Putting a price on carbon

Economic instruments to mitigate climate change in South Africa and other developing countries

Proceedings of the conference held at the University of Cape Town, 23-24 March 2010

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Preface

The conference, *Putting a price on carbon: Economic instruments to mitigate climate change in South Africa and other developing countries,* was organised by Associate Professor Harald Winkler, Dr Andrew Marquard and Meagan Jooste, who are all researchers in the Energy and Climate Change Programme of the Energy Research Centre (ERC) at the University of Cape Town. The conference was held at the University on 23 and 24 March 2010.

There has been extensive debate among researchers in developed countries whether an emissions trading scheme or carbon tax is the best means to 'put a price on carbon'. Other economic instruments could contribute to mitigation of greenhouse gas emissions indirectly, including tradable certificates for renewable energy or energy efficiency. The conference organisers intended to take up the debate on how such instruments might apply in South Africa and other developing countries, putting carbon pricing in the context of broader policy on climate and development. This has not been done in depth previously.

Specifically, the intentions behind the conference were to:

- Build on discussions undertaken at a side-event and a workshop at the Climate Change Summit 2009 (see the scoping papers on economic instruments to mitigate climate change in South Africa at www.erc.uct.ac.za),
- Contribute to the development of climate policy in South Africa, by further exploring practical options for putting a price on carbon,
- Deepen the understanding of economic instruments,
- Broaden the community of experts working in this emerging field, by attracting papers from researchers and analysts in cognate disciplines who are not currently working on carbon pricing – including economics and environmental economics, but also researchers working on institutional and political dimensions
- Draw on experiences and lessons from other countries, in particular other developing countries in their exploration of the same issues in similar contexts, but also looking at the experiences of implementation in developed countries and examining their applicability in the context of development.

The ERC issued a call for papers in May 2009. In April and May 2009 ERC identified and appointed a Review Committee of the following people:

- Bamikole Amigun, Council for Scientific and Industrial Research
- Prof James Blignaut, Department of Economics (University of Pretoria)
- Michael Goldblatt, Environmental Economist (Palmer Development Group)
- Dr Yvonne Hansen, African Centre for Cities (University of Cape Town)
- Dr Andrew Marquard, Energy Research Centre (University of Cape Town)
- Josephine Musango, Council for Scientific and Industrial Research
- Emily Tyler, Climate Change Economist (Private Consultant)
- Dr Martine Visser, Environmental Policy Research Unit (University of Cape Town)

- Assoc Prof Harald Winkler, Energy Research Centre (University of Cape Town)
- Dr Russell Wise, Environmental and Resource Economist (Australia)

The ERC conducted an internal assessment of the abstracts submitted in response to the Call for Papers and requested the committee to comment on the ERC assessment and ranking of abstracts. The Review Committee finally chose to rank abstracts as follows:

Category 1: Accepted as is, invite author(s) to submit full paper.

Category 2: Would like to accept abstract and invite paper, but request a re-submission which shows a clear alignment with the conference topic (carbon pricing and climate change mitigation).

Category 3: Abstract could be accepted but there is no developing country co-author and thus a re-submission of the abstract will be requested which shows such co-authoring.

Category 4: Abstract not accepted. On the grounds that it is either no relevance to our conference or the developing country context, or the topic does not appear to have been well-thought through.

Authors in categories 2 and 3 were approached to request they amend their abstracts accordingly and resubmit. Once authors re-submitted their abstracts, ERC issued a request for draft papers by November 2009. In early November 2009 reviewers were assigned to review each of the fifteen papers received.

In mid-November 2009 reviewers were asked to complete a reviewer form in the template of the *Climate Policy* Journal's Reviewer form by January 2010. ERC collated reviewer comments and through discussions with the committee chose to reject two of the Draft Papers submitted. During this time one paper's author had to withdraw due to a schedule conflict with the conference. As such, twelve authors were approached to complete edits to their conference papers by mid-February 2010. Authors submitted revised papers based on independent peer review by early March 2010. The ERC then compiled this volume.

The papers in this proceedings address a variety of themes in this area: emissions trading, carbon taxes, fiscal and non-fiscal instruments, policy and institutional dimensions, and lessons from the Clean Development Mechanism.

As can be seen from the list of participants, the conference attracted researchers from a wide range of disciplines who share an interest in the use of economic instruments to mitigate climate change, as well as South African and other developing country government decision-makers.

Five themes emerged from the conference papers, as indicated in the table of contents. All of the academic conference papers are included in this publication; papers that were not peer-reviewed but reflect inputs by South African government policy-makers and a guest researcher from Brazil are not included here. This latter group of papers included the following:

- Lingela, V (Department of Science and Technology). 2010 International strategy to develop technology capability in South Africa through the Clean Development Mechanism.

- Lucena, A et al (Energy Planning Program, COPPE, Federal University of Rio de Janeiro, Brazil). 2010. Calculating the marginal cost of mitigation in various sectors of the Brazilian economy.
- Visagie, M (Department of Trade and Industry). 2010. Climate change and government's drive to promote green employment'.

Acknowledgements

The Energy Research Centre would like to extend a thank you to the members of the conference Review Committee for their time assist us in the planning of the conference, as well as reviewing the conference papers included in this document.

We are also grateful to our funders, the European Commission Directorate-General for Environment. Their sponsorship has allowed the Energy Research Centre to conduct research into economic instruments to mitigate climate change in South Africa and to organise this conference.

Finally, to the organising committee and support team of the conference: we thank you all for your hard work in making this conference a success.

