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1. Introduction

The democratic transition that began in South Africa in the early 1990s was accompanied by policies that sought to reconfigure the relationships between the environment, the economy and society. As a signal of new intent South Africa's policy makers drew eclectically on international best practice to craft the celebrated National Water Act (NWA) (1998), the National Environmental Management Act (2008), the White Paper on Energy (1998) and hastily signed United Nation's conventions to fight desertification (UNCCD), biodiversity loss (UNCBD), atmospheric pollution (Montreal Protocol), wetland destruction (Ramsar Convention) and climate change (UNFCCC). Implicit in these policies and the adoption of conventions was an acknowledgement that the environment was finite; something more than an abstract place visited by affluent white people. The policies acknowledged the scarce and valuable nature of environmental resources such as water, clean air biodiversity and heritage and equated access to these resources with human rights – a move that resonated easily with the public discourse of the time. Promoting sustainable and more equal access to environmental goods and services was to become an important component of the democratic and economic transition.

Until recently the institutional and leadership follow-through required to affect the social and economic changes embodied in these policies and conventions was absent. Vested interests in the coal-fired electricity lobby prevailed over energy decisions, the NWA (1998) had lost momentum and respective State of the Environment reports tracked increasing degradation especially in and around cities. More than ever the environment was seen as a "luxury good" (Martinez-Alier, 1995) to be conserved when, and only when, other social and economic needs had been met. In 2010, however, motivated by the need for structural reform of the South African economy (and particularly a more labour intensive industrial development trajectory) and rising global advocacy on climate change, the "green economy" entered the country's policy discourse, most notably in the State of Nation Address (Presidency, February 2010).

As with preceding notions of economic opportunity such as "industrial conglomeration", "local economic development" and the "digital economy", the "green economy" runs the risk of becoming a fad, especially if viewed as something distinct from conventional economic theory. If South Africa is going to make good on the opportunities in the green economy, a clear understanding of the nature of these opportunities and the transitions required to realise them will have to become common-place within the country's civil service.

This paper maps developments in the (1) energy, (2) climate change adaptation and (3) water sectors that have the potential to benefit the South African economic development process. Whilst the risks associated with environmental disasters form part of the analysis, the emphasis is on the concepts and emerging opportunities that could benefit South Africa's development cause. The underlying assumption is that economic growth is necessary and important; not only is this growth compatible with environmental considerations, but in South Africa's case it is inextricably dependent on such considerations.

2. Economics and the environment

Key Findings	**Research items**
Green economics is good economics, in which market failures are addressed. Green economics views the economy, society and the environment as inter-dependant components of the same system. Green economics returns economic principle to macro-economic planning Where the South African economy ignores the environment it has developed structural barriers to growth and employment. The green economy has the potential to meet South Africa's transformation and employment needs. Innovation is central to the green economy. Successful green economy will retain competitive advantage and develop new competitiveness. The green economy addresses perverse incentives to degrade the environment. Alleviating poverty in the face of environmental degradation is difficult and expensive.	Calculate the value of environmental goods and services in South Africa. Include environmental influences in a more complete understanding of comparative advantage in South Africa, Explore water and CO_2 balances in South Africa's trade, and assign values to embedded water and CO_2.

Economic theory has long been predicated on notions of environmental value, even if this has not always been explicit. Ricardian theories of comparative advantage rely on the relative availability of environmental resources between countries; the seminal Hecksher-Ohlin trade theory (1935) predicts international trade based on the relative abundance of countries' environmental resources; and the analytical notion of *ceteris paribus* assumes a continuation of the relative environmental stability that has been a feature of the modern era. Thomas Malthus in the late 18th century was the first to posit that the environment would impose economic constraints, an idea that has been more recently revisited by Meadows *et al.* (1972) in their "Limits to Growth" as well as exponents of "peak-oil". The realty, however, is that Malthus was wrong and empirical evidence of how economic opportunities and associated wealth has been allocated over the past century suggests that both Ricardo and Hecksher and Ohlin – the elegance and insight of their respective theories notwithstanding – failed to capture important components of the ensuring economic activity. Technological innovation has progressively allowed economies to dislocate from their environment, at least in the medium term, and trade patterns have tended to reflect intra-firm interests, strategic alliances and the relative accumulation of human capital more than differences in countries' environmental endowment.

Industrial country success does not, however, imply that the environment is insignificant for economies. As Diamond (2005) shows, historically, where affluent ruling classes have imagined they are able to insulate themselves from environmental degradation the result is always social and economic collapse. It is already clear that some of the technological innovations that have under-pinned the affluence of industrial economies impose externality costs.

At its core economics rests on the idea that there are mutual gains from transactions between consenting parties, but these gains are less certain if the deal between the two parties imposes costs on people who are not part of the exchange. When economic actors impose costs ("negative externalities") on others without paying the price for their actions, markets fail and the economic assumption that market transactions left to their own devices will be good for society becomes flawed. At the core of ecological thinking is the notion that everything is connected; the living and material world have co-evolved so as to be inextricably dependent on each other. In this world it is extremely difficult for a transaction not to generate externalities – either positive or negative. Good economics accounts for these externalities, rewarding positive externalities and dis-incentivising negative externalities. How to go about this is a matter of policy choice, but requires research, technology and actions. By way of example the environmental degradation caused by climate change – in the words of Nicholas Stern, "The biggest market failure the world has ever seen" - is an externality to fossil fuel energy, land use practices and cement production. Some estimates predict climate change will cost the global economy $40 billion (World Bank, 2007) to $50 billion (Oxfam, 2007) per annum, although more recent estimates are much lower (0.03 to 0.09 percent of GDP by 2050 was the estimate produced by the US's Central Budget Office).

Calculating and attributing the burden of responsibility for environmental degradation has become the subject of vexed international negotiations. The hope is that apportioning costs to perpetrators will incentivise the type of behaviour changes and institutional and technological innovation that reduces degradation. This innovation[1] needs to facilitate better use of finite resources, bring into use new resources and protect the functionality of existing resources and as with Malthus's dilemma change is imperative. The ability to innovate in appropriate ways is crucial. The intransigent and the laggards, whether countries or companies, will be left playing economic catch-up.

It is the same need for innovation that has spawned the green economy; an economy that is valuable, knowledge intensive, labour intensive and in many ways engenders a re-organisation of economic value and a more complete form of economics. Globally, the green economy is valued at $5 trillion (IPAP2, 2010), but it is the transformational nature of green economics that makes it particularly relevant to South Africa. Implicitly, the green economy represents a return to founding economic principles in which externalities are internalised and prices are a better reflection of value. It is these principles that lead architects of modern economic theory such

[1] Innovation in this context is reflects the definition of Luecke & Katz (2003): "Innovation is generally understood as the successful introduction of a new thing or method." Innovation need not be new to the world, but can be new to the firm, community or individual.

Ricardo, Smith and Keynes, to be so optimistic about the welfare potential of market economies and trade. Green economics also represents a departure from the focus on business economics that predominated the late-Twentieth Century at the expense of classical economic theory. The transformative potential of the green economy is based on:

i. The valuing of common property resources (air, water, space, soil fertility, biodiversity) that underpin economic value and make a particular contribution to the social welfare safety net, but the degradation of which is often not charged to perpetrators.

ii. A return to economic first principle in which prices reflect value and social and environmental externalities are not ignored, simply because they are not priced into firm's ledgers.

iii. Markets that function in favour of redistribution.

iv. A reconfiguration of the relationship between people and their environment through an environmentally sensitive built-environment

v. A reform of economic structure so as that more fiscal resources are allocated to small[2], decentralised, knowledge intensive enterprises that make limited use of finite environmental resources, and which draw efficiently on renewable resources.

As South Africa grapples with the obdurate legacy of the apartheid economy, complete with the structural challenges of simultaneous skills shortages, unskilled labour surpluses, a predominance of capital intensive and spatially concentred corporate giants (many of them State owned), the need for transformation has never been more apparent. It is the same need that informed the "Industrial Policy Action Plan"[3] and it is the potential for the green economy to aid this transformation that makes it so important; potential that was alluded to in the State of the Nation Address (11-02-2010).

How exactly South Africa transitions from its current economy to a green economy and realises the associated benefits, represents the central challenge. South Africa confronts this challenge in an age of technological and information abundance, but the country has had only limited success in establishing the institutional and governance prerequisites for effective innovation and technology assimilation (Lorentzen, 2009). Bringing economic principles to bear on these processes and decisions can be helpful. Some ecologists and conservationists object to the

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[2] South Africa currently relies on large companies, many of them State-owned, for much of its economic activity. Innovation and structural reform of these firms is essential, but in general, large firms tend to be capital intensive and employ few people relative to the capital (including natural resources) that they require. The employment that they do create tends to be highly centralised, and dependent on high skill levels. Smaller firms have capital:labour ratios that are better suited South Africa's labour surplus, and smaller firms are more capable of supplying decentralised employment (Rogerson, 1999; Bery et al 2002)

[3] It is the same realisation that saw $183 billion (6 per cent) of the government bail-out packages that were circulated in 2008/9 allocated to "green stimuli" (New Energy Finance, 2009).

idea on moral grounds – "the environment cannot be commodified" and "pollution should be a crime not a cost" are among the objections – but at its best environmental economics involves far more than trading environmental goods and services such as atmospheric carbon dioxide. Rather it is about structuring incentives so as to change human behaviour to achieve desirable outcomes whether this is a particular type of innovation, less pollution or less water consumption. It is this more encompassing notion of the green economy that has such potential in South Africa. Economics is also useful in assessing policy options. Only by applying the economic principle of opportunity cost (the cost of inaction or the counterfactual) that a true sense of the best option can be gained. For example, growing sugarcane yields some benefits, but the merits of sugarcane cultivation should be compared to the opportunity cost of a scenario in which water and land used in sugarcane cultivation is redeployed in the next best option and not, as is often the case in non-economic analyses, to a world in which no value is generated from that water or land. Using a similar logic, the Umvoto Institute has suggested that the environmental cost of mining the remaining gold reserves in South Africa exceeds the value of the reserves; the opportunity cost of gold mining makes the activity unviable unless gold mines escape the full cost of environmental remediation.

3. Renewable energy

Key Findings	Research items
Globally, successful economies of the future will be "low carbon", and competitive advantage will be influenced by countries' extent of renewable energy. Globally investment in renewable energy technology is growing rapidly. South Africa has comparative advantage in wind and solar energy, but has not realised this potential. Over the lifespan of utility scale energy plants renewable energy options are likely to be significantly cheaper than fossil fuel energy, when all costs and benefits are considered. The role of Eskom as the monopoly supplier and monopsony buyer of electricity in South Africa is an impediment to diversification and energy security. Transmission losses in South Africa are high due to the centralised production of electricity and the large distances over which electricity is transported. South Africa's choice of energy technology, then, influences the balance of trade and payments, and has a critical influence at this time on macro-economic stability. The introduction of renewable energy by South Africa's neighbours will alter relationships within the SAPP.	Thorough economic (not merely financial) review of costs and benefits of different energy sources to address the biases introduced by ignoring externality costs associated with health, water and climate change. Identify the shortfall experienced by major municipalities when these are unable to "on-sell" Eskom electricity to end users. Support R&D that leads to locally manufactured solar technologies. Explore the food vs. fuel issue in a southern African context and considering both supply and demand constraints on food. Explore the scope for flex-pricing at the margin. Review energy decisions in terms of full-cost economic assessment and be based on assessments of opportunity cost. Identify "decoupling" opportunities with reference to economic decisions.

3.1 The global energy regime

The role of energy sources in the choice of industrial development pathways has, in the past, not been widely acknowledged outside the energy literature. Yet energy choices are coming to be viewed as critical to development strategies, particularly as the consequences of fossil fuel-intensive industrial pathways become apparent in the form of macro-economic instability and environmental impacts.

Access to energy and mobility is closely correlated with human development and economic growth (see Figure 1). Globally the energy system is in a state of unprecedented flux: as Jeremy Bentham of Shell's Global Business Environment points out, "Everybody knows that the energy system a century from now will be very different from that of today". Energy flux will have economic implications. Between 1985 and 2004, the world spent between 1.75 per cent and 2.25 per cent of its GDP on oil. When the oil price peaked at $120 bbl in early 2008, the world spent 8 per cent of its GDP on oil (UBS, 2008) in the process exposing a multitude of fragile financial deals, creating fragility in other deals and making a global recession difficult to avoid. Perhaps most critically, energy regime flux is taking place at a time when the majority of the world's population, living in developing countries, is on the cusp of industrialisation and a phase of economic development that is likely to be energy intensive.

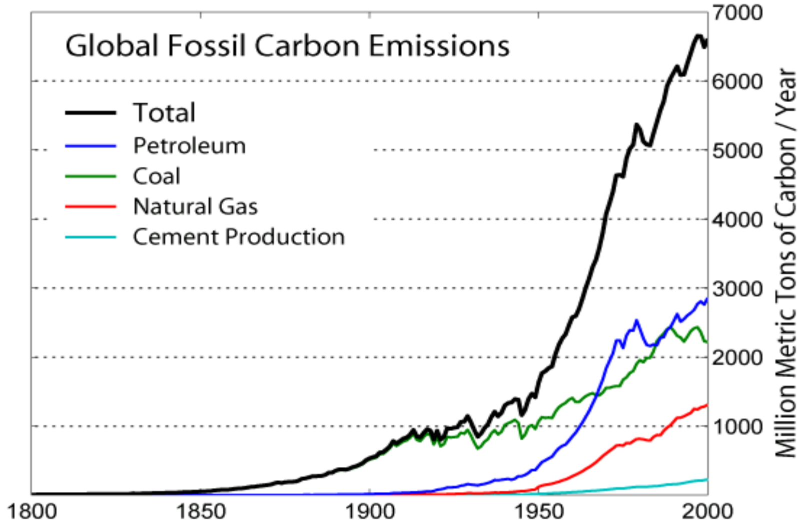
There are three fundamental variables in the global energy regime: "demand", "supply" and the "environment" and it is the need to simultaneously consider challenges to all of these variables that is driving change.

- On the demand side, global energy consumption in 2008 reached $5 * 10^{20}$ joules, which is equivalent to an average power consumption of 15 TerraWatts ($15 * 10^{12}$ W) (IEA, 2009). Growth in demand has increased at an average of 3.4 per cent over the past century and is expected to double between 2005 and 2030 (IEA, 2009). Oil multi-national companies talk about a "step-change" in energy use as countries such as India and China industrialise (Shell, 2009).

- On the supply side, 82 per cent of global energy is derived from fossil fuels (oil, coal and gas). Fossil fuels represent a finite resource and whilst the stock of known reserves is large and growing as new search techniques are introduced, the growth in the supply of "easily accessible" oil and gas is expected to drop below the rate of growth in demand for the first time in 2015 (Shell, 2009).

- Environmental considerations relate to the disruption of terrestrial and hydrological systems during the mining of fossil fuels and the emission of greenhouse gases when these fuels are burnt. Greenhouse gas emission since the 1850s have already raised atmospheric temperatures 0.81°C (IPCC, 2009). Emissions under business as usual would commit the world to more than 4°C warming by the end of the century, an increase that would usher in uncontrollable climate change and severe economic and social costs (IPCC, 2007). Estimates of climate change cost are contested, but the Stern Review placed the "social cost of carbon" (the full cost on all people and the environment) at £70 per ton of CO_2 (Stern *et al*, 2006).

