in urban areas. Members of the taxi industry stage protests at the high fuel prices, and incidents of violence increase.

The costs of road maintenance soar, since asphalt is a by-product of oil refining and the costs of operating machinery have risen steeply. As a result, road infrastructure deteriorates. This negatively affects the distribution of many goods, including food.

Food

Farmers are very hard hit by the rising prices and shortages of fuel. Farmers make representations to the government for subsidies on their fuel costs, as an increasing number face bankruptcy. Food prices continue to rise as high levels of inflation return to South Africa for the first time in nearly 20 years. With the financial ruin of many farmers, food production decreases, creating shortages which drive prices even higher. This creates severe problems for the poor. The problems in agriculture require that certain food categories have to be imported. Food producers in various parts of the country are severely hit as drought years become more frequent and high temperatures continue to prevail as a result of climate change.

The demand for biofuels increases dramatically as a result of the oil price spike. Many farmers have great incentive to produce corn for ethanol, reducing the land available for food.

Government is forced to intervene in the pricing and availability of food supplies in order to avoid conflict. Key staples have to be subsidised to ensure that the poor have access to food. Localised food shortages necessitate the development of system of emergency food distribution and production to supply hard hit communities. This places an additional cost burden on the state, in the context of a diminished fiscus due to declining taxes, an outcome of economic recession.

Conflict and Security

The high price of oil and its increasing scarcity increases global, regional and local conflicts. Both China and the US have passed their own oil production peaks and have been roaming the world to secure their primary interest from a wide range of sources. As the scarcity of oil intensifies so too does the competition to control the global supply. These conflicts are centred in the Middle East, Central Asia and the west coast of Africa.

An all-out war erupts in the Middle East and continues to disrupt oil

supplies. A US led bombing campaign in Iran leads to the closure of the Straights of Hormuz and an Iranian retaliatory missile attack on the Saudi Arabian oil fields. As oil is diverted across Saudi Arabia using the pipeline to the Red Sea, there are an increasing number of attacks on the pipeline because of the anti-US backlash that sweeps through the Middle East. China and Russia conclude an alliance that pits them against the US over the control of the central Asian oilfields. Nigeria descends into a civil war as ethnic factions fight to control oil reserves.

In South Africa, the reduction in mobility coupled with shortages and high prices of fuel begins to undermine social stability. Many individuals panic and begin to hoard both fuel and food. This results in both food and fuel shortages which drives up prices further. Unemployment is still the biggest social problem as many large businesses continue to retrench workers as sales continue to fall. High food prices lead to a rise in the rate of HIV/Aids deaths, resulting in a growing number of HIV orphans. As a result of all these factors, violent crime increases as vulnerable people become desperate. In some areas large gangs openly loot houses and shops where security is weak. The army and security services are on continual high alert as poor people protest their circumstances and often take to looting of supermarkets and other food stores. This is widespread across the country, but especially common around urban informal settlements.

Governance

Increasing local conflict, high prices, unemployment, low levels of mobility begin to break down the structures of governance. The administration in many smaller towns collapses, as they are unable to collect the revenues to sustain their operations as many people default on their rates and other services payments. Central government is no longer able to step in and cover these deficits as it too is under fiscal pressure. There are many reports of motorists being attacked as they travel through the countryside. Trucks are often stopped and looted of their contents as rural people attempt to cope with the collapse of their support systems. This disrupts the distribution of goods to rural areas as well as the distribution of food to urban areas.

Groups in both rural and urban areas fill the gap created by the lack of governance and set up their own militias to protect these areas. The leadership is most often self-appointed and acts primarily in its own interest. The country is increasingly fragmented into small units controlled by uncoordinated militias.

Climate and environment

In the midst of economic and financial chaos, governments abandon negotiations on lowering carbon emissions. The use of coal and trees for fuel increases, and large areas of forest in countries like Brazil, Indonesia and Malaysia are cleared for biofuel crop production. Thus despite the reduction in oil consumption, CO_2 emissions continue to exceed the levels required to stabilise the atmospheric concentration of greenhouse gases below 450 parts per million. This sets the world on a course for exceeding the 2^0C temperature rise threshold, setting in motion catastrophic and irreversible climatic changes later in the century and into the next.

Scenario 2: Renaissance – Putting the nation on a sustainability war footing

Introduction

There is an almost daily report highlighting some aspect of the very serious resource and environmental challenges we face in the not too distant future. A common feature of many studies into global warming and resource depletion is that things are far worse than was imagined, anticipated or predicted previously. We are being urged in no uncertain terms that we need to change our consumption patterns; our economic system is unsustainable. We need to embark upon a more sustainable course with vigour and urgency, using all the ingenuity and passion we can muster to create a paradigm shift of truly revolutionary proportions. The Chief Scientific Advisor to the British Government couldn't have spelt it out more clearly when he said that Antarctica is likely to be the world's only habitable continent by the end of this century if global warming remains unchecked.[1] The Intergovernmental Panel on Climate Change has told us clearly that we have eight years, as a global community, to avert a climatic tipping point when an irreversible process of dramatic climate changes will take place threatening the very conditions of life on our planet. The stakes could not get much higher. Time is short and every day of inaction limits the options and raises both the short and the long term costs. The evidence indicating the likely destructive, combined effects of global warming, peak oil and global financial imbalances is sufficient for reasonable people to be very concerned about the future of their children, and indeed of the species. Critics of peak oil and climate change impacts have not effectively critiqued these arguments which they simply tend to dismiss without properly engaging with the evidence.

Our second scenario assumes that we take seriously the analyses based on our current state of knowledge and concentrate our efforts to mitigate the effects of oil depletion and climate change as well as financial imbalances. The mitigation actions required to avert the effects of peak oil are consistent with those required to mitigate climate change.

This scenario presents a very brief vision of a sustainable future as a target toward which South African society can strive. It summarises some broad principles of sustainability and then draws attention to practical steps that can be taken to achieve that goal and to directions that should be avoided. The objective is to 'point an arrow' towards a future that should secure a civilized society for the great majority of today's population as well as future generations.

'Sustainable' means "that which can be maintained over time." Heinberg (2007) suggests as a yardstick the durability of previous civilizations, which lasted up to several hundreds or even thousands of years. The World Commission on Environment and Development (1987) defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Thus intra-generational equity should be the

1 *The Independent, 2 May 2004.*

driving value behind a vision of a sustainable future. In terms of this value poverty and a high degree of inequality are incompatible with sustainable development. Sustainable development is usually understood to include economic, social and environmental dimensions.

Environmental economist Herman Daly has suggested three conditions for sustainability, focusing on the resource base (see Meadows, Meadows and Randers, 2004):

(1) the rate of use of renewable resources must be less than or equal to their rate of regeneration

(2) the rate of use of non-renewable resources must be less than or equal to the rate at which they can be replaced by sustainable renewable resources

(3) the rate of pollution emissions must be less than or equal to the rate at which they can be absorbed and processed by the environment

Daly (1996) also emphasizes the difference between growth, defined as an increase in size or quantity (e.g. of populations or resource throughput) and development, defined as qualitative improvement. Growth will ultimately run up against finite limits, since we only have one Earth. William Rees introduced the notion of humanity's Ecological Footprint, the total land and water area needed to support the global population. Currently our collective footprint is calculated as nearly 25 per cent greater than the capacity of the biosphere to support us (Heinberg, 2007).

In terms of these definitions, current global (and South African) society is living – and growing – unsustainably. Peak oil highlights this by crystallising our dependence on a finite fossil fuel whose supply will inevitably decline. Making the transition to a sustainable economy and society – and avoiding collapse – will be no easy or automatic adjustment. This is especially the case in South Africa, where 90 per cent of our energy resources are non-renewable. This means that the state will have to intervene with plans, based on a clear policy of sustainability. This scenario assumes that the state has – or will soon make – such a policy in clear and unambiguous terms.

Insofar as plans are concerned the state would not substitute the use of oil with other non-renewable resources. Attempting to delay the transition from oil to renewables through more intensive use of other non-renewables, such as coal, gas and nuclear power, has two major disadvantages. The first is the contribution to global warming and climate change resulting from the burning of more fossil fuels (which are also required to extract uranium for nuclear power generation). The second drawback is that less oil (and other fossil fuels) will be available further into the future, and their cost will be much higher, making the ultimately necessary transition to renewables much more difficult and costly. In this scenario the state would therefore embark proactively on a crash (i.e. large scale and rapid) programme aimed at conversion to sustainability before oil, gas and coal prices rose further and the consequences of peak oil manifested.