THEME 1: CARBON PRICING AND THE POLICY ENVIRONMENT

Aligning South African energy and climate change mitigation policy

Emily Tyler

Abstract
This paper considers the alignment of energy policy in South Africa with the Cabinet's mitigation vision of a 'peak, plateau and decline' greenhouse gas emissions trajectory to 2050. First, the term 'policy' is defined as having a number of levels and components. Following from this definition it is argued that, at the level of written and stated energy policy, the intention exists to move towards a more diverse, efficient and less carbon-intensive energy sector. A number of policy instruments are being developed which go some way towards achieving this, although targets set are too low. However, at a policy paradigm level, the dominant energy policy paradigm and the orientation and capacity of the country's energy institutions are fundamentaly misaligned with the Cabinet's mitigation vision. In particular, vested interests within these institutions constrain policy co-ordination and hence alignment.

The paper then explores how greater alignment could be secured The establishment of a single, overarching, co-ordinating energy policy institution through intervention at the highest political level appears to be a prerequisite. This institution could then govern appropriately oriented institutional capacity, either by creating new institutions, or mandating existing institutions to deliver on low-carbon initiatives. It is suggested that, whilst new capacity may be optimal, it could be unrealistic to attain this level of sector transformation within the timeframes required by mitigation policy, given the strongly entrenched energy sector interests in maintaining the status quo.

Keywords: Policy paradigm, peak plateau and decline, mitigation wedges, renewable energy, institutional orientation, contested interests

1. Introduction and overview

This paper considers the alignment of existing and emerging energy and related policy areas with South Africa's climate change mitigation aspirations. Areas of synergy and conflict with the country's climate change mitigation objectives are explored, and the paper considers how greater policy alignment could be achieved. The paper begins by discussing the concept of 'policy', and deriving a working definition for the purposes of the analysis. Climate policy in the current South African context is then defined in section three, followed in section four by a consideration of the concept of energy policy paradigms, and particularly their application to the climate mitigation objectives.

Sections five and six consider recent energy policy developments from the perspective of meeting carbon mitigation objectives, with section seven concluding that whilst climate mitigation and energy policy are aligned in intent and written form, they are strongly misaligned at the level of policy paradigm and institutional orientation. Section eight explores some possible ways in which this misalignment could be addressed, with section nine concluding and identifying areas for future research.

2. 'Policy': a working definition

There is no universally agreed definition of what constitutes 'policy'. Policy could encompass the set of decisions undertaken by government, but it could also include the influences which determine both the way in which these decisions are interpreted, and which decisions end up being implemented. Further, it may include the context that determines the types of issues considered for decision initially. Policy is unlikely to be static, but rather continuously evolve as existing decisions are adapted and modified. A more detailed discussion of the definition of policy is beyond the scope of this paper. However, for the purposes of this paper, certain concepts are drawn from Marquard (2006) and expanded on by the author, for use as a working definition:

- At its broadest conception, policy is governed by the policy paradigm, defined as 'the system of ideas and standards that specify the goals of policy, the kinds of instruments that can be used to attain them, and the very nature of the problems they are meant to address'(Menahem quoted in Marquard (2006)).
- Policy comprises both formal decisions, and informal decisions made during the policy development process. These are linked inter-temporally as decisions result in further decisions, and structurally, as decisions are detailed and implemented.
- There is both an administrative and a political function to policy development.
- Institutional capacity is an important determinant of policy direction, encouraging or constraining the elaboration of policy along particular paths.
- Policy development can be contested due to conflict of interests within the policy making community. This could result in a lack of coherence between the various components of policy.

- A policy can be referred to as actualised if it is embedded in an institutional context, attracts resources on an ongoing basis for implementation, and results in further policy development in a similar direction.

Policy is therefore understood to comprise a range of written policy documents (white papers and regulation), statements by policymakers, intentions and directions as included in green papers and strategic documents, institutional capacity and orientation, and actualized policy. Policy is also continuously evolving, is often contested and incohesive, with the dominant policy paradigm driving policy focus and direction.

3. South African climate mitigation policy

South Africa is in the early stages of developing climate change mitigation policy, with only policy intentions and directions existing at this stage. The major components of this policy direction include: the First and Second National Communications to the United Nations Framework Convention on Climate Change (UNFCCC), 2004 Climate Change Response Strategy, the 2005 Technology Needs Assessment, the Long Term Mitigation Scenarios (LTMS) process, the African National Congress (ANC)'s 2007 Polokwane Resolution on Climate Change, the 2008 Cabinet Response to the LTMS, outlining a strategic mitigation vision based on a 'peak, plateau and decline' trajectory, the March 2009 Climate Policy Summit Discussion Document, and international commitments made at the 2009 Copenhagen Conference of the Parties to the Kyoto Protocol.

The peak, plateau and decline trajectory most succinctly encapsulates the broad climate policy direction as it currently stands, described as a shift 'from an energy-intensive to a climate-friendly path as part of a pro-growth, pro-developoment and pro-jobs strategy' (van Schalkwyk 2008). The trajectory is depicted in Figure 1 below, together with the LTMS graphs upon which it is based.