Figure 1 : Historic CO_2 emissions by sources



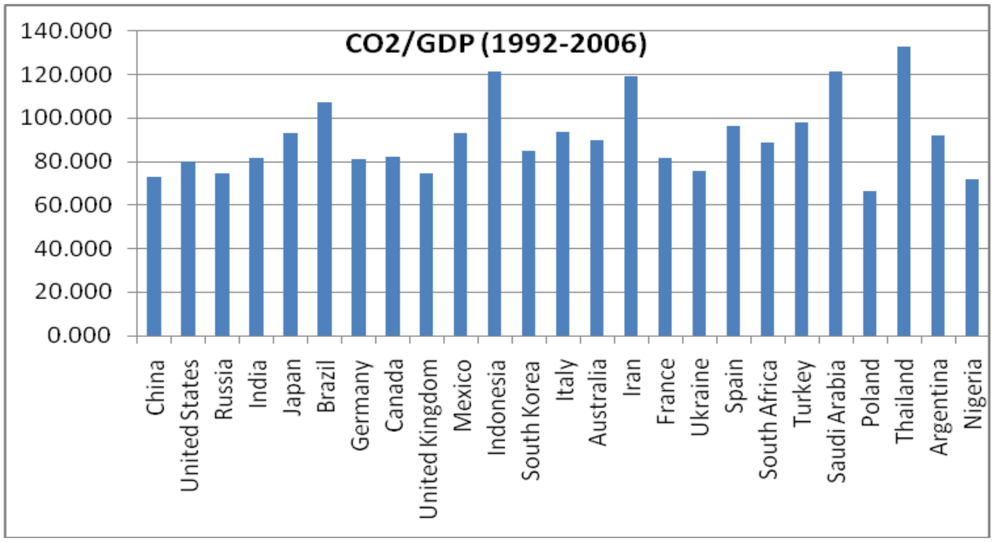
Source: IEA, 2005.

Note: The highly correlated relationship (1800-2000) between historical economic growth and greenhouse gas emissions is illustrated in this diagram of historic CO_2 emissions from different sources. The trend line for emissions shows clearly the impact via the economy of two World Wars, the 1930 depression and the recession brought on by the 1970/s oil price crises.

In terms of energy, then, and specifically the energy required to fuel economic growth and development in the world's poorest countries, the past is not repeatable. Business as usual will not fit the purpose. Rather a decoupling of economic growth and development from te emission of greenhouse gases is required. This decoupling involves change, and the economic success stories of the coming century are likely to be defined by those regions, cities and companies that are best able to transition to renewable energy sources and energy efficient economies.

Until recently it was assumed that decoupling would involve economic losses. What now appears likely, is that decoupling will involve a reorganising of the global economy with a new set of "winners" and "losers". For South Africa decoupling could provide the basis for precisely the economic reform that it requires.

Figure 2: Emissions intensity (CO_2/ GDP) in 2006 divided by intensity in 1999.



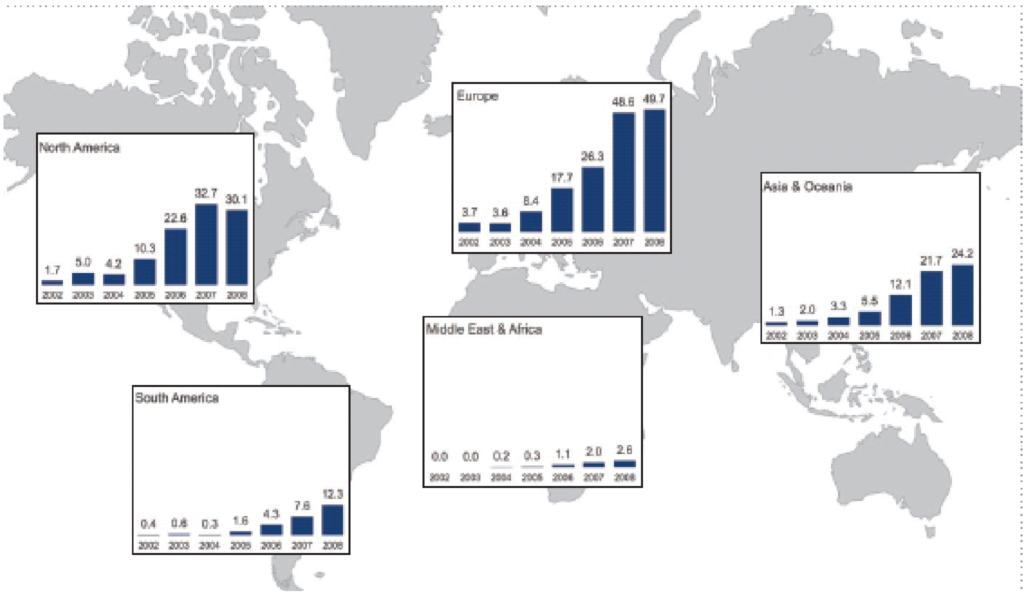
Source: Authors own figure from World Development Indicators

Note: Most countries have managed to reduce their intensity as growth has become associated with services. South Africa's intensity in 2006 was 86.9 per cent of intensity in 1992.

Decoupling is not easy. A review of the of the emissions (GDP/CO_2) intensity of the world's top 25 emitters between 1992 and 2006 that the respective economies have fared variably in removing CO_2 from their economies (Figure 2). South African intensity decreased 12.9 per cent over this time. China decreased 36.9 per cent, the United States 24.6 per cent, Poland 51 per cent and Nigeria 39 per cent. In general oil and coal producing countries have struggled to decouple. Neither is emissions intensity the definitive proxy for efforts to address climate change. Climate change is caused by the absolute accumulation of greenhouse gases in the atmosphere. Intensity reductions mask the fact that greenhouse gases continue to accumulate as economies grow – and in aggregate terms can accumulate rapidly during periods of rapid economic growth.

A general notion of what the global energy future will look like is already emerging. The Prime Minister of England has said, "There is little doubt that the economy of the 21st Century will be low carbon"; in China the talk is of an "ecological civilisation" (Hu Jinato, 2009); and a "global green new deal" (UNEP, 2009) and a "re-industrial revolution" (Hawken *et al*., 1999) are descriptions that have been used elsewhere. What is less clear is exactly how this transition will be made. If the 15th Conference of Parties (COP-15) of the United Nation's Convention on Climate Change revealed anything it is that the transition from a fossil fuel dependent world economy to renewable energy dependence is complex and fraught with vested interests. However, this has not prevented some cities, companies and regions jostling for first mover advantage in the renewable energy sector. Neither has it prevented the flow of investment into renewable energy (see Figure 3).

Figure 3: **The increase and distribution of total (public and private) investment in renewable energy between 2002 and 2008.**



Source: UNEP 2009.

Note: The figure reveals just how little of this growth accrued to Africa

In 2008, for the first time, investment in new renewable energy capacity exceeded investment in fossil fuel energy. In 2009 total investment for the year was $145 billion; less than the estimated $500 billion that is required to generate sufficient renewable energy to stabilise global temperatures at 2°C (UNFCCC, 2009; UNEP, 2009) and 5.6 per cent less than investment in renewable energy in the previous year (Ren21, 2009). But the renewable energy sector fared better than other sectors in 2009 and the Asia-Oceania region overtook The Americas and came in marginally behind Europe as an investment target. Investment in Chinese wind power grew 27 per cent for the year, while investment in Chinese solar energy grew 97 per cent (Bloomberg New Energy Finance, 2010). Understanding the motivations and mechanics of the world's growing renewable energy sector is important for South Africa as it looks to enter this industry.

The leading renewable energy countries built their industries on the back of domestic policies and supply to the domestic market.

- Europe's success was established on the back of a half century of research and innovation motivated by environmental concerns and the aspirations of technology firms such as Siemens Energy, Dong Energy, Vestas as well as traditional oil companies (Shell plc and British Petroleum plc) seeking to diversify and secure their futures. While Scandanavia and Germany have provided Europe's traditional renewable energy innovation centres, Spain has capitalised on its comparative advantage in solar and wind energy to develop a number of utility-scale projects (the 30 MW PS10&20 projects near Seville, the 60 MW Parque Fotovoltaico Olmedilla de Alarcon near Madrid and the

Navarra Wind Farm Project). Many of these companies and their innovation efforts have been predicated on the recognised public good of renewable energy and accordingly have been state-owned or state funded. Dong Energy, the Danish company that is now a leading player in the global wind energy market, developed around North Sea gas interests, and remains 73 per cent state-owned.

- North American enterprises such as Peregrine Power, GE Energy, SunPower and Clipper Wind Power developed under the protection of import duties, but have been motivated by the pursuit of private profits and financed by venture capital interests. The United States leads global wind capacity (25.2 GW) and competes with Brazil for the status of world's largest biofuel producer. United States policies are motivated by domestic interests: energy security and low cost energy in the case of wind power and support for rural economies in the case of biofuels.

- In the Asia-Oceania region China became the world's leading producer of renewable energy in 2008. Chinese efforts are motivated by domestic energy demands and the growth of the domestic manufacturing sector. China has developed utility scale solar, wind and hydro projects drawing on international technologies, but has simultaneously developed its own technologies in the more labour intensive solar-thermal sectors. China is the world's leading manufacturer and exporter of solar water heaters, with companies such as LDK Solar and Orisi now major manufacturers and exporters of technology. Taiwan and Korea, similarly, have used their large technology companies such as Samsung and LG, to enter the market whilst at the same time supporting smaller start-ups such as Motech, Solartech, E-ton and Neo-Solar (Mathews, 2010).

3.2 The South African energy regime

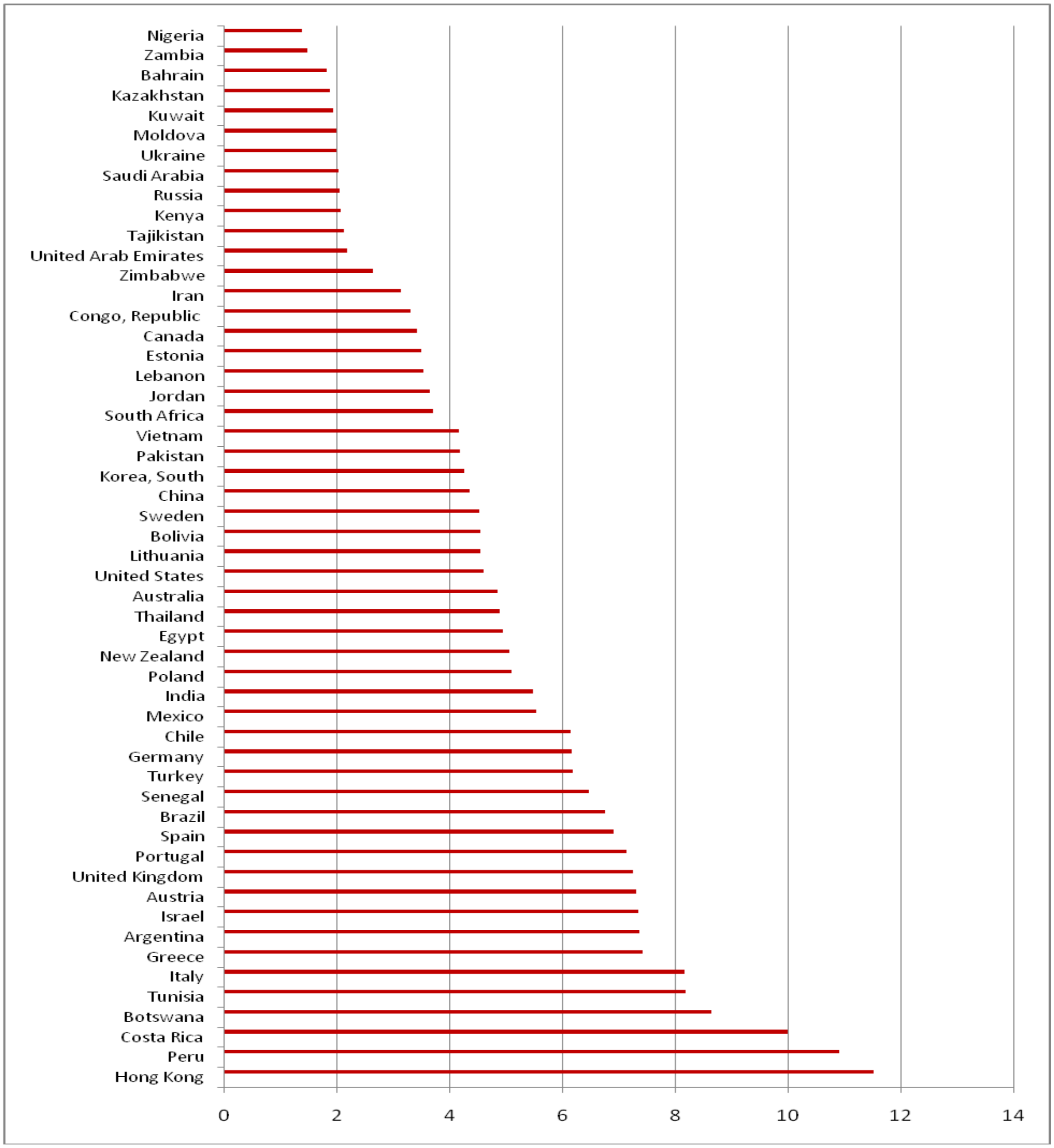
The South African economy is both energy and CO_2 intensive. South Africa's recently launched IPAP2 identifies a range of renewable energy technologies for "support", "exploration" and "develop[ment]". The intention is to reduce the country's dependence on existing energy sources, all of which present long-term problems. Coal-fired electricity constitutes 93 per cent of all electricity in South Africa, but is associated with greenhouse gas emissions, sulphur dioxide pollution, large volumes of water consumption and relatively few jobs. The balance of South Africa's electricity supply is made up of nuclear, hydro and gas. The generation of nuclear power does not emit greenhouse gases, but is dependent on Uranium-235, a non-renewable source of energy. South Africa has 1.8 GW of nuclear capacity at Koeberg and plans for the extension of this capacity are being furtively rekindled in spite of being officially scrapped in 2008 (Greyling, 2010). Nuclear power has the ability to supply energy on demand and at low marginal costs ($0.04-$0.05 per KWh) (UK ERC, 2007), but the financial rationale for nuclear disappears when the decommissioning costs of plants and radioactive by-products are factored in. There is, as yet, not environmentally or socially acceptable means of disposing of radio-active waste which has a half-life of 24,000 years. In the United States efforts to find geologically stable disposal sites in the Yakka Mountains have run into billions of dollars and proved unfruitful.

South Africa pipes gas from the Pande and Temane reserves in Mozambique, using infrastructure that cost $1.2 billion. Gas only produces 0.2 kg of CO_2 per kilowatt hour – roughly a fifth of that for South African coal - and it is speculated that undiscovered deposits exist off the west and south coast of the country. But most of the gas imported by South Africa is used by SASOL for the emissions intensive synthesis of “gas to oil synfuel programme”.

South Africa’s large scale hydro-energy capacity (860 MW in 2008) is not classically considered a renewable energy source because of its dependence on dams and the environmental impacts of this infrastructure. Hydro-energy does, however, have a strategic role to play as a means of storing renewable energy. The intermittent supply of solar, wind and ocean energy makes it difficult to reconcile supply with demand needs. By pumping water to high altitude using renewable energy when it is available, and releasing it through turbines during peak demand periods, intermittency can be overcome. South Africa has such capacity at its Palmiet and Drakensberg Pumped Storage schemes, and is currently investing in new capacity at Steelpoort. In addition South Africa’s State-owned utility Eskom is an investor in the Inga Hydropower project on the Congo River in the Democratic Republic of Congo. The project is expected to produce 40 000 MW once fully operational, but no capital investment has been made to date.

As with the global energy regime, South Africa confronts an increasingly truncated set of energy options and ultimately will have to draw on renewable energy. To date, however, South Africa has struggled to enact its 1998 policy objective of diversifying its energy sources, and has struggled to “decouple” to any significant extent. A target of a 34 per cent reduction in CO_2 relative to the unquantified counterfactual of “business as usual” in 2020 (and a 42 per cent reduction by 2025) was set prior to COP-15 late in 2009. South Africa’s target falls short of the “required by science” (IPCC, 2007) reduction of greenhouse gas emissions, but it is not yet clear whether or how this target will be achieved. Reaching the 2020 target would require a more than 3-fold increase in the uptake of renewable energy, given that between 1992 and 2006 a 12.9 per cent reduction in intensity was achieved.

Figure 4: GDP ($ PPP 2000) per kg of oil equivalent energy in respective country economies in 2006.



Source: World Development Indicators accessed 2010.

Note: South Africa generates roughly $2.7 (PPP 2000) per kg of oil equivalent which is similar to many oil producing countries. Energy efficient growth (and development) is obviously desirable, but commodity producing countries are likely to remain energy dependent and need to focus on alternative forms of energy.