Further the state would identify what Porter (1998) calls clusters. These clusters are regions that have an abundance of factor conditions i.e natural resources, be it a crop or propensity to produce a crop, a mineral or some other factor condition that could even include wind in the current context. These factors conditions would be identified and exploited. For example a

particular region that produces a crop which is suitable for the production of bio diesel, a region that has an abundance of water that could generate hydro electric power or a region that has a suitable wind pattern to drive turbines to produce electricity.

These regions would then leverage their ability to produce energy and create industries that can be powered by that particular form of energy. Through doing this certain regions would then create the capacity to export their particular form of energy, and in some cases, by-products to other regions. These initiatives would then be linked to local economic development initiatives to stimulate local economic growth and often create situations where poverty alleviation projects could flourish.

Leadership from the top

The State President drives a credible and convincing mitigation programme based on visionary leadership which leads by example. The vision requires a rethink of GEAR and ASGISA. The South African economic model would shift from a growth model to a steady state model, which would still retain an important principle of GEAR. Economic growth, currently measured in terms of the gross domestic product (GDP), is the total value of goods and services produced annually in the economy – measured in monetary units. The steady state economic policy requires more state intervention than under GEAR, to shape markets in a sustainable direction. But like GEAR the new policy is premised on the primacy of market driven transactions rather than the state assuming a delivery role in the economy. Because those sectors of the economy (agriculture, forestry and fishing, mining and quarrying, and manufacturing) that involve the use of physical resources cannot continue to grow indefinitely, state regulations ensure that the throughput of materials is both highly efficient (aimed at zero waste and based on circular flows) and on a scale commensurate with the physical conditions for sustainability.

The mission is defined as a course which embraces energy efficiency, energy independence and sustainable living through the widespread adoption of the use of renewable energy sources and energy savings. Strategically, South Africa targets its energy usage on the anticipated depletion rate of around three to five per cent per year. The President and his Cabinet colleagues and senior civil servants have all bought into the vision and mission. By leading by example the state secures the buy-in of the other vital sectors of society (e.g. business and civil society) that need to be behind the effort.

Local governments are critical stakeholders in this regard. Without the buy-in and support of the local tiers of government the state's intervention would be severely curtailed. As it would be vital that city leaders began to embrace the inevitability of change the Presidency would concentrate on prompting the emergence of leadership by city officials. This would demonstrate that they mean what they say and are prepared to walk their talk.

The Presidency and national government have undertaken an exercise to strategically position the country and the economy and on the basis of this have formulated a comprehensive set of mitigation plans that cascade to the local tier of government. The effect of these plans is that the nation has been on an almost war footing for the past 12 years (i.e. between 2007 and 2019). Some of the plans would comprise the following:

- A carefully crafted information and educational campaign, nationwide that the previous patterns of consumption are unsustainable and that things need to change.
- Government initiative through a comprehensive energy saving and awareness campaign in terms of which:
  - All government departments would have energy saving quotas.
  - New building regulations would be developed which were readily adopted by the building industry because of the effective communication strategy and the lead that the President had taken in this regard.
  - Legislation to prevent the private sale of national strategic assets: coal would be declared a strategic asset.

In order to help chart a course toward sustainability, Table 5 lists both unsustainable and more sustainable options for population, energy, transport, economy, agriculture and urban planning. This list is not meant to be exhaustive, but rather indicative of the directions SA society would take and avoid.

Table 5: Towards a sustainable future

NO / reduce / reduce dependence on	YES / increase
POPULATION	
• Uncontrolled growth	• Stabilise and reduce by humane methods
ENERGY	
• Coal • Natural gas • Nuclear power • Wood • Bio-ethanol • Biodiesel (using arable land or food crops) • Tidal power (when damaging estuaries) • Hydrogen produced from fossil fuels	• Solar, wind and wave power • Geothermal power (for home heating) • Biodiesel (especially from algae) • Hydrogen storage of electrical energy (including fuel cells) • Increased efficiency • 'Electranet' with smart technology to manage electricity use • Reduced distribution distances
TRANSPORT	
• Petrol & diesel-powered road vehicles • Hydrogen fuelled cars • Air travel • Coal and oil-powered railways	• Cycling • Walking • Electric rail (heavy & light) • Electric road vehicles (limited) • Home deliveries • Telecommuting

ECONOMY	
• Growth economy	• Sustainable economy
• Globalisation (of goods trade)	• Localisation (of goods trade)
• Over-specialisation	• Self-sufficiency (where possible)
• Intra-industry trade	• Labour-intensity
• Capital-intensity	• Mass production of most efficient and durable models of consumer goods
• Planned obsolescence	• Zero waste
• Linear production processes	• Circular production & consumption processes
• Throw-away products	• Reduction, re-use & recycling of materials
• Excessive packaging	• Reduced packaging
• Poverty & inequality	• More equitable distribution of income & wealth
	• Equality of opportunity

AGRICULTURE	
• Petrochemical fertilizers & pesticides	• organic & permaculture (e.g. mixed cropping)
• Fossil fuelled mechanisation	• biodiesel-powered
• Large-scale	• small-scale
• Capital intensive	• labour-intensive
• Mono-crop	• rural & urban
• Irrigation-intensive	• drip irrigated

URBAN PLANNING	
• Suburban sprawl	• Community-centred
• Low-density housing	• Mixed land-use zoning (agricultural, residential, commercial, community services)
• Energy inefficient architecture	• Suitable for cycling and walking
• Poorly insulated buildings	• Densification along existing railways
• Car-dependence	• Warehouses close to railways
	• Worker residences close to factories
	• Energy efficient, well-insulated buildings

Specific sectoral effects of the approach adopted in this scenario

Population

One of the fundamental problems underlying resource depletion, environmental degradation and climate change is the unsustainable level and growth rate of the human population. Quite what is a sustainable level of population at the global and national levels is a contentious and complex matter. Society would stabilize populations as fast as possible by humane methods. China has succeeded in reducing its

population growth rate to almost 0,5 per cent per annum, and lessons of this process would be incorporated into South Africa's population policy.

Energy

South Africans replace fossil fuels and nuclear power (which uses a non-renewable mineral – uranium – as a feedstock) with renewable energy sources: solar, gravitational (as captured in hydro and tidal power) and geothermal energy. Solar power is harnessed directly as heat or converted into electricity by photovoltaic cells which are provided in the form of solar panels to residences and commercial enterprises with government assistance. Solar power is also captured indirectly in the form of wind and wave energy, and via photosynthesis as in the production of biofuels and the state appropriately shapes the market for these products through an effective mix of penalties and incentives. Biodiesel produced from algae is one of the most promising forms of renewable liquid fuel, as it does not compete with food production and can use waste or saline water. Since solar and wind energy are intermittent sources, they need to be supported by a storage medium; hydrogen could fulfil this role to an extent. In addition to renewable energy sources, South Africans improve the efficiency of energy use through the development and usage of high efficiency electrical appliances and – when resources permit – the adoption of 'smart' technologies that optimise household and business energy usage.

Transport

The US Department of Transport records that in 2002 the average car in the US consumed 2086 litres of fuel while the average motorcycle consumed 144 litres. In other words, the average American car consumed over 14 times more than the average motorcycle. There were about 136 million registered cars and just over five million motorcycles on US roads in that year. If those car drivers used motorcycles instead, they would have saved 264.4 billion litres of fuel or 22 per cent of US oil consumption. (Ratcliffe:2007b). There is thus a strong case to be made for choosing smaller cars or even motorcycles to get around, in order to save fuel and to reduce wastage. Incentives can be found to encourage more efficient forms of transport.

A transport system based on non-renewable fuels is unsustainable. In addition, it is important to recognise that a car-based transport system has many costs beyond fuel use. These costs include the significant amount of energy and oil products that go into the manufacture of cars (Heinberg, 2003: 161) and the construction of roads. Furthermore, the use of land for roads and parking lots carries negative environmental consequences, such as their contribution to urban and global warming, habitat destruction and loss of arable land. Improving vehicle fuel efficiency standards would not address these additional costs of road transportation, and would merely delay the inevitable transition from petroleum fuels. Hydrogen-powered vehicles have similar disadvantages, and are not efficient, as hydrogen first has to be created from other energy sources. The future South African scenario would see the state penalising the use of cars in favour of more energy efficient forms of private (and public) transport.