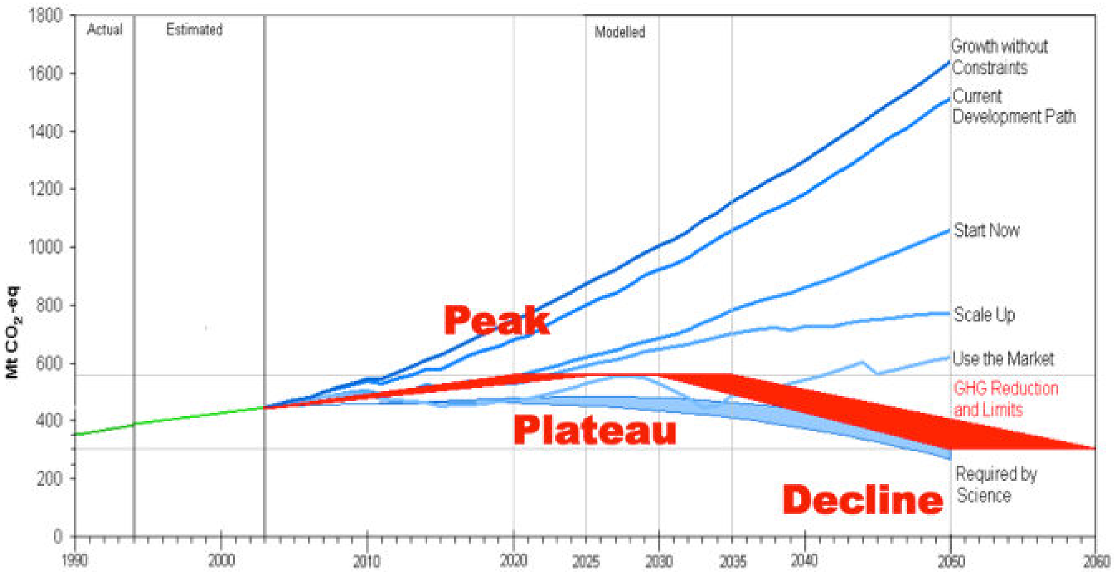

Figure 1: LTMS graphs and Cabinet's peak, plateau and decline trajectory

The trajectory, depicted in red, allows emissions to rise to 2020/25, then plateau until 2035, before declining from 2035 to meet the required-by-science target identified by the LTMS of between 30% and 40% reduction by 2050. This trajectory was confirmed on the international stage in 2009 with the South African delegation to the Copenhagen COP offering to reduce emissions by 34% of a business as usual trajectory by 2020, and 42% by 2025, subject to international technological and financial assistance.

Combining Cabinet's strategic vision with direction from other policy processes and building blocks, clarity on a number of energy related aspects of climate change policy direction emerges, revealing the following current energy-related climate change policy direction:

- Emissions will rise to 34% below current projects by 2020, peak at 42% in 2025, plateau until 2030 and then decline to 2050.
- Renewables and nuclear will contribute in equal measure to a long term carbon neutral grid, with interim targets by 2030. Feed-in tariffs will support renewable energy.
- CCS will be mandatory for new both coal-fired power generation and will be explored for existing coal plants and CTL.
- Energy efficiency measures will be immediately implemented, building on the electricity crisis response. A mandatory national efficiency programme will be introduced.
- Economic (carbon pricing), fiscal instruments and regulation will be employed to support a low carbon economy
- In the transport sector, vehicle efficiencies will be pursued, as well as electric vehicles, R&D for hybrids and passenger modal shift.
- Institutional support for the above will be fast-tracked.

Whether the strength of the Cabinet's strategic vision is retained as the written and institutional climate mitigation policy is developed depends on a number of factors. Most important among these is where in government the issue of climate mitigation is championed, and what level of influence this champion, or these champions, have. Currently the lead department is the Department of Environmental Affairs, and there are some indications that the Planning Commission may adopt elements of the mitigation agenda. Whilst the ANC and Cabinet appear fully behind the peak, plateau and decline trajectory, the weight this is given will depend on how well it is aligned with the overarching policy paradigm within the new government, which is strongly pro-poor and pro-jobs. International pressures, stemming from both the negotiations under the UNFCCC and Kyoto, and from trade regime developments will also influence the strength of the eventual policy framework.

4. Energy policy paradigms

Marquard (2006) constructs a set of four possible consecutive energy policy paradigms to assist in analysing the state of energy policy in South Africa. The paradigms and analysis provide insights into the question of climate and energy policy alignment at its broadest level.

The least sophisticated paradigm is termed 'Autarky' (0), where there is no coordination of the energy sector. This is followed by (1), 'Energy supply' where the policy objective is to ensure adequate energy supply to match a growing economy. Paradigm (2) 'Supply-demand' sees an awareness of energy demand as a factor in policy, and characterises many of the OECD energy systems today. Finally the hypothetical 'Structural-cultural' paradigm (3) includes cognisance of societal and behavioural factors as part of the energy system. Marquard proposes that the more sophisticated policy paradigms (2) and particularly (3) are better able to respond to policy challenges such as climate change given their expanded view of the energy system and its interactions with society as a whole.

A wider consideration of energy policy such as that envisaged under the Structural-cultural paradigm is strongly aligned with the Cabinet's mitigation vision; as the country progresses along the peak, plateau and decline trajectory an increasingly profound overhaul of the way the country currently uses and thinks about energy will be required. Marquard's paradigms imply an increasing level of co-ordination and planning, both within the energy sector and between the energy sector and the rest of society.

Importantly for the analysis in this paper, Marquard writes that the ability to shift paradigms is determined by institutional capacity, and the ability for institutional innovation within the sector.

5. South Africa's historical energy policy, and the 1998 White Paper

Prior to the 1994 political transition, the South African energy sector could be said to be operating within an 'Energy supply' (1) policy paradigm (Marquard 2006), with the individual energy supply communities of electricity, coal, liquid fuels and nuclear dominating the policy development and implementation process, and largely acting in silos. Energy services were almost solely delivered through the provision of cheap electricity powered by coal, with a third of liquid fuels also coming from the abundant coal reserves via Sasol's coal-to-liquids process. Very little thought was given to energy efficiency or planning for any alternative mode of energy service delivery in the future.