Priority in IPAP2 is given to concentrated solar thermal (CSP), wind and biomass, but the recent commissioning of two new coal fired power stations Medupi and Kusile (of which Medupi will become the world's fourth most carbon intensive power station) indicates a disregard for policy objectives. South Africa is a late (and in some quarters, reluctant) entrant to the global renewable energy sector, and as such will be playing technological catch-up on many of its peer countries. This may not be as disastrous as it sounds; there is some potential for "late-mover advantage" (Mathews, 2010), an approach that was applied by East Asian countries (Japan, Korea, Taiwan) in the electronics sector and allows late adopters of technologies to pursue less risky innovation pathways by drawing on the best available technologies, lessons learnt and even identifying gaps in the market.

3.3 South African renewable energy potential

Even late-movers need to get moving. To take advantage of late-mover advantage South African decision makers require understanding of developments in the global renewable energy sector and deliberate efforts to pursue the opportunities presented by this sector. This in turn will require regulatory and financial reform of the energy sector, and more data sharing and public engagement than has characterised this sector in the past.

- **Wind:** Globally, wind energy remains the greatest source of renewable electricity and accounted for 1.5 per cent of energy supply at the end of 2008 (WWEIA, 2009). In 2008, the industry reported a turn-over of $60 billion and experienced a 27 per cent increase in installed capacity. In the same year the United States overtook longstanding industry leader, Germany, as the country with the most wind capacity. Bulgaria, Turkey and China have (of the countries that have more than 100 MW installed) all doubled their wind capacity in the last two years. In 2008 the global wind sector employed more than 440,000 people (WWEA, 2009). It is anticipated that 1,500 GW of wind energy will have been installed globally by 2020 (WWEA, 2009), roughly 12 per cent of global electricity supply, although the Energy Watch Group believes that capacity could be as high as 7,500 GW by 2025. Innovation in the wind sector is focussed on the height of turbines and length of rotors, the weight and strength of material used to construct turbines and the efficiency and strength of the "gearbox" located at the centre of the turbines.

  South Africa's coastline presents good wind power potential (Diab, 1993; CSIR, 2007). The Western Cape currently has 10 MW of wind energy installed, but the Province's Sustainable Energy Action Plan (2007) identified 2,800 MW of wind potential in the region. The World Bank believes 100 MW of easily implementable wind capacity is available in South Africa. The country' largest windfarm is being planned for Jeffery's Bay, but physical investment is being frustrated by the inability of aspirant Independent Power Producers (IPPs) to secure power purchase agreements from Eskom (MRPSA, 2009).

- **Solar:** Solar power can be broadly split into solar-thermal technologies that capture and transfer heat (SWHs) and photo-voltaic (PV) technologies that use the chemical properties of panels to convert solar radiation into direct-current electricity. Globally, solar represents the fastest growing source of renewable energy, with PV capacity roughly doubling every two years. In 2008 13 GW of grid connected solar capacity existed, while 145 GW(thermal) of solar-thermal (solar for hot water production in boilers and swimming pools) had been installed (Ren21, 2008). Germany is the fastest growing PV market in the world, while Spain is the most rapidly growing supplier of this market. China and Turkey respectively have the greatest solar-thermal capacity. Innovation is a feature of the solar industry, with much effort focussed on concentrated solar power (CSP) at large scale plants, for grid connection.[4]

The Desertec Industrial Initiative, an ambitious project to build a CSP plant in the Sahara that could supply North Africa and Europe with electricity, is attracting significant attention within the solar sector, although at this stage no investment decisions have been taken (Edkins, *et al*., 2009). Destertec was initiated by the Club of Rome and the German Trans-Mediterranean Renewable Energy Cooperation (TREC), but is now being developed by its own foundation (http://www.desertec.org/).

South Africa has excellent solar potential, particularly in the Northern Cape. Amorphous silicon and copper indium diselenide (CIS) receivers are most likely to give the best PV results under South Africa's sunny conditions while crystalline silicon is better suited to cooler (even partly cloudy) conditions (Jardine & Lane, 2002). The World Bank Group (2010) has proposed 100 MW of South African CSP in the near term and investors such as Mbeleko and a consortium backed by Macquarie have indicated a willingness to develop this sector together with the South African government. In the short term South Africa is unlikely to become a lead-manufacturer of parabolic dishes, but could produce flat-mirror CSP systems as part of a two-tracked import and local manufacture strategy.

While some progress has been made with SWH roll-outs, the expansion of utility-scale PV market has been hindered by the same lack of power purchase agreements.

Biofuel: Investment in biofuels comprised 13 per cent of the total investment in renewable energy ($120 billion) in 2008 (Ren21, 2009) although this was down on previous years due to lower oil prices. Globally 79 billion litres of biofuel were produced in 2008. South Africa has modest biofuel potential, provided the production of feedstock does not exacerbate water shortages. Cartwright (2008) citing Dufey *et al.,* (2007) and the South African Biofuel Feasibility Study (2006) produced the figures in Table 1 suggesting South Africa is able to compete on price with the US, EU and China when it comes to the production of biofuel.

[4] CSP technologies reflect and concentrate irradiation to a central point, using either flat mirrors or more sophisticated parabolic mirrors.

Table 1 Bioethanol production costs per litre*

Country/feedstock	**Estimates** Dufey, Vermeulen and Vorley (2007)	**Estimates** South African BTT Feasibility Study (2006)	**Estimates** UNCTAD (2006)
South Africa (sugarcane and maize)	-	US$ 0.45-0.46	US$ 0.41
Brazil (sugarcane)	US$ 0.25	US$ 0.23	US$ 0.27
Thailand (cassava)	US$ 0.27	US$ 0.29	
Australia (sugarcane)	US$ 0.38	US$ 0.32	
US (maize)	US$ 0.40 – 0.50	US$ 0.47	US$ 0.41
EU (wheat/beet)	US$ 0.51 – 0.80	US$ 0.97	US$ 0.61 and 0.68 respectively.
China (sugarcane 2005)	US$ 0.53	-	-
Chicago bourse (July 2007)	-	US$ 0.55/ litre	-

* Excluding taxes and subsidies

The modest bioethanol blending targets proposed in the feasibility study (8 per cent of the petrol market and 2 per cent of the diesel market) would reduce the extent of imported refined oil in South Africa. Due to constraints on refining capacity South Africa is forced to purchase some of its liquid fuel in a refined form (as opposed to crude oil) on the spot market, and this comes at great expense. Liquid fuel imports represent the greatest single import item for South Africa over the past 15 years (between 12 and 20 per cent of all import costs per annum).

In the southern African context, the "food versus fuel" debate that has made for emotive biofuel headlines does not apply. South Africa's maize surplus is important to the food security of the southern African region, with its propensity for drought and famine, but South African agriculture is supply constrained. Too much of the available fertile land and water underperforms in terms of its potential contribution to food security. The principal reason is a lack of investment in rural infrastructure and the production process. Agriculture in the region is caught in a low-risk and low-return scenario. Biofuels represent one means of securing investment in rural economies and boosting production of both food and fuel. Prices fluctuate, but on average between 2002 and 2007 maize farmers received between $80-160 per ton for their produce in commodity markets. The same ton was worth $204 if used for bioethanol (based on the bioethanol price of $0.51 per litre that is recommended in the draft Bioethanol Strategy).

- **Balance of renewable energy:** Whilst solar and wind are likely to comprise the core of South Africa's renewable energy sector, South Africa's renewable energy balance will be comprised of biomass to energy (52 MW of global capacity), mini-hydro (85 MW of global capacity), ocean energy (0.3 MW) and possibly geothermal (for which 10 MW is available globally and which has significant potential in Kenya).

Astutely the Industrial Action Plan (IPAP) identified the need for industrial and vehicle-based demand side management to contribute to the transition towards renewable energy. South Africa is an energy profligate country (Spalding-Fecher *et al.* 2000; Winkler, 2008) and energy efficiency reduces the quantum of fossil fuel energy that is required to be displaced by renewable sources. Insulated ceilings, compact fluorescent lightbulbs, timers on light switches, insulated geysers and an upgrade of manufacturing machinery all have the potential to reduce energy demand easily, quickly and at low cost (LTMS, 2009). The LTMS estimated that industrial energy efficiency approaches would actually save R34 for every MWh reduced. In the transport sector, public transport, smaller and more fuel efficient vehicles and improved transport infrastructure have similar potential. In 1994 Eberhard & Van Horen identified the need for demand-side interventions and technologies in transforming the national energy sector, but progress between 1994 and 2005 was almost non-existent. The rolling power outages that began in 2005 catalyzed a knee-jerk reaction that included mandated electricity cuts for mines and other energy intensive companies. Winkler (2008) points out that this reaction, unplanned as it was, was economically expensive, but outages did usher-in a new awareness of energy saving opportunities and highlighted conspicuously energy intensive enterprises.

From a very low base, South Africa has managed some demand side management gains, as is evidenced by country’s emissions intensity improvement. But there are fundamental impediments to further efficiency gains. The first is that that the dominant player in the South African energy sector, Eskom which occupies the position of both monopoly supplier and (for the time being) the monopsony buyer of electricity, makes a profit from selling electricity and has no incentive to promote energy savings. The second, and more critical, constraint involves the forward selling of bulk electricity by municipalities to end users. South Africa’s major municipalities acquire electricity relatively cheaply from Eskom (the City of Cape Town acquires electricity at R0.22 kWh – R0.33 kWh if overheads and transaction costs are imputed) and once they have provided the indigent population with a minimum quota of free electricity, sell this electricity at a considerable premium. The forward selling of electricity represents an important revenue stream for municipalities, and demand side management efforts that undermine this income are not unanimously welcomed.

3.4 The case for renewable energy in South Africa

South Africa has abundant coal reserves and it is often argued that the country should be entitled to exploit its coal in the same manner as industrialised countries did in the past. This argument fails to acknowledge that simply having an energy resource does not always make it a good decision to use that resource. South Africa also has abundant stone resources, but moved on from the stone-age when substitutes became available. Just as South Africa has abundant coal, so too does it have comparative advantage in solar (Mbeleko, 2009), wind (Diab, 1995, CSIR, 2001 & 2010) and possibly ocean energy (CEERC, 2007) and can be cost-competitive with European countries and the United States in the production of biofuel (Cartwright, 2008).

The global shift in investment from fossil fuels to renewable energy technologies represents an acknowledgement that the world cannot continue burning fossil fuels without inflicting inflict irreparable damage to economies and societies (Stern, 2007; Krugman, 2010[5]). The global energy future lies with renewable resources and the transition to renewable energy will define a reconfiguration of national and regional competitive advantage.

Climate change awareness and investment in renewable energy in South African society has lagged the world, but there are non-climate change reasons why it makes sense to pursue a transition to renewable energy aggressively. Energy investment decisions should, ideally, consider all of these factors:

- **Cost and cost stability:** Cheap electricity is favourable for competitiveness and economic growth.

  South Africa is assumed to have "cheap" coal-fired electricity. This energy can cost as little as R0.17 per kWh if the external costs of emissions and water are ignored. During periods of peak demand, however, Eskom is required to draw on more expensive forms of energy, namely nuclear (R 0.17-0.18 per kWh), pumped storage (which adds R0.15 per kWh to the cost of coal-fired electricity) and finally gas and diesel turbines that produce electricity at a cost of R2.10 kWh (NERSA, 2009). Clearly not all South African energy is cheap and the increasing need to draw on expensive forms of contingency energy in conjunction with the rising costs of extending the grid to remote households have been behind recent electricity price increases. In addition coal-fired electricity imposes very real health and environmental costs on society. Spalding-Fecher and Matibe (2005) estimate these externalities to amount to R0.05 kWh, but Weitzman (2009) points out that climate change itself could make this externality much larger. Power utilities do not currently have to include these costs in their investment decisions. This too, however, is changing; as Economics Nobel Laureate Joseph Stiglitz points out, "Not charging power utilities for environmental costs is simply bad economics," (Stiglitz, 2003, p.255).

  Renewable energy is often cited as being too expensive. Costs vary across technologies and location and price comparison is complicated by the varying lifetime of different technologies, the varying times at which expenses are incurred, the subjectivity involved in pricing or excluding environmental impacts and the fact that energy prices do not always reflect energy costs (Corey, 1981; Awerbush *et al* 1996). Internationally, the best cost estimates for renewable energy are in the range of $0.060 per kWh for wind, $0.07-0.20 per kWh for photovoltaic depending on technology and storage capacity, $0.065 per kWh for solar thermal, $0.115 per kWh for small-hydro and $0.045 per kWh for tide energy (UNDP *et al*. 2000; UKERC, 2007; NERSA, 2009), but significantly these prices are falling annually and in South Africa will become cost-competitive with even the cheapest forms of fossil fuel energy by 2015. Crucially renewable energy does not generate the external costs imposed by greenhouse gases or the health costs imposed

[5] Paul Krugman, NY Times, 5 April 2010.

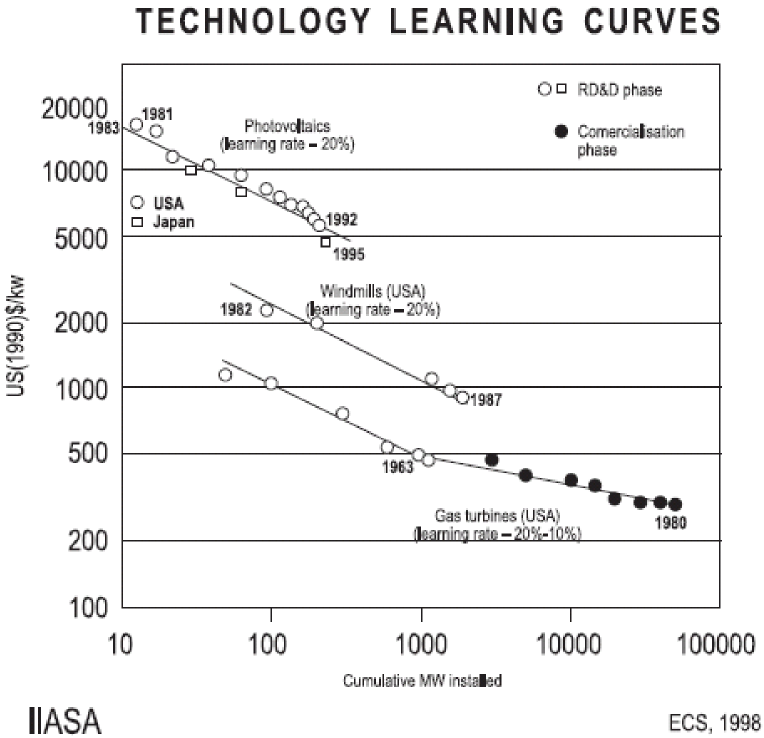
by pollution in the vicinity of coal fired power stations and mines. The carbon dioxide used to manufacture a utility scale wind-turbine is typically off-set within 2 months of the turbines operations.

Arguably the most attractive feature of renewable energy costs, however, is their predictability. Fluctuating coal, oil and uranium prices have a long history of causing macro-economic instability. The geographically diffuse production of renewable energy makes it difficult for price-distorting cartels such as OPEC to form and control prices. More importantly, the marginal costs of producing renewable energy once capital has been financed are negligible and predictable, facilitating a more stable influence of energy prices on macro-economic development.

The combination of more stable and (in the medium term) lower energy costs from renewable energy will provide precisely the type of competitive advantage that South Africa sought to create with its policy of cheap and abundant coal-fired energy in the 1970s and 1980s. In a certain sense the strategy of that time worked, but competitive advantage shifts, and the combination of higher commodity prices and environmental concerns requires a shift to renewable energy.

Cost reduction potential: Investments in utility-scale energy supply represent a 30-50 year lock in of technology and capital. Such investment decision need to be anticipatory of future costs, future environmental constraints and legislations and future needs. The scope for innovation and cost reduction in the fossil fuel sector is limited, indefinite expansion of this sector is not possible and the price of fossil fuel is volatile and likely to rise under the influence of cartels and large corporations dependent on a diminishing resource. In contrast, renewable energy technologies are evolving and prices at which renewable energy is supplied have already dropped significantly.