Transnet develops a sustainable transport system powered by electricity generated from renewable resources, as well as from biofuels that do not compete with food production (e.g. biodiesel made from algae).

Given petroleum's high energy density compared with these alternatives, transport has to be scaled down and made much more energy-efficient. Cycling and walking replace cars for short journeys, particularly in urban areas. Dedicated and safe cycle routes are developed throughout all of the major cities, which also have related health benefits in urban communities. Metropolitan authorities implement and manage light electric rail systems in South African cities. The central government implements and manages heavy electric rail, essential for bulk transport and freight between cities and towns. Electric road vehicles also have a place in the transport mix, but not on anything like the scale of current internal combustion engine vehicles. Telecommuting becomes a significant way of reducing transport needs, as do home delivery services.

Economy

The South African transportation system shrinks as oil and other fossil fuels deplete, and consequently trade in physical goods and tourism becomes increasingly localised. Local communities are incentivised to aim at self-sufficiency in the first instance and to resort to longer distance trade only when necessary. Much more business is conducted via the Internet and other forms of telecommunication. State subsidies/penalties prompt the replacement or retooling of existing oil-based industries (such as automobile manufacturing) in favour of mass production of solar panels, wind turbines, hydrogen electrolysers and fuel cells, and biodiesel reactors. Additional value is created through innovation and technological development, raising the quality of goods and services over time.

Agriculture

Industrial agriculture relies heavily on fossil fuels for fertilizer and pesticide inputs as well as to power tractors and harvesters and to transport products to markets. The use of petrochemicals gradually degrades the quality of soil and pollutes rivers, lakes and oceans. This unsustainable form of agriculture is gradually replaced by organic and permaculture methods that do not rely on fossil fuel inputs. As a result of transport restrictions, agriculture becomes much more localised and small-scale, and includes urban food production. It also becomes more labour-intensive. Biodiesel is an increasingly important fuel source for operating farm machinery and transporting produce to rail links and local markets.

The agricultural sector is characterised by many unpredictable factors. Both climatic and economic factors often place severe strains on farmers who regularly live on the threshold of profitability. Dramatic changes in economic conditions as well as changing climatic conditions create enormous difficulties for farmers. The sector is also characterised by long lead times in meeting new or changed needs. New plants or trees often take several years to mature and bear fruit.

Urban (and rural) planning

City planning changes to give serious consideration to the way in which our cities are working and the dramatic impact that peak oil will have for city residents. New planning approaches enable the creation of self sustaining urban communities, where residents live, work, school their children, and

have access to medical facilities and other social services within a small range of distance. Appropriate building codes ensure that new buildings are designed to sustainable specifications and utilise natural temperature control and ventilation. Old buildings need to be retro-fitted to use less energy. Sustainable urban communities with higher densities requiring low levels of mobility and transportation, some of which have already emerged in inner city social housing projects, take root. Metropoles are divided up spatially in ways that make economic and social sense and which enable smaller scale urban living. These areas are connected by fast, efficient and reliable public transport to facilitate the movement of goods and people between them, following a significant increase in investment in new appropriate public transport infrastructure.

In practice citizens are doing much more walking and cycling to and from amenities and work related opportunities shift to the suburbs. More walking requires more security, particularly in our crime ridden country. Security problems increase as high oil prices affect employment and affordability of staple foods.

The supply of food is also re-structured. The planning model is specifically geared to prompt ways of producing food within the city and distributing it locally to reduce the dependence on food produced using highly mechanised means with the use of fertilisers and pesticides, which are fossil fuel by-products. This urban agriculture utilises unused land in creative ways – local municipalities play an important role in making public tracts of land available for this purpose through the public-private partnership (PPP) policy already in place.

One of the outcomes of the above is that many local authorities in smaller towns are acting proactively and creating incentives to attract people back to rural areas. National government actively encourages the development of new rural settlements called Eco-villages which are self-sustaining small communities. Strict guidelines need to be adhered to to qualify for Eco-village planning permission. Incentives for their creation are offered to encourage their growth. Furthermore, recycling of materials has become a national obsession and dumpsites are regarded as community assets where innovative uses are found for components of demolished buildings. Many old buildings have been converted to make them more energy efficient which has significantly reduced demand, while all new buildings have to comply with the new requirements of the new building code. The use of natural heating and lighting has effected significant energy savings. There are regular national “Invent” competitions that encourage local innovations.

South Africa is also making good strides with the implementation of its revolutionary, locally designed solar panels that have taken many homes and buildings off the electricity grid. Massive savings in electricity have reduced the need to build new power stations and saved the country billions of rand in capital costs. This money is used in building a world class public transport infrastructure. In addition, less coal is used, saving this strategic resource for future use. Most new housing schemes install the solar panels and homeowners significantly reduce their electricity bills. However, production does not keep pace with demand and second-hand systems fetch a high price in the market.

It is vital that our city leaders begin to embrace this inevitability.

Leadership by our city officials is necessary and needs to come through actions that are taken as example. This will be a demonstration that they mean what they say and are prepared to walk their talk. The bottom line is that we need to plan for a significant reduction in oil use and the consequences that flow from this even if we have to throw some of our current comforts out in the process.

Visionary leadership

In this scenario we assume that it is widely understood that a comprehensive set of mitigation actions are required to prepare the country for a future with less oil. It is assumed that there have been no major technological breakthroughs regarding liquid fuels and that we have defined a course which embraces energy efficiency, energy independence and sustainable living through the widespread adoption of the use of renewable energy sources and energy savings. The nation has been on an almost war footing for the past 12 years. This has required the support and cooperation of all sectors of society including government, business and civil society. It required visionary leadership from national government and the Presidency in particular. The Presidency and national government required strategic positioning to enable the formulation of effective plans that cascade to the local tier of government. This 'sustainability revolution' has been compared in scale and scope to an industrial revolution, but is happening much, much faster.

Global demand for oil continues to outstrip supply and nations compete for this resource in more and more hostile ways. Oil well technologies have ensured that the rate of extraction is able to increase even though the number of oil fields passing their peak continues to rise. This creates the conditions for very rapid decline in the fields where it has been utilised. Strategically, South Africa targets its energy usage on an anticipated depletion rate of 8 per cent per year.

Through a carefully crafted information and educational campaign, nationwide there is a growing awareness amongst people that the previous patterns of consumption are unsustainable and that things need to change. The government has taken the lead and has been at the forefront of a comprehensive energy saving and awareness campaign. All government departments were given energy saving quotas. New building regulations were developed which were readily adopted by the building industry because of the effective communication strategy and the lead that the President had taken in this regard. Through the efforts of the President there is buy-in from all sectors towards this national effort that has put energy independence at the heart of government policy. A national campaign to create energy efficiencies has encouraged innovation and new industries have emerged. Legislation has been passed which prevents the private sale of national strategic assets. Coal is declared a strategic asset. The proactive stance that South Africa took has positioned it among the leading countries in the world with regard to energy independence and efficiencies. Our locally developed technologies are sought after globally and our approach to sustainability is emulated widely. Our experts are in constant demand.

Energy clusters have been established to leverage sustainable energy resources that are in abundance in certain regions. These regions have been encouraged to "export" superfluous energy to neighbouring regions, thus creating a situation of internal trade that stimulates growth

in the energy industry.

Our cities followed the lead taken by other visionary cities worldwide. Through their association, a national campaign to re-localise has been at the heart of local government strategy.

Many local authorities in smaller towns are acting proactively and are creating incentives to attract people back to rural areas. In the cities, a comprehensive strategy has been adopted to incentivise urban agriculture and to restructure neighbourhoods bringing people closer to their work and to reduce journey times. Dedicated and safe cycle routes have been created throughout all of the major cities which has also had health related benefits in urban communities. Energy demand has fallen significantly as people travel less. Public transport development has become a national priority and new routes connecting integrated communities continue to be built. The rail network, now links directly to sources of hydroelectric power, and has been upgraded and become a very attractive means of transport. South Africa has, with Portugal, upgraded the Cabora Bassa dam back to full capacity.

Section 5

Risk Identification, Assessment and Management

Under the Renaissance Scenario there is a list of practices that we have identified for the various tiers of government. What are the risks that these necessary practices would either not be implemented or if implemented be implemented too late with too low an impact? In order to answer this question we do a preliminary risk analysis on these actions, assess the likely impact of the risks on the successful completion of the actions and identify what should be done to manage these risks to ensure maximum impact of the action items (see Appendix D for a detailed Risk Assessment Table).