The 1994 political transition opened a policy window as the political landscape was transformed, and the individual energy supply communities influence was relaxed (Marquard 2006). Within this window, the 1998 Energy Policy White Paper was developed, which has yet to be superceded. The Paper identifies five policy objectives: increasing access to affordable energy services, improving energy governance, stimulating economic development, managing energy-related environmental and health impacts, and securing supply through diversity. These are significantly broader than the historical focus on securing energy supply, and extend to environmental and societal concerns, particularly the issue of electrification. Energy demand is addressed explicitly, as is the need to reduce greenhouse gas emissions. Demand subsectors are even considered before the supply side is addressed in the paper. The White Paper itself follows an integrated energy planning structure, which 'recognises that energy is not an end-good in itself, but is rather consumed as a means to some end…. The role of policy is thus to facilitate the optimal consumption of energy resources to meet social needs' (DME 1998: 19). As such it contains elements of a Supply-demand type policy paradigm, and potentially even a Structural-cultural paradigm.

The Paper therefore holds considerable promise in laying the policy basis for a sector well equipped to respond to the challenges of climate change mitigation. From a paradigm perspective, it can be seen to be progressing the existing energy policy paradigm (1) towards (2) or even (3). On a written policy level, it sets out objectives relating specifically to energy efficiency, renewables, energy diversification and sector level planning, all of which are essential for climate mitigation.

6. Policy developments between 1998 and the present

The period 1998–2009 was dominated from a South African energy perspective by electricity: the electrification programme, the reversal of electricity sector liberalisation, and the 2007 electricity supply crisis. On the sidelines there have been the financing difficulties of the Pebble Bed Modular Reactor, the transport infrastructure bottlenecks in the coal subsector, and hints of a pending supply crisis in the liquid fuels subsector. From a policy perspective, there has been a noticeable lack of sector co-ordination and guidance, and slow and low levels of mitigation-aligned policy implementation.

6.1 Failure of energy planning, co-ordination and liberalisation

The 1998 White Paper made provision for both integrated energy planning (IEP) and national integrated resource planning (NIRP) in the electricity sector, acknowledging that capacity and data limitations in South Africa made this difficult. The Department of Minerals and Energy (DME) conducted a first IEP in 2003, but the second has not progressed past draft status. NERSA was identified to undertake NIRP in conjunction with Eskom, and successfully managed the first two NIRP, with the process having been transferred to Eskom for the third, with limited consultation (Winkler, 2009). Therefore, whilst the exercise has been undertaken on paper to some extent, a national process of energy planning and co-ordination has not been embedded. This can be argued to be due to lack of government capacity, with the result that dominant planning in the sector is being undertaken by Eskom. A potential paradigm 2 policy tool therefore has been subverted to a that of a paradigm 1 (Energy supply) tool, focused solely on an individual energy supply sub-sector in isolation of substantive consultation with the broader energy community or society at large. This reduces the electricity sector's ability to respond to climate mitigation challenges to that of the utility, whose objectives are not necessarily directly aligned with national objectives.

The 1998 White Paper spoke of the need to address the lack of data and transparency of information in the energy sector for the purposes of planning and co-ordination. However, little progress has been made in this regard. Skills and capacity are still largely concentrated in the dominant supply-side institutions, informing the incumbent energy policy paradigm, and perpetuating the status quo. Some data capability has been incorporated under the proposed South African National Energy Development Institute (SANEDI)'s functions, but at the time of writing SANEDI still has not received the resources or institutional backing to operate.

On the objective of securing energy supply through diversification and liberalisation as envisaged in the White Paper, the situation has, if anything, regressed since 1998. Attempts were made at liberalisation early on in the decade but the lack of direction on new generation capacity, resistance by municipalities and the electricity supply crisis sharply reversed this with Eskom being confirmed as the sole purchaser of generated power by Cabinet in 2007. More recently, government has announced an independent systems operator (ISO) outside of Eskom in the State of the Nation Address (The Presidency 2010) which may represent a renewal of the liberalisation objective. To date, little appears to have been done to address the energy efficiency opportunities raised by the 2007 electricity crisis, nor to manage or prevent the pending liquid fuels supply crisis. Initial forays into nuclear by Eskom and the government (PBMR) have been postponed or appear directionless. This lack of co-ordination and prioritisation is demonstrated in the experience of NERT, which was tasked with driving all inititiatives relating to the electricity crisis (Rossouw 2009). Despite its important energy security mandate, it is being rendered impotent due to a lack of financing and a lack of staffing continuity since the DME was split into Energy and Minerals (Creamer 2009).

Governance in the sector has been improved with the establishment of the National Energy Regulator of South Africa (NERSA), but co-ordination between government departments and policies has not progressed, nor has government capacity been strengthened.

As the preceding discussion demonstrates, planning, co-ordination and liberalisation in the energy sector has failed dismally over the past decade. In some cases this is due to a lack of capacity within government, in others to a lack of sufficiently resourced and appropriately oriented institutions. Particularly, there is no one overarching, capacitated and powerful co-ordinating policy institution to drive a coherent policy direction with a national agenda. This state of affairs remains unchallenged by powerful supply side focused vested interests, as it maintains the status quo of a centralised supply side oriented oligopolistic energy sector based on coal.

6.2 Slow and low levels of implementation of climate mitigation-aligned energy policy

Progress on managing greenhouse gas emissions in the energy sector has been slow in the past decade, although a foothold has been established. Subsectoral white papers, strategies and masterplans refer consistently to the need to diversify the energy mix, and to support renewable and nuclear energy, and energy efficiency (for example the Electricity Regulation Act of 2007 and 2008 Energy Act). Targets have been identified, and whilst these are consistently much lower than what is required to implement the peak, plateau and decline trajectory, they are in place, with the mechanisms to realise them slowly being developed.

Little has been done around the use of energy-efficient and off-grid renewable interventions for the poor, whilst electrification was relatively effective. The low-income subsidised housing sector is still composed of highly energy-inefficient dwellings with residents using dirty fuels with correspondingly high incidence of poor health. The electrification campaign extended the country's reliance on centralised coal generated grid electricity.