Figure 5: Technological learning and cost reduction, PV, wind and gas turbines as a result of R&D and commercialisation (Japan and the United States).



Source: **International Institute for Applied Systems Analysis (IIASA) (1998)**

It is difficult to know what solar power will cost once it becomes a large-scale proposition, but not all renewable sectors have the same inherent scope for innovation and cost reduction and not all are innovating at the same rate. The scope for further innovations and cost reduction in specific technologies should be one of the key determinants of energy strategies, as it is likely to produce the ultimate "winners" in terms of energy supply technologies.

- **Employment creation:** Globally renewable energy makes up just 4 per cent of the energy mix, and yet it already employs more people than the fossil fuel industry (UNEP, 2009). Specific estimates of employment figures vary, but what does not vary is the understanding that renewable energy is more labour intensive than fossil fuel energy. South Africa's current coal-fired energy sector employs an estimated 0.3-0.7 people per GWh (Austin *et al*, 2003; WC DEA, 2007). New coal technologies are marginally more labour intensive and employ at least 0.7 people per GWh. Nuclear and gas employ 0.1-0.2 people per GWh. In contrast the figures for solar thermal are 8.7-10.4 people per GWh, for photovoltaic energy 6.2-12.6 people per GWh, for wind 5.6 people per GWh for landfill gas to energy the figures vary between 1.3 people per GWh (Austin *et al*, 2003) to 23 people per GWh (WC DEA). For biomass, which included biofuel, waste collection and sustainable forestry the figures are 16.3 to 23 employees per GWh. Apart from the obvious potential for renewable energy to contribute to South Africa's employment creation, the jobs created by renewable energy are decentralised and frequently in rural areas.

Given that high unemployment defines South Africa's poverty (OECD, 2008; Gordhan, 2010) technologies that alter the capital:labour ratio of South Africa's key economic sectors have to be prioritised. Without altering this ratio, the experiences of 2003-2007 when the economy grew at over 5 per cent but unemployment persisted above 22 per cent, will remain a feature of high growth periods.

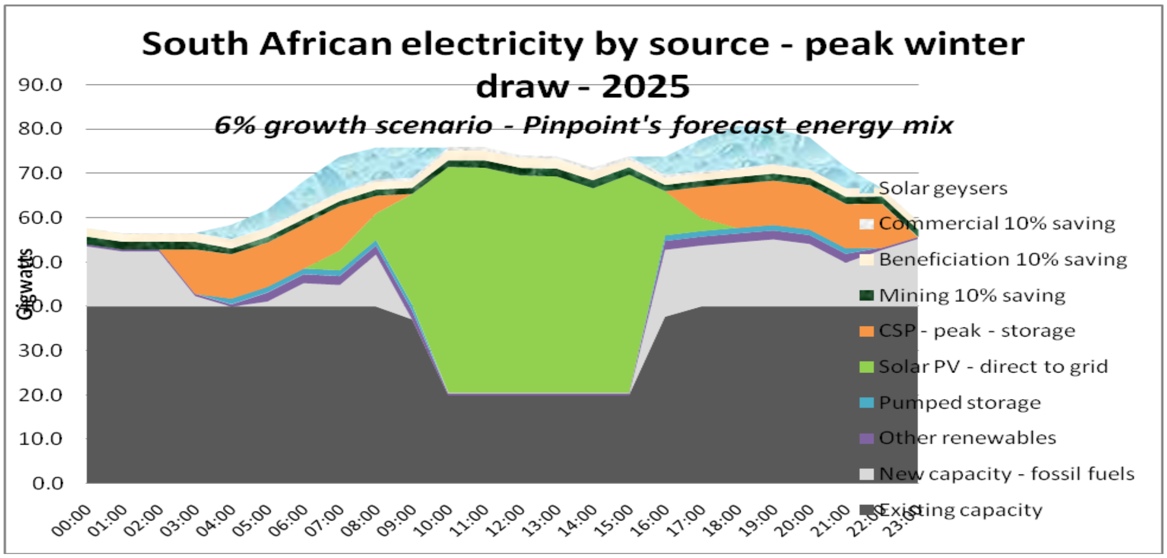
- **Water:** South Africa is a water scarce country and water constraints impose seasonal limits on economic activities in all provinces. The National Water Act (1998) promotes the use of water as an "economic good" and suggests the need to allocate the national water resource to optimise the benefits to the country, and reciprocally to ensure that development is water rational. It requires 1.35 litres of water to produce a kWh of electricity in South Africa using Eskom's current feedstocks and generation approaches. Eskom receives water at preferential rates relative to households and manufacturers, but still required R1.26 billion in 2009/10 to acquire the water it needed (NERSA, 2009). The opportunity cost to the South African economy of this water is more than Eskom pays for it. New coal fired power stations are "dry-cooled" but still consume some water and the extraction of coal remains water intensive. With the exception of CSP technologies (which can be dry-cooled but tend to be water cooled due to cost) and biofuels, renewable energy technologies do not require water.

- **Balance of trade:** South Africa has committed to increasing its budget deficit through the period 2010 to 2012, principally as a result of increased allocations to State Owned Enterprises and public infrastructure, and will target a deficit of 9.8 per cent of GDP in 2001/12 (IPAP2, 2010). There is a strong case for this expansion, but running a budget deficit will place additional pressure on South Africa's balance of trade and payments. Where the country's trade and payments accounts continue to be defined by growing imports relative to exports, the risk that is inherent in expanding the budget deficit could be exposed, leading to capital flight and currency risks. This is a particular risk for South Africa where a misalignment between slowing economic growth and increasing demand for imported goods has emerged. South Africa needs to grow its economy in a manner that substitutes some imports and stimulates exports; in 2007 South Africa's share of the global export market was only 86 per cent of what it was in 1994 (Hausman *et al*., 2008). Currently the bulk of imports is comprised of machinery and transport equipment required for mining (collectively 38 per cent of all imports), manufactured goods and articles (20 per cent of all imports) and oil (18 per cent in 2007) (Hausmann *et al*., 2008).

  The balance of payments will also be further affected by shifting roles within the Southern African Power Pool (SAPP). The pool consists of 12 countries and South African exports constitute between 50 and 100 per cent of electricity to six of these countries. Many SAPP members are relatively advanced, however, in the development of domestic renewable energy sectors. Both Namibia and Botswana have benefitted from investors' frustrations with being unable to secure power purchase agreements in South Africa (Pinpoint Energy, 2009), and it is likely that dependence on Eskom imports will diminish in these countries with associated implications for export earnings.

South Africa's choice of energy technology, then, influences the balance of trade and payments, and has a critical influence on macro-economic stability. Under Eskom's plan to meet its energy targets for 2025, which relies heavily on coal, nuclear, industrial energy savings and some solar water heaters, the country would experience an estimated $46 billion net outflow of capital due to foreign purchase of equipment and fuel (Pinpoint Energy, 2009; Greyling, 2009). Under an aggressive commitment to utility scale renewable energy, net outflows would be limited to $2 billion in spite of the need to import technology and services (Pinpoint Energy, 2009).

Figure 6: Alternative 2025 energy mix for 6 per cent growth.



Source: Pinpoint Energy, 2009

- **Equity:** South Africa is an unequal society and one of the articulated aims of the post-apartheid government has been to reduce inequality. The type of renewable energy and energy efficient technologies envisaged in IPAP2 – even though the targets are modest - would see a redistribution of revenue away from the country's centralised suppliers of coal, oil and electricity. The creation of IPPs and REDs would also see provinces other than Gauteng, Mpumalanga and Limpopo associated with energy revenues.

From the above analysis it should be clear that energy decisions, which for a long time focused on reconciling supply and demand, have broader economic and social implications. Accordingly, a broader set of factors should be included in such decisions and, where they are, the case for renewable energy becomes very strong (see Table 2). Certainly energy decisions cannot be left to the narrow confines of short-term financial benefits and costs.

3.5 Regulatory and financial support for renewable energy

If it is assumed that renewable energy is both a good idea and desirable, the issue becomes how to go about creating the required energy stock and how, given the high cost of capital in South Africa, to finance the creation of this capital stock. (The questions could equally be framed, “If renewable energy is such a good idea, why has not been introduced already?”). The answer requires an analysis of the regulatory and financial barriers to energy sector reform.

Regulatory reform is a necessary process in the introduction of renewable energy. South Africa has the policies and targets that affect this reform:

- The 1998 DME White Paper on Energy Policy identified “managing energy related environmental impacts” and “securing supply through diversity” as two its five headline objectives.[6]
- The country has a Renewable Energy White Paper (2003) that established a target of 10 GWh or renewable energy by 2013.
- The Presidency announced a target of reducing greenhouse gases by 34 per cent by 2020 providing a signal of intent.
- The country has various tertiary education (Energy Research Centre, Centre for Renewable and Sustainable Energy Studies) and government (Central Energy Fund, CEF Carbon, CEF Sustainability) institutions engaged in credible renewable energy research.

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[6] The other three objectives, “Increasing access to affordable energy services”, “Improving energy governance” and “Stimulating economic development” are all broadly compatible with a shift to renewable energy.

Table 2 Multi-criteria assessment showing a balance of important considerations to be factored into the choice of different energy supply options

	Compar. advant.	Cost	Cost reduction potential	GHG emission	Macro-economic	Employment	Water	Tech & instit. complex	Demand relief	Equity	TOTAL
Coal	3	3	0	0	1	1	1	2	3	0	**14**
Nuclear PBMR	1	1	0	3	1	0	2	2	3	0	**13**
Gas	0	2	0	1	1	2	2	1	3	1	**13**
PV-CSP	3	1	3	3	2	3	2	2	1	1	**21**
Solar thermal	3	2	3	3	2	3	3	2	1	3	**25**
Wind	3	2	3	3	2	3	3	2	0	2	**23**
Geothermal	1	1	2	3	2	2	2	1	3	1	**18**
Hydro	2	2	1	2	1	2	2	3	2	2	**19**
Biomass	2	2	3	1	3	3	2	2	3	3	**24**

Source: Western Cape Government, 2010; Cartwright 2010 following Hallegatte, 2008

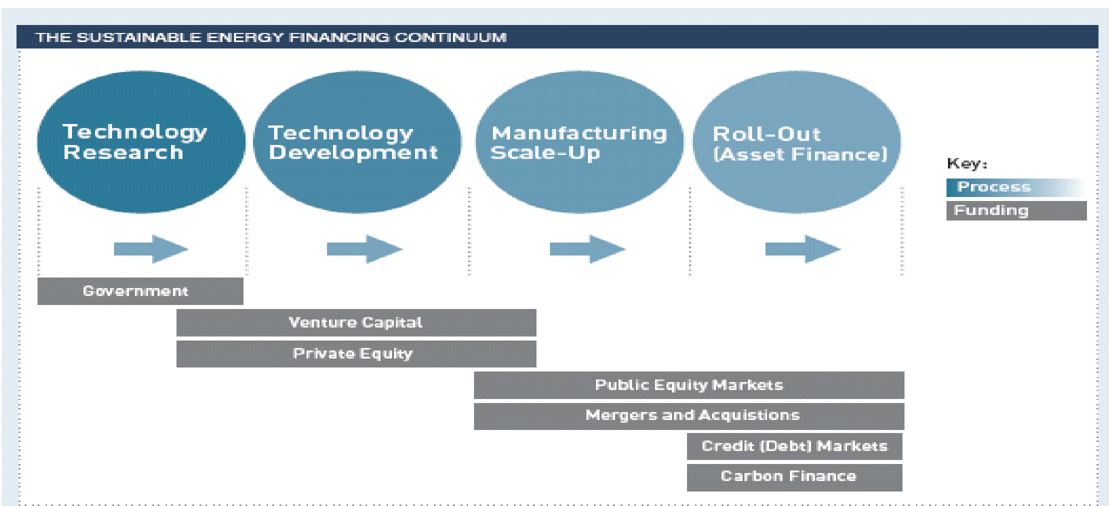
To date, however, vested interests in the coal sector and State-owned power utility Eskom have prevented the application of these policies. As the monopoly supplier and monopsony buyer of South Africa's - and much of Southern Africa's – energy, Eskom has come to control the regional energy sector. This is in spite of the presence of a regulator and a bespoke energy ministry and policies that permit the much needed decentralisation of supply and energy governance reform. Policy allows for Independent Power Producers (IPPs) to sell renewable energy to the national grid and proposes six Regional Energy Distributors (REDs) for the managing of national energy supply and demand. Under the RED proposal, the REDs will come under the umbrella of an Energy Ministry-controlled holding structure called Electricity Distribution Holdings Industry (EDI Holdings). Policy changes have further seen the formulation of generous renewable energy feed-in tariffs (REFITs) that provide attractive incentives for suppliers of renewable energy, proposed the privatisation of up to 30 per cent of Eskom and seen the separation of the former Department of Minerals and Energy into a bespoke energy ministry. The policies are sound, but the institutional commitment to change and the issuing of power purchase agreements (PPAs) at REFIT prices has been lacking to date. Eskom's Single Buyer Office is currently responsible for issuing these contracts, and allegations have been made that having the incumbent monopoly responsible for diversifying supply represents a conflict of interest and underlies the tardy progress to date (MRPSA, 2009). Serious allegations have been levelled suggesting that politically vested interests in the continuation of South Africa's coal-fired energy regime are central to the obfuscation (Greyling, 2010), but fundamentally the required transition is constrained by the fact that Eskom is an inward looking and un-transparent institution. The origins of this culture date back to the Petroleum Products Act (1977) which legislated against the circulation of energy information and prevented the State from collecting and publishing data in the energy sector that would have allowed for the development of balanced and progressive energy policies (Eberhard and Van Horen, 1994). The offending Act no longer exists, but reforming the culture of Eskom has proven difficult. The SOE operates in silos of "generation", "transmission" and "connections" with inadequate sharing of information between the three (Lorentzen *et al*., 2009). Flux in the global and national energy sector requires change, but the necessary innovation is very difficult in the absence of information.

The same culture, lack of energy data and public accountability, contributed to the economic difficulties that currently afflict Eskom. The SOE is required to raise in excess of R400 billion to ensure its supply over the next 25 years, and the inward focus of the institution has seen it revert to tried and tested, but outdated coal-fired sources for its expansion programme – sources that are likely to prove costly over the 25 year lifetime of the plants. In the interim Eskom has discontinued State subsidies for energy supply capacity and introduced tax liabilities and the possibility of paying dividends to its shareholders (currently only government). The changes affected the financial security of the company, lowered its credit rating and increased the costs of capital to Eskom.

Funding a business as usual expansion of Eskom's capacity will prove difficult enough without governance and regulation problems. Eskom's $3.75 billion World Bank loan application has been approved, but the Bank was placed under international pressure by civil society groups not to finance "the world's fourth most carbon intensive power plant". The World Bank's funding for the construction of Medupi, is conditional on, "A longer term relationship with South Africa which is aimed at placing South Africa on a low carbon road", but would also expose South Africa to the conditionality of World Bank finance for the first time since democracy. In defending the loan approval, bank official Hussain, claimed: "The challenge is about the economic growth imperatives of South Africa, especially in the post-recession phase. Nearly one in four South Africans does not have access to energy." What Hussain's statement failed to acknowledge was the links between negative environmental externalities and coal mining and coal-fired electricity generation.

How then should South Africa go about financing the creation of renewable energy capacity, particularly when some of this capacity requires large up-front investments in order to access the benefits that discussed above? The answer lies in aligning renewable energy projects within a diversified but accountable energy governance framework (which South Africa has in the form of the 1998 White Paper and subsequent legislation) and a combination of public and private funding.