Actions required under Renaissance Scenario

The various tiers of government would have to initiate the following actions in order for South Africa to start moving towards a sustainable development path:

National Government

- Implement a Sustainable Development Strategy (initiated and driven through the Presidency).
- Pursue the above strategy globally through multi-lateral forums, to mitigate the impact of peak oil, climate change and financial adjustments on Africa.
- Require every government department to undertake energy efficiency and carbon footprint audits and set targets for their reduction.
- Regulate the price of liquid fuels sold domestically by Sasol so as to mitigate the impact of sudden crude oil price spikes and volatility on South African consumers. Alternatively, consider the construction of a new government owned Sasol plant built using clean coal technology. Being government owned it would be able to provide fuel to the market at less than import parity prices resulting in a cushion for consumers.
- Implement a national population control plan.
- Formulate and implement national regulations to enforce energy efficient housing and a national planning guideline to enable local authorities to secure food production on municipal land through public-private-partnerships (PPPs).
- Redirect Safcol to implement and manage a national reforestation programme.
- Formulate and implement national waste disposal regulations to enforce waste sorting (starting with households) and recycling at a local level.
- Promote clean industries through incentives, subsidies and tax breaks.
- Formulate and implement a national transportation plan to enable and subsidise an effective integrated public transport system, dis-incentivise the use of forms of transport reliant on non-renewable fuel and incentivise energy efficient alternative modes of transportation (like cycling).
- Reduce the extent of national debt through regulating local financial

and home loan markets primarily through greater capital adequacy and homeloan borrower equity requirements.

- Initiate research into the establishment of energy clusters and facilitate the expansion of local industry that may be supported by regional energy sources.

Provincial Government

- Transform the provincial Growth Development Strategies (GDSs) into Steady State Development Strategies (SSDSs) and implement these strategies in partnership with cluster drivers and champions and the emerging sector.
- Support for energy clusters identified by central government through creating disincentives for organisations that do not make use of locally produced sources of energy

Local Government

- Design and implement energy efficient local transport systems (such as cycle paths, electric trams, etc.).
- Design and implement waste recycling systems and land-fill gas capture systems in line with national regulations.
- Ensure the delivery of energy efficient housing in line with national regulations.
- Design and implement water efficient irrigation systems for both residential and commercial agricultural sectors at a local level.
- Set aside land as municipal commonage for food production and sponsor PPPs to implement and manage.

Risks undermining the Required Actions

The following significant risks have been identified at the various tiers of government that could severely constrain or undermine these plans:

National Government

- The national government, and also the ANC and the tri-partite alliance are split with political and ideological differences (i.e. between neo-liberal laissez faire and socialist economic approaches) that paralyses any attempt to remake GEAR, and introduce specific interventions for: a sustainable development strategy; energy efficient regulation of housing, development and transportation; food security; and financial regulation.
- Elements in the business sector intersect with elements in the state to block certain policies seen as antithetical to their interests.
- Government is unable to form sufficient alliances both with African states and other global players.
- The ideology of privatisation/commercialisation, with respect to Safcol and Sasol, persists and wins out.
- Citizens fail to get the message and heed the imperative to have smaller families.

The impact of each of these risks on the government's sustainable

development strategy as well as on the fiscus itself varies from significant to less significant. However, the combined impact of all the risks referred to has a serious effect on the government's ability to rule and to collect taxes, and undermines its legitimacy in terms not only of the sustainable development strategy but also of its role as enforcer of law, order and justice.

Provincial Government

- External economic and external and internal political resistance undermines the provincial governments from changing their Growth Development Strategies (GDSs) into Steady State Development Strategies (SSDS).

The impact of this risk is to undermine the Presidency's Vision of Sustainable Development because currently provincial GDSs are closely linked to local economic development and broad-based black economic empowerment (BBBEE).

Local Government

Many municipalities are unable to complete the policy, design and planning of the local transportation systems (such as cycle paths, electric trams, etc), and the associated business plans in a Local Economic Development context.

Many municipalities are unable to complete the policy, design and planning of the waste recycling systems and land fill gas and capture systems, and the associated business plans in a Local Economic Development context.

The National Home Builders Registration Council (NHBRC) as well as many municipalities are unable to enforce the new energy efficient housing (including requirements for rooftop solar panels) regulations, in respect of new structures as well as retro-fitting existing structures.

Many municipalities are unable to get buy-in from domestic and commercial property owners to commit to an efficient water usage system.

Many municipalities are unable to make available sufficient commonage for food security, and on whatever land it has made available, to manage the growing and distribution of vegetables and fruits at an affordable price by BBBEE entities.

The risks with the greatest impact on the local governments, as well as on the overall sustainable development strategy are the municipalities' inability to implement the efficient usage of water and to provide for food security (as envisaged above). The critical impact of these risks relates to food and water being basic necessities and to the likelihood of intense social conflict erupting at the local level around these resources, and undermining the efficacy and legitimacy of many local governments.

Risk Management

The other risks although not as critical in their impact individually, could have a critical combined impact on both the legitimacy and the financial sustainability of local government.

To reduce the potential impacts of all these risks the various tiers of government need to modify them. It may be convenient to think of

three different types of "modification" responses: (i) corrective – a response that corrects a risk that has already started to be realised; (ii) preventative – action to prevent the most damaging aspects of the risk arising; (iii) detection – systems that will highlight when something has gone wrong.

The following are the types of modification actions that the various tiers of government will have to undertake in order to ensure that the Presidency's sustainable development strategy is formulated and implemented as soon and as effectively as possible:

National Government

The Presidency plays a key role in initiating discussion with governmental and extra-governmental stakeholders (where necessary) and making the necessary regulatory and legislative changes (where this can be driven through cabinet consensus) to achieve:

- Buy-in from all significant internal and external (to government) stakeholders of a national sustainable development strategy (Vision, Mission, Values, Objectives and Goals);
- The objective of facilitating multi-lateral global agreements to mitigate the impact of peak oil, climate change and financial adjustment, particularly on Africa;
- A consensus within government to: re-regulate the price of fuels sold by Sasol; alternatively, to consider the construction of a new, government-owned Sasol plant built using clean coal technology.
- A strategy within government to re-position Safcol, the state forestry company, to achieve reforestation as an integral part of the sustainable development strategy, rather than its current focus on commercialisation;
- In consultation with critical stakeholders (particular the religious institutions and leadership) a strategy to reduce the national population growth rate according to set targets;
- Amendments to the national building regulations to make energy efficient housing mandatory, and a national transport plan that makes energy-effficient local transport systems (including bicycle lane systems) mandatory in local municipal areas;
- In conjunction with the Ministry of Finance and the Reserve Bank consultation with the financial sector to change financial regulation to ensure greater capital adequacy and higher levels of borrower equity in banks home loan books.

Provincial Government

The Presidency drives a strategy of Steady State Development through first winning over provincial Premiers, and second identifying and winning over business champions (from the formal sector) of competitive industrial clusters within each province and region. These cluster drivers assist the state to shape and implement a strategy that focuses on local economic development (LED) (i.e. drawing in emerging local entrerprises) based on renewable resources (the utilisation of which is incentivised by the state through subsidies, tax breaks etc.) and regional competitive advantage.

Local Government

The executive mayors' offices play a critical role in initiating and ensuring that the actions required of the local municipalities are in fact implemented, to achieve:

- The design and plan of the bicycle system, the physical spaces in the town that need to be served by the system, the municipal officials responsible for ensuring plan completion, a budgeted amount to cover ex-house planning services (if required) and deadline dates for both intermediate deliverables and the completion of the overall system;
- (1) The commission and the design of a system for the management of the sorting of waste (funded by the Presidency)
- (2) A monitoring system that has defined a specific plan to be completed by the municipality's waste management department, namely:

The collection of different types of waste separately through the provision of feeder bins for the various types of waste proximate to residential areas;

The collection and storage of these waste types at a central depot; the outsourcing of the recycling of the waste artefacts to empowerment companies;

- The projection of the future supply and cost of water to residential and commercial properties, and the introduction of water saving techniques and water efficient irrigation systems;
- The incorporation of municipal commonage for local food (vegetables, fruit) production, on a managed outsourced basis to BBBEE entities, either on existing municipal-owned land on new purchases. This is incorporated into a revised Integrated Development Plan (IDP).