The 2003 Renewable Energy White Paper commits the country to 10 000 GWh contribution of renewable energy to final energy demand by 2013. NERSA is developing a Renewable energy feed-in tariff (REFIT), which pays a subsidy to renewable energy generators, and which is expected to provide a long awaited kick-start to the renewables sector in the country, enabling South Africa to meet its renewable energy target. Whilst the pricing structure has been agreed, with the Department of Energy (DoE) providing the regulatory framework in the regulations on new generation capacity (5 August 2009), Eskom is reportedly still to sign off on the power purchase agreements which would give effect to the first renewable energy generation under the REFIT.

There is a renewable energy subsidy office (REFSO) within DoE, established in 2005, which administers a subsidy for assisting in the capital financing of both grid and non-grid renewable energy projects. By 2009 only six projects, with a total installed capacity of 24MW had been subsidised, to a value of R15 million (DoE 2009).

The World Bank has funded a Renewable energy market transformation (REMT) project of the DoE, which is hosted by the Development Bank of Southern Africa. The project aims to assist the country meet its 2013 renewable energy target by supporting DoE develop a regulatory and policy framework for renewable energy, and developing institutional and financing support within the economy for renewable energy uptake.

Treasury has levied a 2c/kwh charge on electricity generated from non-renewable sources, implemented in July 2009. Eskom, as the sole purchaser of electricity for the national grid faces this charge, and whilst it can be passed on to consumers, the utility has to absorb the charge within its tariff schedule. This is essentially the country's first 'carbon tax', and whilst it pales into insignificance against the 35% increases requested by Eskom, the tax is now established and can be escalated in future.

The 2005 Energy Efficiency Strategy stipulates a national energy efficiency target of 12% by 2015, disaggregated to include sectoral targets. The electricity crisis resulted in immediate mandatory electricity rationing for the country's large power users, which have now been transformed into targets under the Power Conservation Programme (PCP) of an average of 10% reduction from a baseline consumption. This programme, identified as a key part of the crisis response is a government initiative with a suggested timeframe of 2008–13 (NERSA, 2008). It consists of three components, the Energy Conservation Scheme (ECS), which envisages the inclusion of pricing interventions to encourage energy efficiency, the Energy Growth Management component, which aims to allocate power to new connections efficiently, and the trading Rights to Consume scheme, which enables electricity consumers to trade energy efficiency rights in order to cost efficiently meet their targets under the ECS. NERSA published a draft consultation paper on the PCP rules in December 2008, and the programme has been reverted to the National Energy Response Team (NERT) to commission a review and make recommendations for Cabinet (Rossouw 2009). NERT is a public-private structure which has all but ground to a halt due to fudning issues and a lack of continuity during the restructuring of the DoE (Creamer 2009). Potentially one of the strongest instruments for aligning climate mitigation and energy policy has therefore been derailed through a lack of policy prioritisation and institutional focus.

NERSA has regulated that a component of electricity tariffs are allocated to demand-side management (DSM) activities, which are managed and undertaken by Eskom. Eskom has itself implement an Accelerated Energy Efficiency Plan (AEEP) which focuses on reducing electricity demand by 3000MW by 2012, and a further 5000MW by 2025 (www.eskomdsm.co.za, accessed 16 December 2009). However, given that Eskom generates its primary source of revenues from electricity sales, the AEEP does not appear to be aligned to the utility's business model.

The 1998 White Paper specified the establishment of institutional capacity to enable energy efficiency targets to be met. The National Energy Efficiency Agency (NEEA) was established in 2006 by the DME, and located within the Central Energy Fund (CEF). It has been agreed that part of the funds raised through the DSM levy will be allocated to energy efficiency initiatives, although these funds appear still to be largely under the control of Eskom. The intention exists for a NEEA governance body to oversee the use of the funds (www.cef.org.za). However, the NEEA still has not been given the mandate and resources to function effectively.

SANEDI, established by the 2008 Energy Act may provide the institutional capacity required to drive both renewables and energy efficiency. It is intended as the institution which is mandated to increase energy efficiency throughout the economy, reducing energy intensity and optimising the use of finite energy resources and also has functions in energy research and development in all fields of energy other than nuclear (*Government Gazette* 2008). SANEDI is currently hosted by CEF to avoid the costs of a new entity to the country, but remains without resources and with a number of institutional issues still to be resolved before it can function effectively.

A Biofuels Industrial Strategy of 2007 has been developed, with a target of 2% penetration of biofuels in the national fuel supply by 2013. Integrated rapid transit (IRT) systems, which encourage modal shifts away from private vehicles towards public transport, are being developed for eight South African cities prior to the 2010 Soccer World Cup, and some rural networks. The implementation of these systems is a result of co-operation between national, provincial and local government, initiated by the transport departments. It appears that this initiative is happening without involvement of the energy sector, which remains restricted to a supply-side approach of providing liquid fuels.

The country has established a carbon capture and storage (CCS) centre, in March 2009. Under CEF, it aims to have a pilot CCS plant in place by 2020 for coal and liquid fuels, capturing 40 million tonnes per year (SANERI 2009).

The National Nuclear Energy Policy of 2008 envisions a fleet of nuclear generators in the country, with Eskom identified as the operator of this fleet. However, both the PBMR company and Eskom are delaying further progress on nuclear due to a lack of financing.