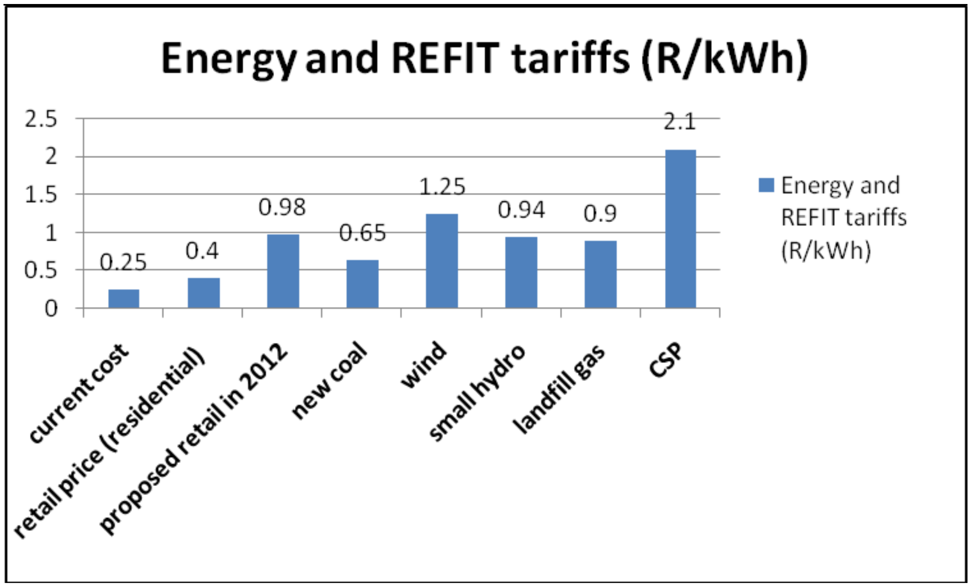
Figure 7: Stylised model of financing combinations in the development of renewable technologies



Source: UNEP, 2009

Renewable energy in South Africa can not be developed by government exclusively; this much was admitted by the Minster of Energy in her annual address to parliament (23-03-2010). The application of technologies developed by other countries and companies opens the door for joint-finance partnerships. Governments have a role to play in these partnerships. In the REFIT policy and the national grid, the Department of Energy has two key instruments for forming constructive energy partnerships. The REFIT is acknowledged as providing adequate incentive to attract private investment into the energy sector. The restriction on this investment at the moment is PPAs. Until investors know how much energy will be purchased from them for supply into the grid they are unable to gear their businesses.

Figure 8: Renewable energy feed-in tariff.



Source NERSA, 2009

The other key financial innovation required, involves introducing a greater measure of price flexibility. Regulated energy prices can introduce stability, but the current approach to electricity pricing and recent price hikes in South Africa places an undue burden on the poor and small businesses and undermines the development of a flexible price-signal for the development of suitable energy alternatives. Brazil, which confronted similar energy issues to those currently experienced by South Africa in 2000, provided one possible solution to energy price regulation. In Brazil large corporate consumers of energy were able to purchase more or less the same quantum of energy they had required the previous year at regulated prices that increased predictably and stability. Additional energy requirements, however, had to be purchased on the open market from independent power producers. The approach, which admittedly requires significant institutional capacity and data to administer, strikes a balance between regulated and free-market prices by restricting free-market principles to the margin.

4. Climate change adaptation

Key Findings	Research items
Climate change adaptation is a process. It is not possible to "climate proof" a project or an economy. Effective climate change reduces the risk and cost of climate change impacts, particularly for the poor and the marginalised. Durban and Cape Town lead South Africa's local adaptation efforts.	Continue downscaled climate models and integrate with SAMs for economic impact. Identify particularly exposed locations and sectors. Identify the un-insured "residual" of climate change risks. Explore links between climate change and insurance costs
There is need for improved downscaled climate projections but the real challenge is to move from confidence in predictions to confidence in responses. In the context of climate change economic flexibility and reversibility become valuable. When all costs and benefits are considered, socio-institutional options tend to be more cost effective than biological options, which tend to be more cost effective than infrastructural options. At the global scale, considerable funds exist for climate change adaptation and South Africa has yet to draw down applications for these funds.	Establish platforms for information sharing and decision making involving government, business and research agencies. Identify and analyse mal-adaptation, and the pre-emptive measures for its prevention. Identify local climate coping approaches for support.

4.1 The need for adaptation

People have been responding to climate variability and changes for as long as they have been around, but climate change adaptation emerged as an international priority at the UNFCCC's Nairobi COP in December 2006, and was formally codified in the UNFCCC's Bali Action Plan a year later. Climate change adaptation is not a surrogate for climate change mitigation – although tensions exist between the respective practitioners as to how to allocate funds and resources between the two. Rather growing recognition of climate change adaptation is based on:

- Realisation that no matter how successful future greenhouse gas mitigation efforts are, the existing momentum in the warming atmosphere and oceans and the inertia of that momentum (the oceans will continue warming and rising for at least 100 years after anthropogenic emissions cease, for example) will see increasingly hostile environments in the future. In 2009 Martin Parry warned that the world was "already unavoidably committed to 2.2°C mean temperature rise."[7]

- Acknowledgement that the extent and rate of temperature changes will not permit a gradual realignment of equilibria at the margin, but is more likely to contribute to complete systems change and unprecedented (in the last 55 million years at least) environmental phenomena.

- Recognition that rapidly warming atmospheric temperatures cause a series of ecological changes that in turn induce social change. Some changes will be positive (longer growing seasons, new sea routes, greater precipitation in mountain regions), but most changes will be adverse (increased frequency and intensity of storms, longer droughts, more intense rainfall events, shrinking and shifting of species habitats, increased plant respiration rates). A more complete list of impacts is contained in the IPCC's Working Group II's Fourth Assessment Report (2007).

- Acknowledgement that without intervention climate change impacts would result in net costs and that these costs would be borne disproportionately by poor and marginalised communities. As such climate change will aggravate poverty and entrench its origins such as inequality, gender biases, rural-urban divides and peri-urban expansion. Already climate change has increased the cost of attaining the Millennium Development Goals.

- Realisation that preparedness and early action at the national and local scales can assist in realising opportunities and reduce the cost of impacts.

- Acknowledgement that existing planning and development efforts can be modified so as to reduce climate risks. Budg*et al*locations, spatial zoning, infrastructure development and crop selection, for example, have the potential to increase or reduce climate risk. The need to keep climate change adaptation budgets distinct from conventional sustainable development budgets has been internationally debated based on the premise that climate change will induce novel challenges and combinations of challenges when compared to past sustainable development and so require separate budgets. The reality remains that some of the best (and most pragmatic) climate change adaptation efforts are those that draw on existing development capacity, meet locally articulated needs and introduce climate change information to sustainable development decisions.

At the UNFCCC-level much work remains on how adaptation finance should be generated, delivered and governed (Persson *et al.*, 2009), and indeed what does and does not constitute climate adaptation. At the local level, the problem is more obvious: it is extremely difficult to know what exactly people and institutions should be adapting to, and when. The University of

[7] Martin Parry is head of the IPCC's Working Group 2, and was addressing the SwissRe Conference on the Economics of Climate Adaptation in Zurich.

Cape Town's Climate Systems Analysis Group produces some of the world's best downscaled climate projections, but even these tend to be at temporal and spatial resolutions that farmers and city planners struggle to apply (Ziervogel *et al*., 2008). Furthermore, while most climate models concur on the trend of temperature and rainfall for given regions, in the context of climate change a drying trend is not inconsistent with more extreme rainfall events and most models struggle to incorporate the social, ecological and institutional responses to these trends and events that ultimately determine impacts.

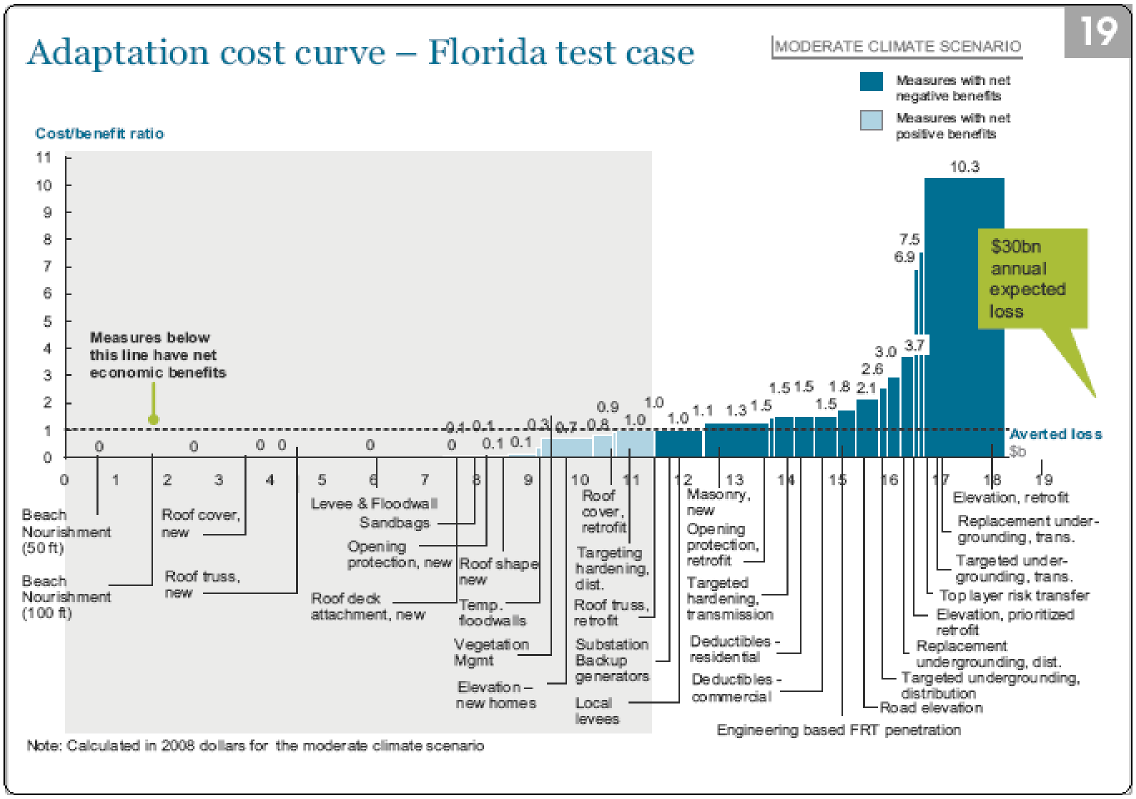
It is the understanding that exact climate change impacts are difficult to predict, but that in general climate change reduces the level of certainty with which planning of all types can take place, that led Tom Downing (one of the architects of climate change adaptation) of the Stockholm Environment Institute to suggest that effective adaptation involves, "The ability to cope with a wide range of difficult to predict contingencies". The fact that it is not possible to "predict and provide" (Downing *et al*., 2007) when it comes to climate change risk reduction, does not mean that nothing meaningful can be done. On the contrary the available science can provide guidance as to the type of events that are likely to become more frequent or more intense and it is possible to plan for uncertainty by retaining options and incorporating flexibility (even reversibility) in decision making.

4.2 Identifying and selecting adaptation options

Broadly adaptation options can be classified as infrastructural (e.g. sea-walls to prevent sea-level rise damage), biological (the rehabilitation of wetlands to mitigate against flooding) and socio-institutional (crop insurance and the legislating against coastal development, for example) and it is deciding which options to apply under location-specific circumstances that is at the core of effective climate change adaptation. Economics can be helpful in making these decisions: McKinsey & Company applied cost-benefit analysis to rank adaptation options (an extension of their marginal abatement-cost curve (McKinsey, 2005)); SwissRe calculated that since 1960 great weather disasters have caused over $1trillion in damages and the UNFCCC recently estimated that by 2030 the world will be spending an additional $36–$135bn each year to address impacts associated with climate change. These figures can be used to mobilise funding: if the cost of the adaptation option is less than the benefit, it makes sense to proceed, and certainly adaptation efforts should begin with those interventions that give the greatest benefit for the least cost (the left hand side of the adaptation cost curve in Figure 9 below). In reality, this is very difficult to do accurately as "costs" are difficult to estimate over time and space, while the best options are often those that are implemented synergistically (social awareness and early warning for example) not discretely. Limitations notwithstanding, cost benefit analyses highlight the import distinction between adaptation options that are (1) "cost negative" – they save money, (2) economically rational – they some cost money but save more money by way of prevented damage than they cost and (3) options that are simply expensive but necessary.

When all costs and benefits are considered, socio-institutional options (which include items such coastal buffer zone legislation, insurance cover, early warning and awareness programmes) tend to be more cost effective than biological options, which tend to be more cost effective than infrastructural options. This is a generalisation, but infrastructural options, in spite of their political allure, are difficult to implement well and have the greatest propensity for unforeseen adverse consequences.

Figure 9: McKinsey's adaptation cost curve.



Source: SwissRe (2009; 48, Figure 19)

Note: The curve ranks options in terms of their financial merit, something that is difficult to do accurately. The approach is useful in identifying cost saving option (below the line), economically rational options (between 0 and 1) and expensive options (above 1), but distinguishing between discrete interventions misses the potential for joint solutions and for social and institutional options that are often the most effective.

4.3 Climate change adaptation in South Africa

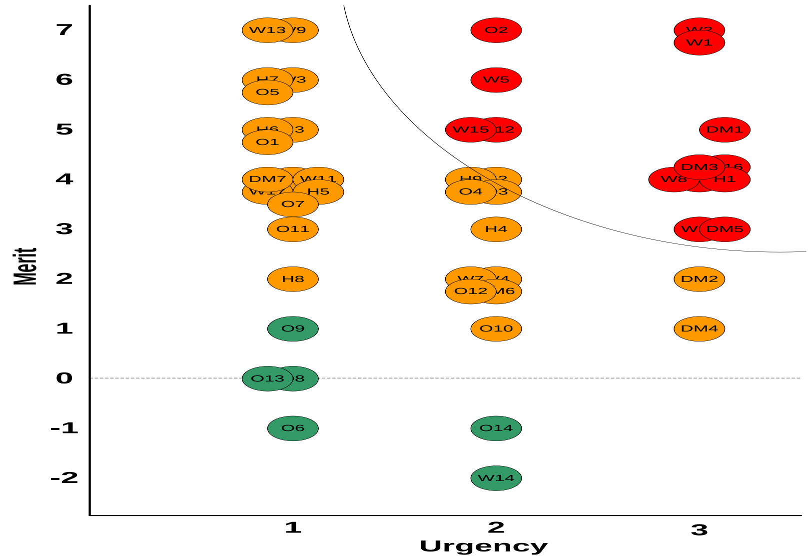
South Africa, as a signatory of the UNFCCC, has submitted a National Climate Change Response Strategy (DEAT, 2004). The strategy supposes warmer atmospheric temperatures with disproportionately warmer nights, a more arid west half of the country, a slightly wetter east and southern coast with rainfall received in fewer more intense events, reduced forestry potential in the north and Western Province, biodiversity losses in the west, central and northern parts of the country and sea-level rise in line with global means for this phenomenon that used to predict upper limit rises of 0.59 metres by the end of the century, but which now entertain rises of up to 6 metres (IPCC, 2007, Hansen, 2008). Like all climate change projections these phenomena may be right on average, but do not adequately describe the full extent of climate change as experienced on the ground.

The most progressive climate change adaptation in South Africa is taking place within municipalities. Both Cape Town and Durban have been internationally acclaimed as examples of how developing country cities might respond to climate change. Cape Town has developed a "Climate Change Adaptation Strategy" and has managed to distinguish itself from the rest of the country in terms of its response to climate change. The City, in conjunction with the University of Cape Town's African Centre for Cities (ACC) has established a "Climate Change Reference Group" comprised of academics, NGO, business and government people and aimed at establishing links between various climate change workstreams taking place within the City. The reference group provides a platform for the type of "socio-institutional learning" (SEI, 2007) that is required for effective adaptation. The high-profile adaptation work in Cape Town revolves around the City's sea-level rise risk assessment that has both valued the economic risk of different sea-level rise events (R5 billion–R22 billion over the next 25 years) and proposed means of reducing this risk.