The NHBRC has included energy efficiency requirements of the new revised National Building Regulations (NBR, revised in terms of government's energy efficient policies) in its criteria for enrolment of housing. The municipality has sent its building inspectors on a refresher course of the NBR, and has also advertised for more inspectors. In the interim both the NHBRC as well as the municipality have augmented their inspectorate through outsourcing. Outsourcing is however only an interim measure.

Section 6

Conclusions

Peak oil, climate change and global financial imbalances are arguably three of the most critical challenges confronting the world and South Africa. The impacts will likely be wide-ranging and deep, affecting all sectors of society. Poorer members of society will suffer disproportionately as they are the most vulnerable to crises. Given the complexity of the issues and their interconnections, an integrated response strategy is essential if South Africa is to mitigate the negative impacts and exploit new opportunities.

The longer that mitigating interventions are postponed, the more costly they will be in the long run, both in direct terms (for example as a result of rising energy and energy-related prices) and indirectly in terms of the economic and social dislocation that could have been avoided. What is required in particular is a massive programme of education and investment into renewable energy and sustainable transport infrastructure on a scale – and with the urgency – of a war-time effort.

Viewed in the broader historical context of the rise and fall of civilisations, humanity is arguably at a turning point. Either industrial societies will begin a cascading fragmentation towards diminished complexity, or they will make a transition to a sustainable, post-fossil fuel socio-economic model on a scale commensurate with available sources and sinks in the biosphere. Either way, we are likely to experience a period of wrenching transition that will require an unprecedented level of national and international cooperation, as well as the understanding and involement of government, business and civil society.

Arising from this study,we can therefore conclude the following:

1. It is by understanding exponential mathematics that we can comprehend how it is that even at modest rates of growth enormous quantities are generated in short spaces of time. When applied to non-renewable resources on a global scale at current rates of growth, it raises cause for serious concern with respect to our current growth models, particularly in relation to resources such as oil, which are required to fuel growth, and on which industrial societies have become increasingly dependent.
2. Oil is a finite non-renewable resource which has a bell-shaped life-cycle curve. This is empirically verifiable. This implies that once the peak is reached further growth in production is impossible. All indications are that during the course of the next few years we will reach the global peak. Thereafter, oil production will decline raising questions as to whether growth can be sustained.
3. In the light of the serious consequences which are likely to result from an energy constrained world, we believe timely mitigating actions are required in order to ensure an orderly transition to a more sustainable way of living.
4. South Africa and the world have not faced challenges on this scale and with ramifications as far reaching as we face in the near future from the combined effects of oil depletion, climate change and the unsustainable global financial imbalances.
5. We can choose the developmental path we want to take into the future. The choices we make now will affect future generations. It seems prudent to choose a path that will lead us to long term

energy sustainability.

6. The longer mitigation is delayed, the fewer the options we have and the more costly and more drastic mitigating and adaptive actions are likely to become. We cannot afford to wait for the oil production peak to occur before taking mitigating actions because we may not be able to fund the actions we need to take given the likelihood of a sustained global economic slump.

7. Investing now in mitigation is a sound risk management strategy.

8. In this light we suggest that South Africa needs now to invest in energy saving measures and the production of renewable sources of energy. To delay investment will come at a very high price once oil supply has peaked, because of the impact it will have on the world and South African economies. We would argue that there is no net advantage in delaying a mitigation strategy.

9. Conservation of our energy through energy saving measures is one of the greatest means we have readily at our disposal to preserve our energy reserves for future generations. Some measures to reduce energy wastage can be effected relatively easily and relatively quickly. For example, reducing the speed limit produces immediate savings which will not only save energy; it will also reduce our current account expenditure and our CO2 emissions.

10. Any serious attempt to adopt mitigation actions to prepare us for the post peak oil world must be led from the top. In order to gain the widespread buy-in required to reduce our oil dependence from all sections of our society will require leadership by example. All senior government members and officials will need to be seen to be reducing their energy dependence.

11. All government departments will need to have targets for reducing their energy, mechanisms for reporting their progress and external auditing of their efforts.

12. Precedent exists in developing strategies for the post peak oil world. A number of countries and cities around the world are effecting policies to reduce their oil dependence and to manage the likely effects of declining oil supplies. For example, the US city of Portland, in the state of Oregon, has a two pronged strategy: one to reduce energy usages and utilise renewables and the second to manage the social changes that are likely to occur.

13. The poor are likely to be the most adversely affected by the effects of peak oil which will pose an ongoing challenge for government. Given that South Africa has a large proportion of its population in poverty, measures to retain social stability will need to be sought.

14. Mitigating efforts on the scale required will require buy-in from all sectors of society. In order to achieve this, an extensive educational programme will be required.

15. Methods of food production are likely to change dramatically as a consequence of oil peaking and as a consequence of climate change. Ensuring our food security will pose a major challenge as commercial farmers have to cope with high input costs and less fuel as well as the effects of global warming which will change their environmental conditions. For those commercial farmers that live

on the threshold of profitability it may mean that they are sent into bankruptcy. A safety net will need to be constructed to ensure that they are able to continue to produce and distribute their produce. It is worth noting that finding new crops to deal with changed market or environmental conditions takes time. Some crops often require four or five years to reach maturity and bear fruit.

16. A major effect of oil depletion will be the impact on the transportation sector and with it the costs of most products. This will change our current globalised commercial relationships and make them much more local. Ironically, relative to other countries, South Africa has an advantage, as a result of the diversified nature of our economy which was brought about during the years of isolation during apartheid. As far as possible we should aim to be self-sufficient. Greater incentives to produce and buy locally are necessary.

17. Our reliance on individual means of transport will have an impact on people's mobility. It is imperative that we invest heavily in good, reliable and fast public transportation. The longer this is delayed the more difficult it will be to fund.

18. Our cities will need spatial restructuring to enable people to work, school the children and access social services in close proximity to where they live.

19. Climate change is real and poses a huge global challenge with very little time left to prevent irreversible global warming. The recent IPCC report indicates that there are eight years left before we cross the 400 CO2 parts per million threshold, which it is believed will take us into a highly risky period where runaway global warming is a possibility. A worldwide effort is required and any new environmental accord could take up to four years to agree and have ratified. This leaves a very small window to effect change which would imply that the required measures will be dramatic.

20. Many of the efforts to mitigate the effects of peaking oil supplies are the same as those that will impact the climate change. However, some measures to mitigate peak oil, such as coal-to-liquid fuels, could exacerbate global warming.

21. All mitigating measures taken to save energy must be consistant with measures to reduce C02 emmissions and thus our overall carbon foot print.

22. Not only are major changes likely to become part of a new global energy regime, but a major economic adjustment is likely arising from the unsustainable financial imbalances currently prevalent in our global trading system. It is not possible to predict the extent and depth of such an adjustment; suffice to say that it would be prudent to have an emergency contingency plan.

23. South Africa will be affected by these adjustments and will need to manage the fallout. Capital inflows expose us to the risk of capital flight when emerging markets are perceived to be too risky for the large fund managers.

24. A new global energy regime will bring with it opportunities and South Africa is well placed to benefit from them. South Africa could become a world leader because:

a. It has come through a difficult political transition and is thus a world leader in conflict resolution.

b. It has well developed institutions for creating social consensus.

c. It has a history of making pragmatic choices in the face of great challenges.

d. It has enlightened leadership.

e. It has a deeply rooted culture of Ubuntu which is able to create social cohesion.

f. It has a history of environmental innovation.

g. It has a diversified economy and a diverse resource base.

h. It has abundant sunlight and opportunities for wind and tidal power.

With these characteristics, South Africa could become:

i. A manufacturer of renewable energy products

j. A developer of environmental benchmarks

k. A developer of methods to reduce waste

l. Manager of the conflicts that are likely to arise as a result of declining oil supplies

25. Different countries have different oil price thresholds that their economies can bear. Most, if not all of the countries south of the Sahara are not likely to be able to bear continually rising oil prices for long. Collapsed economies are likely to generate economic migrants. South Africa has a higher threshold than many of its neighbours. Any collapsed economy in the southern African region could result in large numbers of economic refugees. This is already the case as a result of Zimbabwe's economic problems.