The discussion in this section demonstrates that low-level targets and instruments aligned to Cabinet's mitigation vision have been established by written energy policy. However, this section has also argued that the targets are currently woefully inadequate to meet the scale of the mitigation challenge. In addition, progress on implementation is both typically slow and often resisted by the dominant energy institutions, or is stalled due to lack of co-ordination and prioritisation between institutions. The discussion demonstrates too that there are a number of different institutions operating in the same space, with no clarity on which one is driving an initiative. For example, the NEEA is tasked with ensuring energy efficiency is promoted throughout the economy. SANEDI has a similar function, and the most promising energy efficiency initiative in terms of its alignment with Eskom's capacity and influence, and seriousness of targets is being undertaken by NERT as the PCP. All three institutions and initiatives are in limbo due to a lack of resources, mandate and institutional strength. The overriding reason why the energy sector has underperformed on the implementation of climate mitigation aligned policies to date is argued, therefore, to be the continuing orientation of the well resourced energy institutions towards a centralised, fossil based supply approach. There is limited institutional capacity to support energy efficiency, renewable energy or planning responses to climate change mitigation, and where these are attempted they are thwarted by lack of co-ordination, or more sinisterly, by well established institutions with vested interests in maintaining the status quo.

7. Is current energy policy aligned with climate change policy?

The current status of energy and climate policy alignment can therefore be summarised as being strong on a high level written policy level, but weak in the 1998 Energy White Paper's realisation in regulation, targets and implementation. Where there is alignment, it is still emerging, with targets and ambitions which are orders of magnitude lower than what is required by the climate change policy direction currently being pursued. Implementation is lacking, and a transition to an energy policy Paradigm 2 (Supply-demand) or even 3 (Structural-cultural) has been severely constrained.

The immediate context of severe domestic energy capacity constraints, dysfunctional governance in the parastatals and a slowly growing indication that a low-carbon future is inevitable for the international economy implemented either unilaterally through trade barriers or, more ideally, through a multilateral climate policy agreement, has strengthened the government's statements of intent to diversify the electricity sector, bringing in renewables and nuclear. Less has been said in the areas of liquid fuels and coal.

Under President Zuma's leadership, the DoE has been decoupled from the Department of Minerals, which, although largely symbolic at this stage, does provide for the consideration of energy policy as separate from minerals policy, perhaps signifying a move away from the historical interdependence of the two and the emphasis on cheap, coal-generated power.

However, this recent progress should be considered in the light of both the past decade and the more distant past. Dominance of a supply side, centralised, coal focused approach has been sustained and entrenched through the institutional establishment. Despite various 'policy windows' (Marquard 2006) having opened up during the past decade, moments where there is an opportunity for deep policy change, all have closed without serious challenge to the (1) type Energy supply policy paradigm. After 1994, the political transition provided a shake up of the routes to power of those with vested interests in maintaining the status quo, enabling the 1998 White Paper which contained paradigm (2) and (3) type elements. However, before the policy changes could be supported by corresponding insitutional capacity and co-ordination, the paradigm (1) type institutions reasserted their dominance, and there has been little follow-through on the White Paper's promise subsequently. The 2007 electricity supply crisis also presented a window of opportunity for energy efficiency, liberalisation and diversification, but this too seems to have passed the sector by, with NERT rendered impotent and SANEDI still struggling for resources. The REFIT is promising, but is being held back by Eskom's reluctance to sign the PPAs. The resultant sector structure is vulnerable to climate change mitigation challenges, which ideally require an energy service approach (Structural-cultural paradigm 3) to efficiently and resourcefully reduce the country's reliance on fossil fuels.

The building of institutional capacity and influence, a critical component of a paradigm transition, is a long and slow process, particularly when skills are scarce and vested interests and cultures are entrenched. SANEDI may well represent the beginnings of the institutional counterweight required to elevate the critical climate mitigation options of planning, energy efficiency and renewable energy, and enable the implementation of written policy. However, no change has yet been proposed to the policy context within which SANEDI will be required to operate; there has been no progress on systematic energy sector co-ordination or planning, and DoE has not proven itself has having sufficient capacity and influence to effectively manage the contested interests of the existing institutions to enable SANEDI to function effectively.

The primary causes of the lack of alignment between climate mitigation policy and energy policy can therefore be summarised as:

1. the lack of a single, overarching, co-ordinating energy policy institution which has sufficient power and influence to deal with the vested interests of the existing energy institutions; and
2. existing and entrenched institutional orientation and capacity.

8. Considering possibilities for achieving alignment

So how could this entrenched misalignment be addressed? Firstly, the intervention of an overaching policy institution with sufficient power to override the vested interests which may be resisting progress in these areas currently, and with the ability to enforce co-ordination between both existing energy sector institutions and associated non-energy institutions, appears to be essential.

Secondly, institutional capacity of appropriate weight and oriented towards low-carbon energy sector interventions is likely to be required. The creation of this capacity is both a slow process and very costly. In South Africa, the challenge of skills scarcity compounds the issue. Institutional change takes time, and the capacity and orientation of institutions determines the ability of a country to shift energy policy paradigms (Marquard 2006).

The first requirement appears non-negotiable. It will require a determined intervention, with the highest possible political support and clarification of the lines of responsibility and reporting within the energy sector currently, especially the roles of the Departments of Public Enterprises, Energy, and Science and Technology. An intervention of this nature would require tremendous political will. There is the potential that this may be possible under the proposed National Planning Commission, which has announced climate and energy as areas of focus. However, this depends on the prioritisation of these amongst other policy priorities. Given that the Planning Commission is based within the Presidency, and assuming therefore that it operates with the highest authority, it may have sufficient weight to override the various vested interests which are entrenched within the sector. Currently though, the Planning Commission remains in early stages of conceptualisation and development, and the proposal has faced some political opposition. It may therefore be some time before it is able to fulfill this role. Alternatively, or in addition, the inter-ministerial Energy committee recently announced in the State of the Nation address (The Presidency 2010) and tasked with developing a twenty year IRP, provides an opportunity for the leadership requried in this area.