The City of Durban (and eThekwini Municipality) is the other local government climate change pioneer in South Africa. In 2008, Durban conducted a high-level risk assessment that established generic climate related threats. Durban used this initial piece of work to identify very specific adaptation options, actions and budg*et al*locations in the water, health and disaster management sector. These Municipal Adaptation Plans (MAPs) were then ranked using a multi-criteria assessment so as to establish priorities (Hallegatte, 2008; Van Ierland *et al*., 2007). In Durban options were scored in terms of:

- **Risk reduction:** The extent to which options reduced climate risk.
- **Reversibility and flexibility:** Reversibility and flexibility in decision making came at a premium given the uncertainty over future climate impacts.
- **Ancillary benefits:** Based on the understanding that many climate change coping strategies was used to achieve outcomes that are desirable for reasons other than climate change.
- **Climate change mitigation:** The best adaptation options included greenhouse gas mitigation efforts.
- **Complementary options: A**daptation actions either reduced or retained the set of options available for responding to climate impacts is important. Given the uncertainty, the retention of adaptation options was desirable.
- **Institutional complexity:** Pragmatically, preference was given to those options that were less likely to become bogged down in inter-departmental bureaucracy.
- **Cost: benefit:** Whilst it may not be possible to accurately reflect all costs and benefits, a sense of those options with high benefit and low cost was important.
- **Mal-adaptation risk:** Prioritising those options that had low inherent scope for producing adverse consequences was deemed important, particularly where human and institutional capacity was limited, or where understanding of the underlying environmental dynamics was poor.

Figure 10 A ranking of adaptation options in the eThekwini Municipal Adaptation Plan.



Source: Constable and Cartwright, 2009

Note: The plan applied a multiple criteria assessment to establish the relative "merit" of options and then further ranked priorities in terms of their "merit" and "urgency". The options were divided into water sector interventions (W), health interventions (H), disaster management (DM) and other (O).

The multi-criteria approach to decision making is particularly apt at integrating adaptation options with South Africa's complex set of economic priorities. The Durban Municipal Adaptation Plans represent a novel application of this decision-support tool. The great advantage of this approach is that it forces decision makers to consider parameters that might not conventionally be considered. In so doing it establishes the relationship between day-today decision making and climate change and allows climate change adaptation efforts to be built on the back of existing programmes.

4.4 Financing adaptation

Whilst climate change should be expected to present unprecedented challenges and combinations of risks, much of what is considered climate change adaptation is also best practice in sustainable development. Identifying this overlap represents a sensible point of departure for a developing country. At the moment, however, this view is at odds with that taken by the UNFCCC which has called for climate adaptation funds to be additional to ODA and existing development allocations. The UNFCCC uses the Global Environmental Facility to administer its climate change adaptation funds. The funds falls under three categories, the first and third of which are available to South Africa:

i. **The Special Climate Change Fund** finances concrete adaptation activities, especially projects on water resources management, land management, agriculture, health, infrastructure development, fragile ecosystems such as mountain ecosystems, and coastal area integrated management. The current total for the fund is $62 million.

ii. **The Least Developed Countries Fund** is dedicated to least-developed countries (which excludes South Africa). It finances the same activities as the Special Fund for Climate Change. Least-developed countries have access to expedition procedures for the approval of funding to support the implementation of projects in the context of National Adaptation Programmes of Action (NAPAs). The current total for the fund is $116 million.

iii. **The Adaptation Fund** is financed through a 2 per cent share of the profits from the Clean Development Mechanism (CDM) and finances concrete adaptation projects and programmes in developing countries that are signatories of the Kyoto Protocol. This fund is not yet operational, but could be much larger than the SCCF or LDF.

Including pledges, the total amount committed to the three funds in November 2008 was $313 million (Persson *et al.*, 2009). This is much less than most estimates suggest is required for climate change adaptation (Oxfam, 2007) but a number of public and private donors are now active in the climate change adaptation sector. All of the traditional donors to South Africa – DfID, UKFCO, USAid, IDRC, EU, GTZ, World Bank – now have climate change adaptation programmes and funding. The work of these funders is two-fold: first to ensure that their programmes and projects take cognisance of climate change projections and display a measure of resilience to climate change impacts, and second to assist developing countries (including South Africa) to develop new programmes, technologies, crops and institutions, to cope with the impacts of climate change.

In addition climate issues have attracted funding from newer corporate donors including the Rockefeller Foundation, The Bill and Melinda Gates Foundation, The Google Foundation, the HP Foundation. These donors have brought large funds, novel and often more efficient approaches and in some instances new technologies, to climate change responses.

The UNFCCC used the Nairobi Work Programme process to identify the specific types of activities that could be considered for climate change adaptation funding. The list includes:

- **Methods and tools:** for vulnerability assessments, adaptation planning, data, method and tool dissemination.
- **Data observations:** systematic observation and record keeping. Capacity enhancement for collecting and managing observational data.
- **Climate related risk and extreme events:** Enhance capacity to understand, assess and predict climate variability and occurrence of extreme events and vulnerability to these events. Share information on climate risk assessment. Promote use of tools for climate risk assessment.

- **Action planning and practices:** Exchange of lessons learnt and best practice. Assess means to support adaptation and remove implementation barriers.
- **Research:** Adaptation options and technology development and diffusion. Identifying priorities and analysing options.
- **Technologies for adaptation:** Technological options and transfer of technologies.

Countries such as South Africa would do well draw credible links between their domestic priorities – implementation of the ecological water reserve under the NWA, for example (see below) – and the UNFCCC categories. As the McKinsey cost-benefit analysis showed, however, some of the best options are very low cost (even cost saving) and the current global focus on costing adaptation and drawing down funds, should not come at the expense of existing, locally inspired coping approaches - what IIED term "Community Based Adaptation".

The challenge for policy makers, governments and adaptation NGOs is to draw on local coping mechanisms while scaling adaptation efforts and ensuring that efforts reduce and do not simply transfer risk. Without planning there is a tendency for local adaptation efforts to transfer risk from the affluent to the poor and disenfranchised: overhead mist irrigation can be used to cool horticultural crops but depletes water resources. Regressive risk transfers are one example of a broader phenomenon called "mal-adaptation" that highlights the need for measures of effective adaptation that can indicate whether money is being well spent. Developing measures is not straightforward. It is not possible (with the exception of a few localised infrastructure projects) to "climate proof" a city or programme - the potential risks are simply too diverse and complex. It may be more appropriate to pursue "climate risk management", especially as risk is a concept understood across business, NGO and community constituents, but establishing what level of risk to accept can be difficult. Cost-benefit approaches immediately introduces subjectivity over how non-market items such as human life and environmental resources are valued, and how damage and benefits are attributed and costed over time and space. The goals of "climate resilience" or "climate smart" have respectively been proffered by different NGOs for their ability to capture the merits of planning and pre-emptive action. Different approaches suit different circumstances, but ultimately the need is to move from confidence in the prediction of impacts to confidence in the ability to respond both pre-emptively and reactively. As UKCIP articulate, the aim is a process in which people and regions are "adapting well, not well adapted". Reducing the cost of climate change in a general sense is implicit in this approach.

South Africa's economy is exposed to climate change at all scales, and climate risk affects economic decision at all scales. The same is true of the respective economies of South Africa's trade partners and competitors. Securing the future of the South African economy requires the integration of climate science with effective economic and development planning.

5. Water

Key Findings	Research items
Continue with the implementation of the National Water Water as a right, should be distinguished from water production. The allocation of rights linked to water have transformed rural economies. The opportunity cost of water tends not to be factor economic decisions. Leakages and evapotranspiration account for a high South Africa's energy losses. Pollution from mines, municipalities and agricultu availability of water in South Africa and impose hi costs. Close the gap between economically rational allocatio water" and existing allocations. Major differences exist between most and least effic practices in different sectors.	Explore different evaluations of South Africa's wat Explore the success and failure of water markets conditions elsewhere. Calculate the water intensity (Litre per R GD sectors. Calculate the economic value of the "ecological re "human reserve". Calculate the economic value of municipal, agricu pollution, and continue the roll-out of the programme. Identify the gap between "best" and "worst" practi efficiency of different sectors. Identify and showcase water-efficient technologies

For South Africa's commodity-intensive economy, water is an important component of economic growth. Water is equally important in alleviating poverty - lack of access to enough safe water is both a cause and the result of poverty.[8]

"South Africa is a water scarce country" is a refrain increasingly espoused by politicians, environmentalists and even business people, but the origins and economic implications of this scarcity are poorly understood, and attempts to mange this scarcity have faltered. South Africa captures 79 per cent of its available water resource in large dams – the highest proportion of capture in the world (Turton, 2010) but has only 48 billion cubic metres available to it every year once evapotranspiration losses are included. Evapotranspiration is heavily influenced by the building of large dams, with the Vaal Dam officially being the biggest "user" of water in the Gauteng region. The water security on which the South African economy depends, can not be further supported by the building of dams. Rather South Africa is required to pursue an economic development strategy that is both more water efficient and less water dependent.

[8] Strong correlations (R^2 =0.654) exist between the Human Development Index and the Water Poverty Index. The World Bank for a long time headed a consensus that poverty causes environmental degradation, but there is a growing body of literature suggesting a reverse causality or at least compounding feedback loops.

Defining and measuring water scarcity represents an industry in its own right. [9] The World Health Organisation (WHO) believes that 25 litres per person per day is the minimum required for domestic purposes (although Gleick, 1996[10] applies a figure of 50 litres or 0.05 m^3 per capita per day). What most indicators reveal is that at the global scale the world has enough water, but at the local level water scarcity can be acute due to aridity, allocation of resources and pollution. At this level, scarcity is more often than not a "governance crisis, not a resource crisis" (Rogers, 2004) or as Castro (2004) claims, "In the developing world, the problem is more often caused by policy and institutional failure, rather than by technical failure."

Addressing the governance issue was the focus of the 1992 Water Conference in Dublin. The conference culminated in the "Dublin Principles" which in turn gave rise to the concept of "Integrated Water Resource Management" (IWRM) that has come to be seen as the blue-print for effective water management. The five salient "Dublin Principles" involve:

- The river basin is the most natural unit of management, but effective management integrates the specific strategies of catchments;
- Participatory approaches (with explicit roles for women) are most successful;
- Management should be devolved to the lowest (most local) level possible;
- Water is an economic good and should be valued and managed with economic instruments;
- Water demand management should be favoured over water supply management where possible, given the cost of supply side solutions, the facts that South Africa's rivers are already intensively dammed and the evaporation losses that arise .

South Africa was in the fortunate position of being able to draw on these principles when crafting its post-1994 water policy. The result was the National Water Act (1998), a progressive piece of legislation that was fleshed-out in the National Water Resource Strategy (2003). The NWA represents as good an application of the green economy as is available, but few people appreciate quite how radical it is, or how transformative the implementation of the Act would be.

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[9] The United Nations describes water scarcity as, "The point at which the aggregate impact of all users impinges upon the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully" and estimates that 1.2 billion people lack access to safe and affordable water. The "Water Stress Indicator" (Falkenmark, 1989) uses 1,700 m^3 of renewable water resources per capita per year as the threshold below which countries should be classified as "water scarcity".

[10] Paul Gleick claimed that 5 litres a day were required for drinking, 20 litres for sanitation services, 15 litres for bathing and 10 litres for food preparation.

The NWA discontinued private ownership of water based on riparian rights, nominating the Minster of Water Affairs as the custodian of the “unitary” national water resource which includes all ground water. In terms of the Act and the NWRS, available water is allocated according to a hierarchy of users. Top of this hierarchy is the water required to ensure the continued functioning of hydrological systems (the “ecological reserve”). On the same tier is the 50 litres per person per day that is considered a basic human right (the “human reserve”). Next in the hierarchy of users is trans-boundary obligations, which includes water accords with neighbouring countries. This is followed by strategic uses – water that is required for the provision of electricity and the operating of economic priorities (typically mines). The water that remains, if any water remains once these obligations have been met, is to be used to optimise socio-economic gains in accordance with a loosely defined set of criteria for “water allocation reform”. Criteria take into account existing lawful use as well as broad-based BEE, employment creation, potential returns to this water, gender issues and the sectoral and regional distribution of water. Where insufficient water is available in a given catchment or sub-catchment, the Act envisages a process of “compulsory licensing” in which all water use rights are surrendered, and water is reallocated from scratch in accordance with the principles. The Inkomati Basin was the first to be gazetted for compulsory licensing.

Implementation of the NWA was never going to be easy; water is too scarce and valuable a resource in South Africa. Between 2002 and 2006 DfID provided financial and human resources in support of the research and planning that was required for implementation. In spite of this implementation has faltered, largely over contested allocations and the inability of Catchment Management Agencies to oversee the systematic roll-out of its (highly sophisticated) policy, without alienating existing users on whom agencies rely for financial support.

5.2 Resuscitating the NWA

The difficulties in implementing the NWA and NWRS should not discourage pursuit of the Act’s principles. A more equal and economic allocation of water, more than any other existing policy in South Africa, has the ability to contribute to economic and social reform.

The allocation of water in many basins is economically irrational and constrains growth. In particular the large proportion of water (roughly two thirds) that is consumed by South Africa’s agricultural sector is disproportionate with the contribution that this sector makes to employment and revenue. As Lorentzen *et al.,* (2009) point every additional ton of sugar produced in the Inkomati basis requires 1,660 m^3 of water, and this water consumption is not justified by the economic contribution of sugar and comes at the expense of other economic activities.

The NWA insisted that water should be allocated to people or companies who could best use it, rather than those who could most benefit from it. Typically this saw water allocated to people who owned freehold land or capital intensive operations. A more sensible approach would have seen water rights (or some water rights) allocated in accordance socio-economic goals – with priority given to poor female headed households, for example – and then traded to those users that were best able to use them. In this way water would have still ended up being used by those who could generate the most revenue with it, but currently disenfranchised members of the economy would have been included in the process and benefit stream. In addition aspirant water users would have had to pay prices for water that better reflected the scarcity value of this resource – one of the principles in the NWA which pronounces water an "economic good" – and profligate or inefficient users would be weaned out. The Act allows for water markets and water has long between traded informally between farmers in water users associations in South Africa, but including the poor and the disenfranchised in this process has not yet been considered. If deemed necessary, water markets could exist within sectors so as to protect the agricultural sector which does not generate high returns on water but might be argued to play a strategic role in the economy, for example, and water markets (like all markets) would need to be regulated.

5.3 Avoiding the economic impact of water scarcity

In 2009 WWF produced a guide to the economic and business risks generated by poor water stewardship and water scarcity (Orr *et al*, 2009). The origin of these risks, the authors claimed, "Can be found in actions and decisions taken at the local, national and international level, and the interaction of these decisions with biophysical cycles and trends". The report suggests that the best way to avoid water scarcity risks is, to avoid absolute water shortages through pre-emptive management, and where water is already scarce, to stifle the social and ecological amplification of risk (the knock-on effects of scarcity) by providing enough water for basic human needs and for the functioning of hydrological ecosystems.

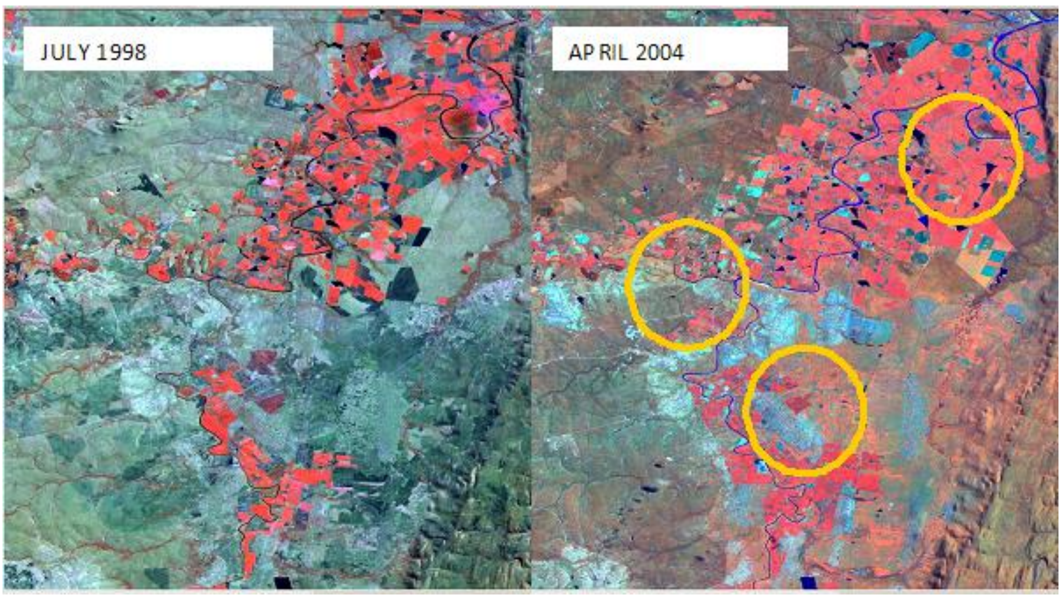
Water crisis management involves the loss of options and very often results in short-termism and the pursuit of options that generate problem of their own. Desalination is cited as an example, providing local relief for water shortages but leading to intensive energy use, environmentally damaging brine discharge and very often the ceding of water rights to desalination investors. Water crises often lead to short-termism a compromise of all-crucial water governance. During the water crises that afflicted north Italy during 2007, for example, the regional companies that both used and managed this water were subjected to speculative attacks from investors, further destabilising the situation and leading to an eventual State of Emergency (see Bloomberg Mobile Messaging, May 2007).