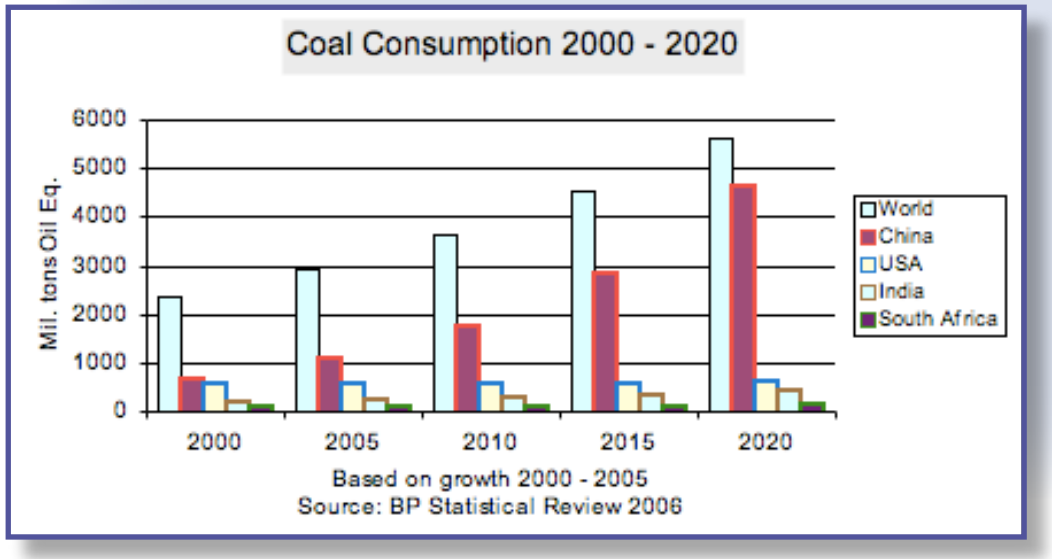
26. From a risk perspective, the risk of delaying taking mitigation actions far outweighs the risks of taking timely actions now.

Appendix A

Historical and projected consumption of key resources

Coal Consumption (Mil tons Oil Equivalent)

#	Country	1980	1990	2000	2005	% Growth last 5 years	Projection based on last 5 year's growth 2010	2015	2020
	World	1801	2234	2361	2930	24	3636	4512	5599
1	China	305	530	667	1082	62	1754	2843	4609
2	USA	386	484	569	575	1	582	588	595
3	India	57	108	169	213	26	268	337	425
6	South Africa	44	71	82	92	12	103	116	130

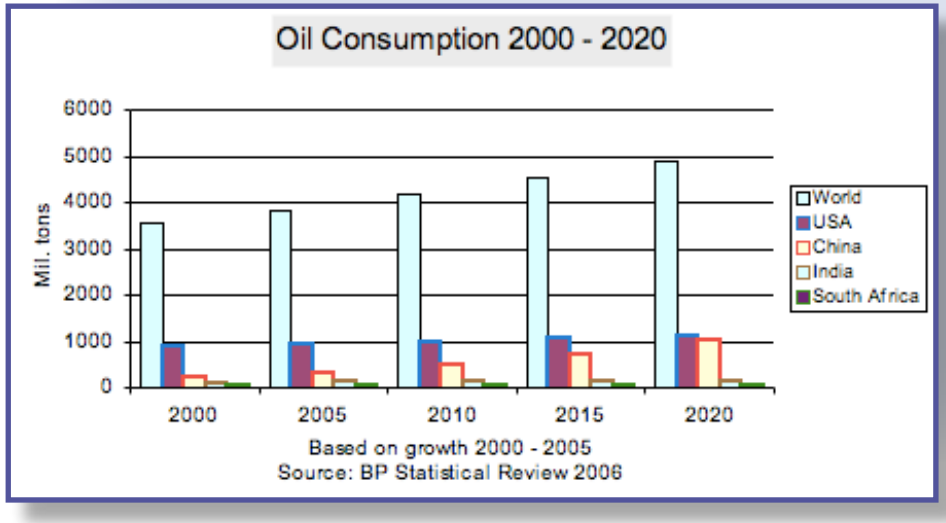


Source: BP Statistical Review, 2006

Note: These extrapolations are intended to illustrate the power of exponential growth and are not to be considered as realistic projections as growth will be constrained by the finiteness of energy and resources

Oil Consumption (Mil Tons)

#	Country	1980	1990	2000	2005	% Growth last 5 years	Projection based on last 5 year's growth 2010	2015	2020
	World	2972	3145	3537	3837	8	4162	4514	4897
1	USA	794	782	898	945	5	994	1046	1101
2	China	85	113	224	327	46	479	701	1027
6	India	32	58	106	116	9	126	138	150
27	South Africa	12	17	23	25	11	28	30	34

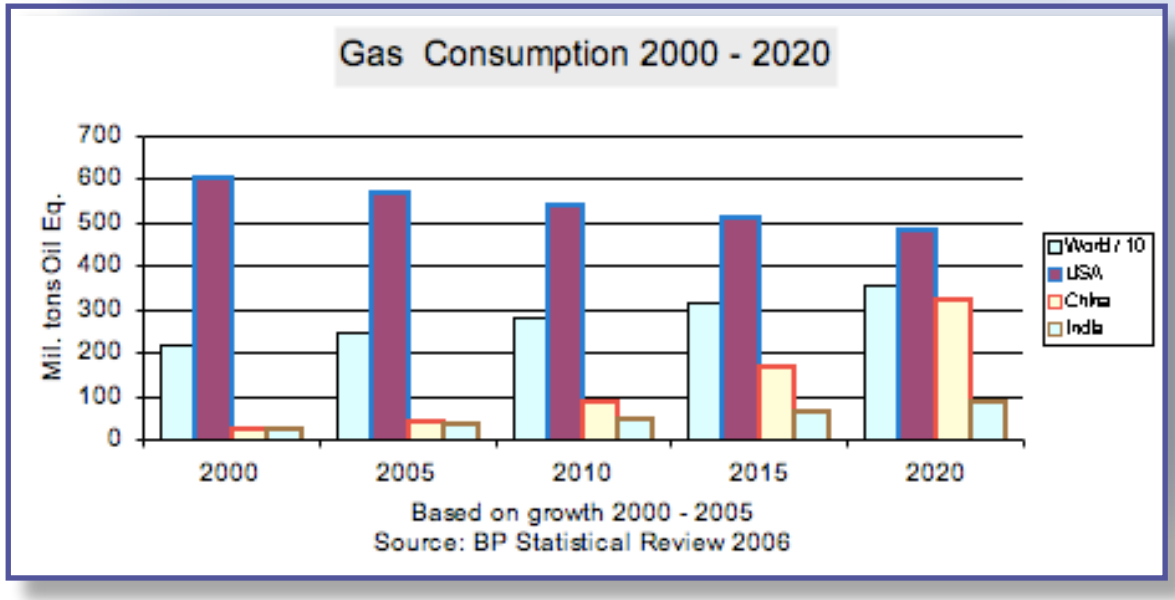


Source: BP Statistical Review, 2006

Note: These extrapolations are intended to illustrate the power of exponential growth and are not to be considered as realistic projections as growth will be constrained by the finiteness of energy and resources

Gas Consumption (Mil tons Oil Equiv.)

#	Country	1980	1990	2000	2005	% Growth last 5 years	Projection based on last 5 year's growth 2010	2015	2020
	World	1307	1794	2192	2475	13	2794	3154	3561
1	USA	517	467	603	570	-5	539	510	483
12	China	13	14	22	42	97	83	164	322
19	India	1	11	24	33	36	45	61	84