The second requirement of institutional capacity could be achieved in two ways. Optimally, new capacity with sufficient weight to counteract the existing capacity which is oriented towards traditional coal-based supply approaches could be established. At best, this is the path of energy planning and liberalisation, and will enable a Supply-demand policy paradigm 2 or Structural-cultural paradigm 3 to be achieved. The IEP and NIRP would be revived and institutionalised, and would be contextualised within a national plan to align economic and social development within the peak, plateau and decline trajectory. The dominance of the energy supply communities in policy-making would have to be dismantled, together with the long-standing cultures of secrecy and non-transparency within these institutions. Such an energy system will place the country in an optimal position to both respond to mitigation pressure from the international community and take advantage of the opportunities which a low-carbon future offers.

However, this is a substantial and possibly overwhelming task, and one which may be beyond the capacity and priorities of the government and ruling party at this time, and particularly given the timeframes within which early mitigation investments need to be achieved. Certainly, substantial international support in terms of funding and specialist skills is likely to be required.

The second way of achieving the prerequisite institutional capacity is to accept the entrenched nature of the current energy policy paradigm and institutions, and to seek climate mitigation alignment within these constraints in the short to medium term. So for example, in the renewables area, Eskom would be mandated to achieve ambitious renewable and nuclear targets, and for industrial energy efficiency, ways would have to found of combining the institutional weight of existing parties such as Eskom, SANEDI, NERSA, the Energy Intensive Users Group, industry and the DoE with a high level of co-ordination and policy direction from the overarching policy institution.

This second way would require a thorough and experienced understanding of the nature of the status quo, and the levers which could be accessed in order to align the agendas of the current institutions with those of Cabinet's mitigation vision. This is likely to constitute a highly strategic, sensitive and negotiated process, which may result in a solution comprising Eskom driving renewables and nuclear, Sasol and the refineries maintaining their special 'energy company' status, but assisting in a centrally driven transport emissions mitigation solution, and a mandatory energy efficiency programme being overseen by a number of institutions carefully co-ordinated and aligned by the overarching policy institution. Given that this centralised way is unlikely to be optimally aligned to the deeper mitigation objectives contained in the Reach for the goal trajectory post-2030, a plan to transition to this type of energy sector environment and Structural-cultural policy paradigm (3) in the medium-to-long term is likely to prove necessary.

Timing for mitigation interventions is critical. In order to reach a peak 2020 / 25, planning must begin immediately. Challenging the existing order of vested interests which date back for decades is likely to take time. This may necessitate the second way in the shorter term.

9. Conclusions and areas for further research

This paper has argued that overall, energy and climate change policy in South Africa are not currently aligned. Whilst written and stated energy policy is to some extent aligned with a low-carbon future, both the dominant energy policy paradigm and the orientation and capacity of the country's energy institutions are fundamentally misaligned. In particular, conflicts between these institutions constrain policy co-ordination and hence alignment. However, on the level of policy mechanisms, a basis exists on which to build alignment in future. This includes mechanisms such as the renewable energy and energy efficiency targets, the PCP, the REFIT and the attempts at energy sector level planning.

The primary causes for the misalignment are, to repeat, firstly, the lack of a single, overarching, co-ordinating energy policy institution which has sufficient power and influence to deal with the vested interests of the existing energy institutions; and, secondly, existing and entrenched institutional orientation and capacity.

In line with this, the establishment of such an overarching, co-ordinating energy policy institution is a pre-requisite for any progress to be made towards aligning energy policy with climate policy. On the institutional capacity and orientation front, two alternatives are proposed. Optimally, there should be a dismantling of the current energy institutional structure and its vested interests, and new climate mitigation oriented institutional capacity developed. However, South Africa is a developing country, with scarce resources, particularly energy sector skills. As such, and particularly considering the timeframe for adopting some of the main mitigation interventions, this approach may well not be possible. The second proposed alternative is then that policy-makers and energy sector participants consider how best to deliver mitigation within the constraints of the existing institutional structures.

The indicative policy alignment requirements require further testing and exploration. A quantitative and modelled approach would substantially deepen the analysis. Reference to international experiences, particlarly the experiences of other developing countries in aligning their energy sectors with a low carbon future may yield significant learnings. In addition, further research on how the second-best institutional alternative could be constructed in each energy sub-sector and for each mitigation wedge will be informative. To this end, research into the various energy institutions' corporate cultures, and how this could be transformed, would give useful insights. The weakening of the Cabinet's mitigation vision has not been considered in this analysis, but the implications of this for energy policy would be useful to understand, particularly if the high level intervention option is attempted. Finally, this paper has not dwelt on the implications of and for industrial policy of a significant energy policy paradigm and institutional shift, which is expected to be a valuable addition.

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Carbon pricing and industrial policy in South Africa

Brent Cloete and Genna Robb

Abstract

Economic instruments to mitigate climate change alter the relative cost structures of sectors within economies and between economies internationally. This will lead to structural changes within economies benefitting less carbon-intensive goods and services. One area of government policy that is particularly important in this context is industrial policy, which aims to facilitate structural changes in economies towards higher productivity activities. To ensure that industrial policy places South Africa on a low-carbon growth path, it needs to start favouring less carbon-intensive industries. Industrial policy must align with the use of economic instruments to mitigate climate change in South Africa to ensure that industrial strategies are implemented that will be sustainable in a carbon-constrained world. This interplay between carbon pricing and industrial policies in South African is investigated by considering, on the positive side, the opportunities created by climate change and, on the negative side, the potential impact of carbon pricing on industrial competitiveness. The paper concludes by recommending ways in which climate change considerations can be incorporated into industrial policy in order to move South Africa towards a sustainable low-carbon growth path. This will ensure that the economic costs of carbon pricing are minimised while potential long-term competitiveness advantages are maximised.