> "Buy Water Stocks: 10 minutes ago ..ITALY DECLARES DROUGHT STATE OF EMERGENCY. ....They are out of Water. And see this from China: "China's breakneck economic growth has left the authorities with a chronic and urgent problem. Chronic WATER shortages have turned clean water into the ultimate precious possessions. This picture is repeated right across China, where every province is either in the midst of a water-related disaster - or panicking about one breaking out". And water, as an investment story, is set to be taken to a whole new level as Beijing comes to terms with one simple fact... They have to spend, spend, spend on water. "China's water crisis is more SEVERE and URGENT than any other country in the world." Suez, Veolia, Impregilo and of course buy more OHL - why worry about Spanish property exposure (which is all non-res anyway) when they are the world leader in reverse osmosis desalination technology - and am yet to see anyway value this properly ´ **(Source: Bloomberg mobile messaging May 2007)**

What then are the opportunities for preventing critical water shortages in South Africa? The NWA correctly emphasises demand side solutions over the building of new dams. There are a number of demand side solutions that are immediately available. These include:

Clamp down on illegal (unlicensed) users, including illegal use of groundwater. The NWA requires all water use to be approved. In spite of this illegal connections have continued. Much illegal use involves the pumping of groundwater on the assumption that this is not part of the national water resource. Groundwater use can alleviate water shortages, but it is part of the same "unitary" water resource that appears in rivers and its extraction requires a license. In 2009 the (then) DWAF admitted that there were 104 mines in South Africa operating without water licenses. Identifying and restricting illegal use is possible with satellite imagery (see Figure 11) and will result in better utilisation of scarce water.

Figure 11 Illegal expansion of sugarcane irrigation in the Inkomati Basin in South Africa



Source: DWAF (2004)

Note: The new red areas in the April 2004 map show land that has come under irrigation since 1998. Given that the basin was gazetted for "compulsory licensing" in 2002, no new irrigation should have been permitted.

- **Plug the leaks.** The cheapest source of water available to South Africa's expanding cities is the water that is already supplied to them. The figures are difficult to establish but up to 30 per cent of available water is "lost" between reservoir and tap (IWA, 2008). Not all of this loss is leakage, some of it is due to administrative and measurement errors. South Africa has a reasonable water network - the country already lowers water pressure during off-peak periods so as to reduce leakage – but maintenance of this network is at risk. Preventing leaks offers potential for significant gains and is cheaper than constructing new supply side infrastructure.

- **Promote efficient irrigation technology.** Agriculture and forestry account for two thirds of South Africa's water use, but there are huge divides between the best available irrigation technologies and those used by most farmers. Uptake of more efficient irrigation technology represents an easy water demand management gain.

- **Prevent contamination, especially by mines, municipalities and agriculture.** Contamination reduces the amount of available water, increases the cost of using water and causes disease and illness for people and livestock. Municipalities that are unable to control the discharge of their sewerage or whose bulk water systems are not patent, are one of the chief culprits. In 2009 the Department of Water and Environmental Affairs initiated the "Blue Drop" programme to test the quality of drinking water provided by South Africa's municipalities and water authorities. Only 38 out of the 787 water authorities attained micro-biological and chemical compliance. Measurement is a start, but improving municipal water quality provides a cost-effective means of reducing the economic burden of scarce water.

  Contaminated mine effluent is another major source of pollution that curtails the availability of water. Poorly managed mine tailing dams have been associated heavy metal and acid pollution. Policing of mine effluent is not difficult, but totally inadequate in South Africa. Coal mine effluent is causing the salination of agricultural land in Mpumalanga and in March 2010 the Grootvlei mine discharged 108 megalitres of untreated acidic water into the Blesbokspruit, a designated Ramsar Convention Wetland, which flows through the Marievale Bird Sanctuary and ultimately into the Vaal River. Farm land effluent is more difficult to police, but nitrate run-off is responsible is known to be responsible for algal blooms and hyacinth growth in rivers.

  Watercourse pollution undermines environmental assets and impairs development efforts, but perhaps most crucially it reduces the availability of suitable water for other users. South Africa's water policy stipulates contamination and temperature levels that are considered polluting, and a "polluter pays" programme has been under development since 2004. Pollution, however, continues to increase. The cost deteriorating agricultural and tourism assets is typically not factored into decisions to award mining rights, but neither is the cost of agricultural and municipal and municipal via water scarcity, typically factored into economic planning decisions. Until such time as these costs are calculated and attributed, water users will face a subsidy to pollute.

- **Encourage sectoral shifts.** The "value" of "benefit" of an increment of water differs at different times and locations (Young, 2005), but different sectors in South Africa use water with varying degrees of efficiency. Crafford *et al.,* (2001) estimated the economic returns to water in South Africa's manufacturing sector at \$25 per m^3, and the returns to mining at \$11.1 per $m^{3.}$ The returns to agricultural water are an order of magnitude lower - \$0.24 m^3 (Lorentzen *et al*. 2007). By gradually shifting South Africa's sectoral priorities to reflect the shortage or availability of water, water-demand can be influenced. The same can be said for trade. Certainly South Africa does not have comparative advantage in water intensive goods, but in spite of this the country continues to produce and export commodities such as sugarcane and coal. Under a more rational economic structure, South Africa would import water intensive goods from countries (including SADC members in the humid inter-tropical convergence zone) and export less water intensive goods and services. The concept of "virtual water" (Allan, 1997) is used to establish the water that is embedded in cross-border trades. The concepts rests on the "opportunity cost" of water - what the water used in the production of exported goods could be used for if it was not exported. It makes no economic sense for water-constrained South Africa to export virtual water.

Innovation, as with all things to do with the economy, offers scope for more efficient use of South Africa's water resource, and alleviating the associated economic constraints. Angloplats Pty LTD has installed reverse osmosis technologies on municipal grey water Limpopo Province, the coal industry is pioneering a purification process that will convert acid mine drainage into drinking water at Emalahleni near Witbank, and aerial surveillance and mapping is being used to detect illegal water use. Typically, innovation is being driven by the private interests of mines and other businesses on using more water (and they risk a semi-privatisation of the water resource), but they do illustrate the potential for making better use of the available resource.

In many ways the South African economy continues to reflect an era when water was considered free and abundant. As water constraints begin to impinge, the judicious and efficient use of the available water will become central to sustained economic growth. So too will the protection of the water resource - negative externalities, when they involve water, tend to be large and difficult to contain. In the NWA South Africa has the legislation required to govern the transition to a more water rational economy. That the implementation of the Act has encountered difficulties is unsurprising given its ambitious remit, the past from which it seeks to change and the dearth of progressive and experienced civil servants in the water sector. This, in no way, constitutes a reason to discontinue its implementation or develop an alternative strategy**.**

6. Externalities, markets, taxes and South Africa's green economy

Key Findings	Research items
Reconciling economic activity with environmental prerequisite for sustained economic growth. The green economy involves more than a new se represents a mode to macro-economic planning. Evaluation of EGS is specific to time, place and better evaluation of key EGS in South Africa economic planning. Environmental scarcity is most acute in poor rura and the poor tend to pay the most (in absolute t EGS. The green economy hinges on the allocation of and the valuing of EGS. The extension of rights to include EGS offers th economic inclusion. A green economy is more prosperous, sustaina involves less people trapped in poverty. South Africa has the policies for a green econ implementation. Use the Municipal Infrastructure Grant to finan infrastructure" protection and rehabilitation.	Explore the compatibility between economic rights to EGS. Explore the absolute costs paid for EGS by affluent and by the rural and the urban. Identify the defining externalities related to wat climate change, their origins, values and econom Identify lead technologies that usher a gre approach in South Africa, and their scope for sca Compare the efficacy of existing efforts externalities. Explore how altered "conditions" in the MIG co include environmental considerations and su economy.

In exploring the green economy, this report highlights examples in which economic decisions fail to consider environmental costs, and the economic constraints that result. How to "internalise" these "externalities" represents contested economic terrain, but is the bedrock of the green economy. Unless externalities are dealt with, prices do not reflect what we value and markets will always yield unforeseen and undesirable outcomes – "market inefficiencies" in the euphemism of economic jargon.

Internalising environmental externalities relies, in part, on valuing environmental goods and services that are not widely traded in markets (the role played by wetlands, for example, in purifying water and buffering flood surges). This approach acknowledges that the global economy resides within the global ecosystem and is supported by its raw materials and services. Robert Costanza *et al*., (1997) valued these ecosystem goods and services (EGS) at

$33 trillion. The exact number is less important than the observation that EGS are valuable and worth protecting.

Once EGS have been valued, people who undermine them need to be charged. This in turn requires the allocation and enforcing of rights. The green economy needs to be explicit about rights: unless there is clarity that the right to clean air is salient over the right to pollute air, or that the right to own land does not constitute the right to degrade that land, correcting the market failures that undermine the green economy will be difficult. Even more complicated, but equally necessary, is the juxtaposing of the right to profits relative to the use of finite resources. Unless the green economy is clear on how it values EGS and assigns rights to this value, it will continue to rely on corporate social responsibility and the work of concerned environmental NGOs. This would represent a massive compromise on the potential that the green economy offers South Africa. Paul Krugman points out in the context of climate change: “Any serious solution must rely mainly on creating a system that gives everyone a self-interested reason to produce fewer emissions. It’s a shame, but climate altruism must take a back seat to the task of getting such a system in place.”

The NWA implicitly pursues this system change through the notion of the “ecological reserve”; protecting this reserve is considered important because of the many services that it supports and the way in which it reduces climate change risk. The carbon market, similarly, seeks to charge polluters for their emission of greenhouse gases and incentivise technologies and activities that reduce emissions. Proponents of the REDD (Reducing Emissions from Deforestation and Forest Degradation) scheme argue that local communities should compensated for not cutting down trees that store CO_2 and there are similar grounds for incentivising the build-up of soil carbon both as store of CO_2 and as a means of improving soil fertility (Akpulu & Ekbom, 2010).

Markets for EGS are sometimes challenged in favour of taxes or fines. The “Pigovian Tax” proposed that people who generate negative externalities should have to pay a fee reflecting the full cost of their activity on society. As Ronald Coase (1960) showed, however, there is (in theory[11]) no difference in the net impact of a market or a tax for externalities, provided rights are clearly specified.

The green economy’s dependence on a clear allocation and enforcement of rights should be good news to South Africa. South Africa has a young but vibrant rights culture and extending rights to include environmental resources, could simultaneously reduce economic uncertainty and including disenfranchised members of the economy; social inclusion is the definitive missing component of South Africa’s market economy. Of course, rights will be contested and any allocation of rights should be accompanied by a means of resolving conflicts and trade-offs.

[11] In practice there are a couple of important differences between cap and trade markets and a pollution tax. One is that the two systems produce different types of uncertainty, the other is that transactions costs affect both outcomes differently.

In some instances trade-offs will involve competing environmental goods and services – desalination relieves the water constraint but burdens climate change due to the energy required. But without the enforcement of environmental rights, the green economy is unlikely to become more than the latest political fad. Certainly, embracing the green economy (an economy that is really just a manifestation of economic first-principle) prior to the allocation of rights and values, will undermine the full potential that this approach to economic development has to offer. As environmental scarcity increases and competition for environmental goods and services is heightened, vested interests and powerful lobby groups will over-run loosely defined customary rights, enforcing a replication of existing divisions of wealth (as expounded by Hernando De Soto[12]).

Enforceable rights are a prerequisite for a green economy, but provided rights can asserted, the issue for the public sector in South Africa becomes how to bring about the behavioural and structural shifts required by the type of green economy described in this report. Ideally, each sphere of government would contribute to a coherent legislative and financial system, but this is both very difficult in practice and improbable. Local municipalities are in most instances at the forefront of environmental impacts and also represent the sphere of government most active in developing responses to environmental threats and constraints. In this regard, the Municipal Infrastructure Grant (MIG) (by far the greatest ”conditional grant” allocation from national to local government in South Africa) represents a crucial lever for change.

As a conditional grant the MIG, which is most commonly managed by District Municipalities, can only be spent in accordance with guidelines laid down by National Treasury. In the past the MIG has been used to breach perceived infrastructure deficits with a particular emphasis on bulk water infrastructure and roads. In spending the MIG municipalities are meant to comply with employment criteria that favour women, the youth and the disabled and because of the size of MIG allocations, municipalities go out of their way to comply. If the conditions attached to the MIG were expanded to promote the type of infrastructure that supported (as opposed to degraded) environmental functions the result would be a more sustainable built environment. Equally, if the MIG conditions acknowledged that the protection and restoration of ecological infrastructure (green spaces, riparian zones, parks, indigenous forests, wetlands, coastal buffer zones, water courses and soil fertility for example) was as valuable to the economy and the quest for poverty alleviation in the same way as built infrastructure, this money could be used to incentivize the type of built environment that contributed to a green economy.

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[12] De Soto believed no market economy could succeed when the majority of the population had no vested interest in that economy. The Peruvian economist famously, and successfully, advocated land and production rights to Peru’s small-scale informal-sector farmers, ensuring they received full value for their land when it was traded to mines or to coca-producing agribusinesses.

7. Conclusion

Most economics requires assumptions about the future. Historically the most common approach imagined that the future would resemble the past, and that (variability notwithstanding) existing environmental conditions would continue. Green economics is different in that it acknowledges that many environmental resources are finite, and that environmental systems have the potential to be irrevocably perturbed. Implementing this approach to economic rests on two fundamental economic principles: (1) prices should reflect scarcity value (what economists call opportunity cost) and (2) prices should tell the truth about what is valued. Where this is not the case markets fail and economies operate in a bubble that will eventually burst, necessitating costly transition.

In this report it is proposed that fossil fuel energy, climate change and water shortages, all represent a form of market failure from which an economic transition is necessary. The regions and countries that affect this transition pre-emptively will emerge as the economic leaders of the 21st Century. Whilst early action in each of these examples, will involve some costs, it is becoming clear that these costs might be quite small,[13] and very small relative to the alternative of environmental and economic collapse.

The rise of the green economy in South Africa should be welcomed both as a necessity and an opportunity. Approaching economic planning from an ecological (or “green”) perspective forces decision makers to consider the full and systemic impact of their actions, rather than the discrete and short-term impact. When the economy, society and the environment are viewed as inter-dependant components of a single system, decision makers become less prone to decisions that have adverse consequences and are better able to identify those interventions that lead to simultaneous solutions and virtuous cycles of improvement. There is, however, a danger that this economy will be seen as an annex of the real economy; a new sector with a few new jobs. This would be at the expense of a more definitive approach in which the extension of rights to environmental goods and services formed part of the social inclusion effort, and the economy of South Africa is better matched to the environmental resources of the country so as to become more prosperous, more labour intensive, more sustainable and have fewer people living in poverty and trapped in poverty by environmental degradation.

In most instances South Africa has the policies to manage the required change. Policy implementation requires clear leadership in which the goals are articulated, the case for pursuing these goals is widely understood and resources are mobilized. The rationale for this approach should be the retention of competitive advantage in the face of environmental change and the creation of new competitive advantages over the medium term.