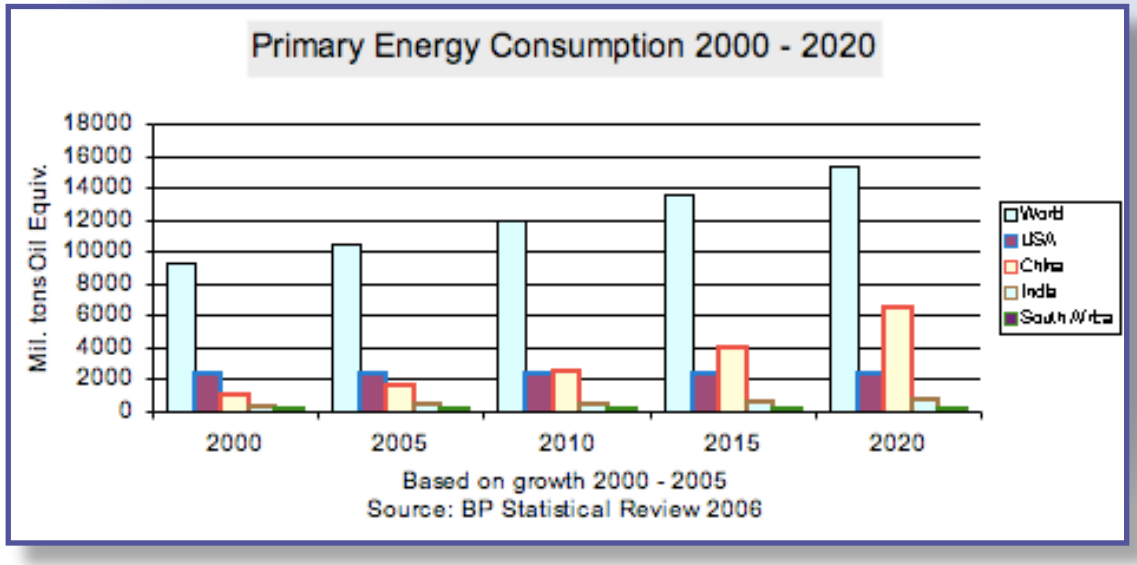


Source: BP Statistical Review, 2006

Note: These extrapolations are intended to illustrate the power of exponential growth and are not to be considered as realistic projections as growth will be constrained by the finiteness of energy and resources

Primary Energy Consumption (Mil Tons Oil Equivalent)

Country	1980	1990	2000	2005	% Growth last 5 years	Projection based on last 5 year's growth 2010	2015	2020
World	6629	8120	9285	10537	13	11958	13571	15401
USA	1813	1967	2312	2337	1	2361	2387	2412
China	416	685	967	1554	61	2498	4016	6455
India	103	193	320	387	21	468	566	684
South Africa	52	91	108	121	11	134	149	166

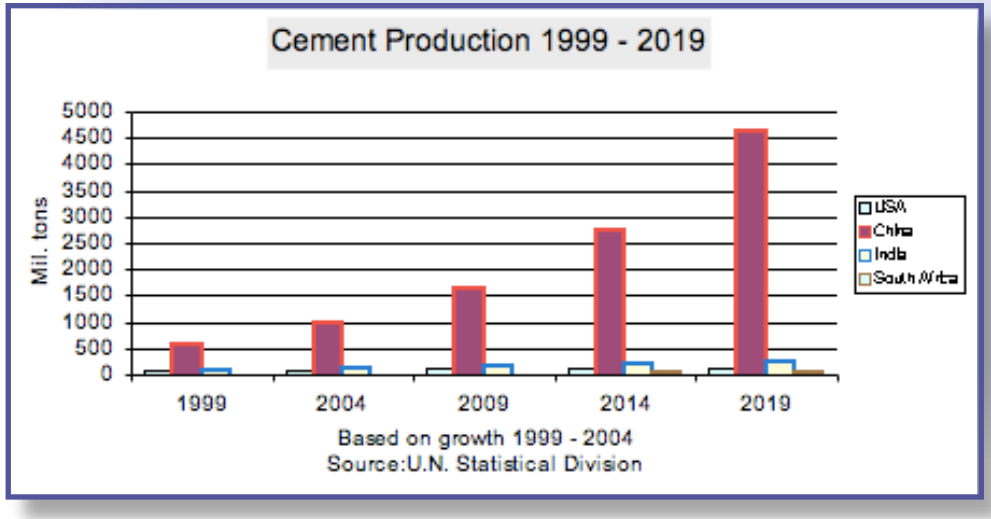


Source: BP Statistical Review, 2006

Note: These extrapolations are intended to illustrate the power of exponential growth and are not to be considered as realistic projections as growth will be constrained by the finiteness of energy and resources

Cement Production (Mil metric tons)

Country	1995	1999	2004	% Growth last 5 years	Projection based on last 5 year's growth 2009	2014	2019
World	No Data						
USA	77	86	97	13	110	125	142
China	476	573	967	69	1631	2752	4644
India	68	100	125	25	156	195	244
South Africa	7	8	12	50	18	28	42

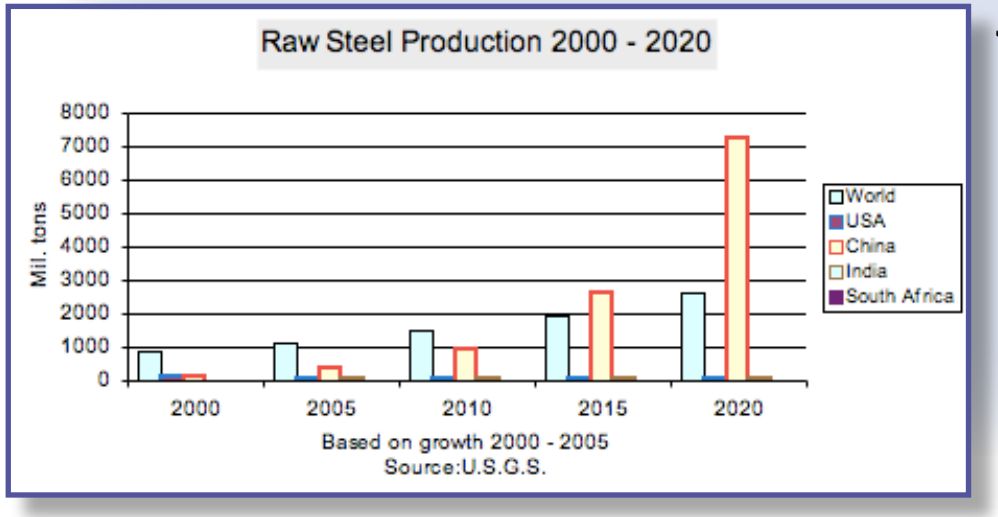


Source: U.N. Statistical Division

Note: These extrapolations are intended to illustrate the power of exponential growth and are not to be considered as realistic projections as growth will be constrained by the finiteness of energy and resources

Raw Steel Production (Mil metric tons)

Country	1995	2000	2005	% Growth last 5 years	2010	Projection based on last 5 year's growth 2015	2020
World	752	846	1120	32		1483	1963	2599
USA	95	102	93	-9		85	78	71
China	93	127	349	175		960	2636	7242
India	20	27	34	26		43	54	69
South Africa	9	7	10	36		13	17	24



Source: U.S.G.S.

Note: These extrapolations are intended to illustrate the power of exponential growth and are not to be considered as realistic projections as growth will be constrained by the finiteness of energy and resources

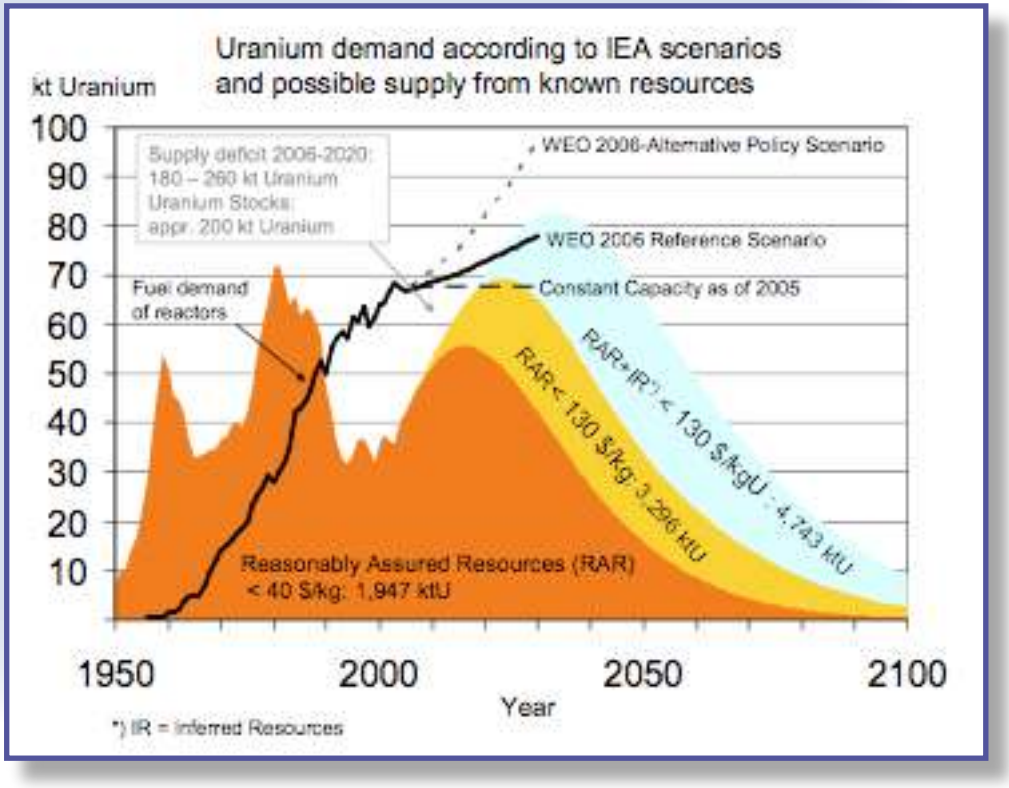
Global uranium production and demand

Appendix B

The figure alongside from the Energy Watch Group (2006: 5) shows "past and projected uranium production. Forecasts are based on reasonably assured resources below 40 $/kgU (orange area) and additionally including inferred resources. The black line shows the fuel demand of reactors currently operating together with the latest scenarios in the World Energy Outlook (WEO2006) of the International Energy Agency."