[13] As Stiglitz (2003) points out, the greenhouse gas pollution taxes that are so vehemently opposed by energy and automobile companies on the grounds that they would impair growth, would actually boost energy independence, economic efficiency and employment

8. Reference list

Adger, N., Arnell, N., Tompkins, E. (2004) "Successful Adaptation to Climate Change across Scales". *Global Environmental Change* (15), pp. 77-88.

Akpulu, W. & Ekbom, A. (2010) The bio-economics of conservation agriculture and soil carbon sequestration in developing countries. Environment for Development.

Alfstad, T. (2004) "Meeting South African Renewable Energy Targets". *Recommend,* 1 (2), pp. 1–3.

Allan, J (1997) 'Virtual Water': A Long Term Solution for Water Short Middle Eastern Economies. *British Association Festival of Science*. University of Leeds. 9 September 1997.

Austin *et al*. (2003) (Agama Energy) (2003) Employment Potential of Renewable energy in South Africa. A Study Commissioned by the Sustainable Energy and Climate Change Partnership, a Project of Earthlife Africa, Johannesburg, in partnership with WWF, Denmark. Johannesburg: Sustainable Energy and Climate Change Partnership.

Awerbuch S., *et al*. (1996) 'Capital budgeting, technological innovation and the emerging competitive environment of the electric power industry', *Energy Policy,* 24 (2): 195-202.

Awerbuch, S. (2006) '*The Economics of Wind. A Critique of IEA and Other Levelized Cost Methodologies'*.

Bery, A; Von Blottnitz, M; Cassim, R, Kesper, A; Rajartnam, B & D van Seventer (2000) *The Economics of Small, Medium and Micro-enterprises in South Africa*. Trade and Industry Policy Strategies.

Bloomberg (2009) *New Energy Finance* Available at: www.newenergyfinance.com/Cartwright 2010.

Cartwright, A (2008) Biofuel, Trade and Sustainable Development; the case of South African bioethanol. Book Chapter in Dufey, A (ed.) *Biofuel, Trade and Sustainable Development*. IIED publications.

Cartwright, A (2009) *Coastal Vulnerability in The Context of Climate Change: A South African Perspective*. Discussion Paper, presented at the Misereor Conference.

Castro J-E, (2004) "Urban Water and the Politics of Citizenship: the case of the Mexico City Metropolitan Area during the 1980s and 1990s" *Environment and Planning* 36(2), pp. 327 – 346.

Constable, L & Cartwright, A (2009) *A Municipal Adaptation Plan for eThekwini*. Report Compiled for Debra Roberts, Development Planning, Environment and Management Unit eThekwini Municipality.

Coase, R (1960) The Problem of Social Choice. *Journal of Law and Economics*, vol. 3.

Crafford, J; King, N, Malubani, T, Anderson, H & De Wit, M. (2001) *Water Resource Accounts for South Africa 1991-1998*. CSIR, Environmentek, Pretoria.

Crafford, J; Hassan, R; King, N; Damon, M; De Wit, M; Bekker, S; Rapholo, B and Olbrich, B. (2004) An Analysis of the Social, Economic, and Environmental Direct and Indirect Costs and Benefits of Water Use in Irrigated Agriculture and Forestry: a case study of the Crocodile River Catchment, Mpumalanga Province. *WRC Report* No. 1048/1/04.

CSIR (2010) Basic Assessment Report for the Proposed Erection of Seven Wind Measuring Masts in the Western and Northern Cape as Part of the National Wind Atlas Project of the Department of Energy: *CSIR Report* No. CSIR/CAS/EMS/ER/2009/0028/B. Stellenbosch.

DEAT, (2004) National Climate Change Response Strategy. Available at: http://soer.deat.gov.za

DME (Department of Minerals and Energy, South Africa) (1998a) *White Paper on Energy Policy for South Africa*. Pretoria: Department of Minerals and Energy. Available at http://www.dme.gov.za/pdfs/energy/planning/wp_energy_policy_1998.pdf.

DME 2003. *White Paper on the Renewable Energy of the Republic of South Africa.* Department of Minerals and Energy, Pretoria. Available at: www.dme.gov.za/pdfs/energy/cabeere/cabeere_page4_2004.pdf

Diab, R. (1988) 'The Wind Energy resource in Southern Africa, in Eberhard, A. & Williams, A. (eds.)*, Renewable Energy Resources and Technology Development in Southern Africa*, Cape Town: Eland Press.

Dow and Downing (2007) *Climate Change Atlas*, Earthscan Press.

Downing, T. E., Cartwright, A and Smith, B (2007) *Defining the Food and Agriculture's Role in Climate Change Adaptation*. Report in partial completion of the compilation of FAO's Climate Change Adaptation Strategy. Available at: http://www.fao.org/climatechange/home/en/

Dufey, A (2006) *Biofuels Production, Trade and Sustainable Development: Emerging Issues*, International Institute for Environment and Development, London.

DWAF (2004). Presentation by Gavin Quibell

Eberhard, A, Van Horen, C (1994) New Imperatives for Energy Policy in South Africa. *EDRC Report* No 26. EDRC, Energy Research Institute, University of Cape Town, 51pp, 1994.

Eberhard, A. & Williams, A. (1988) *Renewable Energy Resources and Technology development in South Africa.* Cape Town: Elan Press.

SwissRe (2009) "*Shaping Climate-Resilient Development – A Framework for Decision Making*", A report for the economics of climate adaptation working group. Available online at http://media.swissre.com/documents/rethinking_shaping_climate_resilent_development_en.pdf (last accessed August 2010)

Edkins, M, Winkler, H and Marquard, A (2009) Large-scale Rollout of Concentrating Solar Power in South Africa. *ISDA project*. Available at: www.climatestategies.org

International Institute for Applied Systems Analysis (IIASA) (1998) Experience Curves for Energy Technology Policy (EXCETP), published as part of the Environmentally Compatible Energy Strategies (ECA) Programme, October, Paris.

IEA SHC (2008) International Energy Agency Solar Heating and Cooling. Available at: http://www.iea-shc.org/

Falkenmark M (1997) Meeting Water Requirements of an Expanding World Population. *Philosophical Transactions of the Royal Society*, vol. 352 (1356).

Gleick, P (1996) Basic Water Requirements for Human Activities: Meeting Basic Needs. *Water International* (21) pp. 83-92.

Greyling, L (2009) Decoupling Minerals and Energy: a new dressing for the status quo? In *New Nexus of Power and Accountability in South African Energy*. ISS Conference Report, November 2009. R Dhada (editor).

Hallegatte, S (2008) Strategies to Adapt to an Uncertain Climate Change. Global *Environmental Change*, 684, pp. 8.

Hawken, P, Lovins, A and Hunter-Lovins, L (1999) *Natural Capitalism; creating the next green revolution*. Little, Brown and Company, First Back Bay.

Hansen, J. 2007. Scientific Reticence and Sea-level Rise. IOP Environmental Research Letters. Available at http://www.iop.org/EJ/article

Hausman, R (2008) Final recommendations of the international panel on growth. Available at: http://www.treasury.gov.za/publications/other/growth/01-Overall%20Summary%20and%20Final%20Recommendations/01-Final%20Recommendations%20of%20the%20International%20Panel.pdf

Ohlin, B (1967) *Hecksher-Ohlin trade model (1935)* published by. Interregional and International Trade. Harvard Economic Studies. 39. Cambridge, MA: Harvard University Press.

Holling C. (1973) “Resilience and Stability of Ecological systems”. *Annual Review of Ecology and Systematics*. 4, pp. 1-23.

International Energy Association (2007) ‘*Energy Technologies at the Cutting Edge: international Energy Technology Collaboration IEA Implementing Agreements’*, available at: http://www.eia.doe.gov/emeu/cabs/South_Africa/pdf, accessed on February 2010

IEA (2009) *Key World Energy Statistics from the IEA*. Paris: International Energy Agency

International Energy Association (2009) *World Energy Outlook*. Paris: International Energy Agency.

IPCC (2007) *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. Geneva: Intergovernmental Panel on Climate Change

IPCC (2007) *Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability* .Contribution of Working Group II to the Fourth Assessment Report of the IPCC. Geneva: Intergovernmental Panel on Climate Change.

IWA (2008) *Journal of Water Supply: Research and Technology*. Available at: http://www.iwaponline.com/jws/

Jardine, C & Lane, K (2002) *PV-COMPARE: Relative Performance of Photovoltaic Technologies in Northern and Southern Europe.* PV in Europe Conference and Exhibition, Rome, 2002.

Lorentzen, J, Cartwright, A and Meth, C (2007) The Impact of Trade Liberalisation on Rural Livelihoods and the Environment Land Governance, Asset Control, and Water Access and Use in the Incomati River Basin in Mpumalanga, South Africa. *In Vulnerable People, Vulnerable Places; Trade Liberalization, Rural Poverty and the Environment* (ed. J Cooke).

Lorentzen *et al*., (2009) *Limpopo Innovation Strategy: final report*. Submitted to the Office of the Premier Limpopo Province and the Department of Science and Technology, Pretoria.

Lorentzen, J (2009) Learning by Firms: the Black Box of South Africa's Innovation System. *Science and Public Policy*. Vol. 36(1).

LTMS (2009) *Long-term Mitigation Scenarios*, prepared for the Department of Environmental Affairs and Tourism, South Africa. Technical Summary. Available at: http://www.environment.gov.za/HotIssues/2009/LTMS2/LTMSTechnicalSummary.pdf

Luecke, R & Katz, R (2003). Managing Creativity and Innovation. Boston, MA: Harvard Business School Press. ISBN 1-59139-112-1.

Martinez-Alier, J (1995) The Environment as a Luxury Good or Too Poor to be Green? *Ecological Economics* 13 (1), pp. 1-10.

Mathews, J (2010) *Renewable Energies as a Developmental Pathway for Southern Africa*. Forthcoming Paper Presented at the HSRC Seminar.

McKinsey (2007) A Cost Curve for Greenhouse Gas Mitigation. *The McKinsey Quarterl*y. Available at: http://www.epa.gov/air/caaac/coaltech/2007_05_mckinsey.pdf

Meadows, D, Meadows, D, Randers, J and Behrens, W (1972) *The Limits to Growth*. Universe Books.

MRPASA (2009) Cited in the *Business Report*, December 3, 2009.

National Energy Regulator of South Africa (2009) Eskom Revenue Application. Multi-year Price Determination. 2010/2011 to 2012/13. *Issues Paper*. Published 30 October 2009.

Orr, S, Cartwright, A & Tickner, D (2009) Understanding Water Risks: a primer on the consequences of water scarcity for business and government. *WWF Water Security Series* 4.

Oxfam (2007) Adapting to climate change: what's needed in poor countries and who should pay. *Oxfam Briefing Paper*, 29 May 2007. Available at: http://www.oxfam.org.uk/resources/policy/climate_change/downloads/bp104_adapting_to_climate_change.pdf

Paul Krugman, *New York Times*, 5 April 2010.

Pegel, A (2009) Prospects for Renewable Energy in South Africa: mobilizing the private sector. *Discussion Paper* / Deutsches Institut für Entwicklungspolitik ; 23/2009) ISBN: 978-3-88985-473-5.

Persson, Å.; Klein, R.J.T.; Siebert Kehler, C.; Atteridge, A.; Müller, B.; Hoffmaister, J.; Lazarus, M.; Takama, T. (2009) *Adaptation Finance Under a Copenhagen Agreed Outcome*. Report Supported by the Swedish Foundation for Strategic Environmental Research (Mistra), through its research programme Clipore (Climate Policy Research).

Ren21 (2009) *Renewables: Global Status Report*. Paris: REN21 Secretariat Available at: http://www.ren21.net/pdf/RE_GSR_2009_Update.pdf

Robert Costanza *et al*., (1997) The Value of the World's Ecosystem Services and Natural Capital. *Nature* 387, pp.253-260.

Rogers, P (2004) *Water Crisis: myth or reality*? Taylor and Francis, London.

Rogerson, C (1999) Small Enterprise Development in Post Apartheid South Africa: gearing up for growth and poverty alleviation, in K King and S McGrath (eds) *Enterprise in Africa, Between Poverty and Growth*, London IT Publications, 83-94.

South African Biofuel Feasibility Study (2006) Available at: http://www.saba.za.org/site/

Shell (2009) *Energy Scenarios to 2050*. Available at: www.shell.com

Spalding-Fecher R & Matibe DK (2003) Electricity and Externalities in South Africa. *Energy Policy* 31(8): 721–734.

Steenblik, R. (2007) *Biofuels - At What Cost? Government Support for Ethanol and Biodiesel in Selected OECD Countries*. International Institute for Sustainable Development (IISD). Available online at: http://www.iisd.org/PUBLICATIONS/pub.aspx?pno=895

Stern, N., S. Peters, V. Bakhshi, A. Bowen, C. Cameron, S. Catovsky, D. Crane, S. Cruickshank, S. Dietz, N. Edmonson, S.-L. Garbett, L. Hamid, G. Hoffman, D. Ingram, B. Jones,

N. Patmore, H. Radcliffe, R. Sathiyarajah, M. Stock, C. Taylor, T. Vernon, H. Wanjie, and D. Zenghelis (2006), *Stern Review: The Economics of Climate Change*, HM Treasury, London.

Stiglitz, J (2003) *The Roaring Nineties: a new history of the world's most prosperous decade.* Penguin Publishers.

Turton, A (2010) Water: our future is evaporating. Commissioned Article in the *Times Newspaper*. 25-01-2010. Available at: http://www.timeslive.co.za/opinion/article277178.ece/Water--Our-future-is-evaporating

Turton, A (2010) How to beat the water crisis. Commissioned article in the *Times Newspaper*. 23-03-2010. Available at: http://www.timeslive.co.za/opinion/article368323.ece

United Kingdom Energy Research Centre (2007) Available at: http://ukerc.rl.ac.uk/UCAT/cgi-bin/ucat_query.pl?GoButton=Year&YWant=2007

UNDP, UNDESA, & WEC (2000) *World Energy Assessment*. New York.

UNEP (2009) Global Trends in Sustainable Energy Investment 2009. *Analysis of Trends and Issues in the Financing of Sustainable Energy Investment*. ISBN 978 92 807 3038, DTI/1186/PA.

Van Ierland, E, de Bruin, K; Dellink, R and A. Ruijs (2007) *A Qualitative Assessment of Climate Adaptation Options and Some Estimates of Adaptation Costs*. Study performed within the framework of the Netherlands Policy Programme. ARK as Routeplanner projects 3, 4 & 5, Wageningen University.

WC DEA (2007) *Renewable Energy Action Plan*. Western Cape Department of Environment. Available at: http://www.wcapeenergy.net/PlanofAction.htm

Weitzman, M (2009) On Modeling and Interpreting the Economics of catastrophic Climate Change. *The Review of Economics and Statistics*, vol. XCI.

Western Cape Government (2010) *Review of Renewable Technology Options Available to the Western Cape Economy*. Report commissioned by the Department of Economic Development and Tourism.

WEC (World Energy Council) (1993). *Renewable Energy Resources: Opportunities and Constraints 1990-2020*, London: World Energy Council.

Western Cape DEAT (2007) *Sustainable Energy Action Plan*. Available at: www.wcapeenergy.net/Documents_Policy.htm

Winkler (2008) *Cleaner Energy, Cooler Climate*. Developing Sustainable Energy Solutions for South Africa. HSRC Press.

World Development Indicators. Available at: http://data.worldbank.org/

World Resources Institute (2009) *Climate Analysis Indicators Tool* (CAIT). Washington DC. Available at: http://www.cait.wri.org

Young, R (2005) Determining the Economic Value of Water: concepts and methods. *Resources for the Future*. ISBN: 1-891853-98-8.

Ziervogel, G, Cartwright, A, Tas, A, Adejuwon, J, Zermoglio, F and Shale, M (2008) *Climate Change and Adaptation in Africa*. Prepared for the Rockefeller Foundation by the Stockholm Environment Institute (March, 2008).