The EWG (2006: 6) concludes that "in the short term, until about 2015, the long lead times of new and the decommissioning of aging reactors perform the barrier for fast extension [of nuclear energy capacity], and after about 2020 severe uranium supply shortages become likely which, again will limit the extension of nuclear energy."

Source: Energy Watch Group (2006)



Appendix C

Government and city led peak oil mitigation initiatives around the world

Country initiatives			
Country	**Aim of initiative**	**Components**	**Documents**
Sweden	To be oil independent by 2020	• Tax relief for conversion from oil • More renewable energy • Measures for renewable fuels • Research and new knowledge for a renewable society • Continued investment in district heating	
Ireland	To plan for the time when Ireland's oil supply is compromised	• A National Strategy • Energy Policy Management • A Common European Approach • Transport • Electricity • Security of Supply • Enterprise Policy • Energy Efficiency • Telecommunications • Technology Development • Environmental Obligations	"A Baseline Assessment of Ireland's Oil Dependence: Key Policy Considerations"
Venezuela	Build regional alliances	• Bilateral treaties with other South American countries • Nationalisation of the oil industry	
USA	Secure oil supplies	• Invasion of Iraq • Positioning of US military bases in Central Asia • Establishment of Africa Command • Development of ethanol	

City initiatives			
City	**Aim of intiative**	**Elements**	**Documents**
Portland	Mitigate the effects of oil depletion by planning for a sustainable future	• Strategy to reduce energy consumption and oil dependence • Strategy to ensure social cohension in the likelihood of social collapse	"Descending the Oil Peak: Navigating the Transition from Oil and Natural Gas"
San Fransisco	To plan for sustainable development in the light of oil depletion	• Legislation enabling a Peak Oil task force will soon be introduced to the full Board by Supervisor Mirkarimi, and the task force will be charged with making recommendations on how the city might work to mitigate the potential devastating effects that could result from Peak Oil.	Resolution on Peak oil
New York	To create a plan for the city to achieve energy independence. Intended for city to adopt shortly.	• Preparing for fuel volatility • Making Transportation More Efficient • Energy efficient buildings • Electricity	"Moving New York City toward Energy Independence"
Paris	Reduce city congestion and provide an energy efficient means of public transportation	• Publicly available bicycles for use by the population which are available all over the city and can be deposited at local nodes.	

Transition towns in the UK	To become energy self sufficient	The first town in the UK to embrace a future without the oil was Totnes in Devon in September 2006 and since then others, including Falmouth and Stroud, have joined it. However, it is not just traditional rural towns that are keen to embrace this do-it-yourself movement. Forest Row in Sussex has become the first transition village and Bristol and London's Brixton district are taking the idea to cities.	
Cities in Australia	To map the major Australian cities to identify communities which are vulnerable to high fuel prices and increases in interest rates.	All the major Australian cities have been mapped to identify vulnerable communities likely to be impacted by disruption to their mobility as a result of high oil prices.	"Shocking the Suburbs- Urban Location, Housing Debt and Oil Vulnerability in the Australian City."

Appendix D

Risk management: using the risk map table

Risk tables are contained in a separate Excel file

Introduction: getting started

Key points about risk management

Risk management is:

a) Integral to managing the performance of the sustainable development strategy.

(b) Thinking through the consequences of an action or inaction in terms of achieving the goals of the sustainable development strategy.

(c) How a series of actions or inactions may damage the sustainable development strategy as a whole.

Risk map input sheet

Risk identification

Risk number

Sequential number as shown or manual input, used for reference only.

Date risk identified

In date format xx/xx/xxxx and is used as a reference only.

Level of risk

Numerical value (whole number) in range 1 to 5. The level of risk describes the importance of the risk in context of the sustainable development strategy.

Level 1 risks are the significant risks that affect the strategy as a whole.

Level 5 risks are those risks that affect say a project, a particular team or department or government tier.

Internal or external risk

Enter I or E in upper case only.

I = internal risk - those risks that are generated or largely generated/ influenced by events from within the various tiers of government

E = external risk - those risks that largely originate from outside of the government.

Risk category

This describes the general headings of risk that could be applied to risks maps in respect of the sustainable development strategy.

Code - "Resources" - Other resources - inadequate systems, processes and staff capacity to deliver objectives.

Code - "Political" - Political and reputation - relationship with key stakeholders and impact of all other risk categories on own reputation.

Risk name

This is a short name to identify the risk - short hand for use when describing the risk.

Definition of risk

Describes the nature of the risk, what would happen to the strategy when the risk materialises.

Impact of the risk on the business plan

Describes the impact of the risk on the sustainable development strategy as well as on the tier of government.

Risk assessment

Life of risk

Numerical value (whole number) in range 1 to 3 where

1 = short term - one that likely to expire within one year.

2 = medium term - one that will last up to three years

3 = longer term - one lasting over three years

This is useful when combined with the internal/ xternal risk measure.

Likelihood of risk happening

Numerical value (whole number) in range 1 to 10 where 1 is a remote possibility and 10 is an (almost) absolute certainty that the risk will materialise.

Generally speaking, the longer the plan the more likely it is that a risk will materialise. However short term internal risks may be more likely in the short term than over the longer term.

For certain types of risk, it is possible to obtain statistical data to support the decision.

Impact of risk

Numerical value (whole number) in range 1 to 10 where 1 is very minimal impact on the SHI's overall business plan and 10 where the impact of a risk would be severe - possibly a "fatal" event.

Risk score

The simple multiplication of the likelihood of the risk occurring x the impact of the risk on the strategy. The higher the combined score, the higher overall risk rating on the strategy.

The risks with the highest overall ratings will be the priority risks to be addressed. Risks have been categorised into the following bands:-

Band 1 - critical risks [shaded red] - those where there is a risk score in excess of 61.

Band 2 - high risks [shaded orange] - where the combined risk score is more than 31 but less than 61.

Band 3 - medium risks [shaded yellow] - where the combined risk score is more than 16 but less than 31.

Band 4 - low risk [no shading] - low level risks that are periodically reviewed.

Risk response

Risk response category

It is generally accepted that there are four alternative responses to a risk - to either accept, eliminate, modify or transfer the risk.

The four alternative responses are interpreted as follows:-

Code-"Accept" the Presidency chooses to accept the risk, either because it presents an opportunity, is integral to the strategy or that there is no alternative but to accept the risk.

Code-"Eliminate" the Presidency chooses to end the impact of the risk on the strategy.

Code-"Transfer" the Presidency chooses to wholly or partially transfer the impact of the risk on the strategy.

Code-"Modify" the Presidency chooses to make alterations to reduce the potential impact of the risk on the strategy. Three different types of modification responses (a) corrective (b) preventative (c) detection

Risk response: how is the risk managed, what action is being taken?

This is a brief description of the action being/ to be taken to manage the risk identified.

Controls: what information gives an early warning of the risk?

Theoretical risk management would describe "controls" as being a subsidiary set of actions to only those risks that can be modified.

Accountability: who is managing the risk?

It is normal to identify the person who is accountable for managing the response to the risk.

Link with the strategic plan: sensitivity on the fiscus

Some of the risks will be operational in nature, having only a remote impact on the fiscus. The majority of the risks will impact on the fiscus.

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