Keywords: industrial policy, climate change mitigation, structural change, knowledge-based industrialisation, competitiveness

1. Introduction

Economic instruments to mitigate climate change, whether carbon taxes or cap-and-trade schemes, place a price on carbon. This affects the relative cost structures of sectors within an economy and between economies internationally by effectively making carbon 'a factor of production that needs to be paid for in the same way as labour or raw materials' (Smale et al 2006: 33; Wooders et al 2009). In a carbon-constrained world with significant carbon prices, it is thus important that countries move to low-carbon economies to preserve their international competitiveness. In order to start moving South Africa towards a low-carbon economy, climate change objectives need to be integrated into all areas of government policy (DEAT 2009). One area of government policy that is particularly important from a climate change perspective is industrial policy.

This paper seeks to evaluate the interplay between policies to combat climate change and policies to support industrial development in a South African context. More specifically, the impact of putting a price on carbon on the implementation of industrial policy in South Africa will be considered. The paper begins by providing an overview of industrial policy in South Africa. It then moves on to consider potential synergies between climate change policy (in the form of a price on carbon) and industrial policies. The possible negative impact of carbon-pricing on industrial competitiveness is also discussed. The paper concludes by recommending ways in which climate change considerations can be incorporated into industrial policy in order to move South Africa towards a low-carbon growth path. This will ensure that the economic costs of carbon pricing are minimised.

2. Industrial policy: definition and purpose

Industrial policy encompasses measures aimed at increasing the efficiency of an economy (Presidency 2009). More specifically, Hausmann, Rodrik and Sabel (2007: 1) believe the purpose of industrial policy is to 'speed up the process of structural change towards higher productivity activities'. Flatters and Stern (2008: 15) feel that industrial policy should aim to 'expand the economic activities available to a country's citizens', while Kaplan (2008: 40) contends that the focus of industrial policy is to 'enhance the productivity and efficiency of firms'.

Theoretically, industrial policy can be defined as different points along a continuum (Chang 1998). The broadest definition of industrial policy includes all government policy that influences industrial performance, while the narrowest definition of industrial policy includes only specific policy measures aimed at developing specific sectors. The latter approach is commonly referred to as 'sector targeting' or 'picking winners'. At the midpoint of the continuum, industrial policy can be defined as consisting of 'core' policies targeting specific priority sectors supported by 'general', non-sector specific policies aimed at increasing the competitiveness of all industries. 'General' policies usually include measures like broad support for research and development or training activities throughout the economy.

3. Industrial policy in South Africa: overview

The Accelerated and Shared Growth Initiative – South Africa (AsgiSA) suggested an active industrial policy approach to move the economy to a more 'inclusive' growth path (DTI 2007a; Presidency 2009). A national framework guiding industrial policy, the National Industrial Policy Framework (NIPF), and the accompanying Industrial Policy Action Plan (IPAP) were completed in 2007 (DTI 2007a; 2007b; MEDS 2007). The NIPF aims to provide a 'framework rather than a blueprint' to guide industrial policy to support South Africa's industrialisation and to facilitate structural change in the economy, (DTI 2007a: 9). The IPAP sets out a prioritisation of industrial policy key actions to be undertaken within rolling three-year medium-term expenditure frameworks (MTEFs).

The main objectives of industrial policy in South Africa (DTI 2007a: 10-11; 2007b: 2) are:

- to facilitate diversification of the South African economy beyond traditional commodities and non-tradable services;
- to intensify industrialisation towards a knowledge economy;

- to promote labour-intensive industrialisation;
- to promote broader-based industrialisation also benefitting historically disadvantaged individuals and marginalised regions; and
- to support industrial development on the African continent.

The NIPF also identifies the need to 'identify and act upon critical constraints and opportunities at both the *cross-cutting and the sectoral levels* of the economy [emphasis added] (DTI 2007a: 10).[1] The first IPAP prioritises six cross-cutting areas (DTI 2007b: 33-41):

- Improving the design and administration of industrial financing;
- Leveraging public procurement;
- Reducing intermediate input costs through the use of competition policy and a review of import tariffs;
- Improving support mechanisms for innovation, technology and research and development;
- Improving infrastructure and logistics; and
- Linking skills development to sector strategies.

The effective implementation of industrial policy is premised on the coordination and commitment of a wide range of government departments and agencies. This is true even for 'narrow industrial policy', given that it often requires departments other than the Department of Trade and Industry (DTI) – which is tasked with implementing industrial policy and sector strategies – to play an important supporting role. The NIPF thus aims to provide a point of intersection between industrial policy and complementary policies and programmes within government to create an environment conducive to industrial development.

Sometimes, however, very selective industrial interventions are undertaken by government departments other than the DTI and presented outside of the national industrial policy framework (Kaplan 2008). Kaplan (2008: 37) refers to these interventions as 'hidden industrial policy' and mentions that they are often undertaken with little consideration of industrial policy objectives, implementation plans and selection criteria. Examples of 'hidden industrial policy' would include the role of the Department of Public Enterprises in supporting very selective interventions like direct support to the armaments industry, support for the development of the Pebble Bed Modular Reactor (PBMR) and subsidised infrastructure and energy to the Coega industrial development zone.

The NIPF prescribes that all sector development work should be based on (DTI 2007a):

- A detailed, realistic and verifiable economic analysis of the sector taking account of the relative size and growth prospects of the sector as well as the potential for employment creation, additional value-added, diversification and growth of exports and production, development of new technologies and broad based empowerment.

1 The definition at the midpoint of the continuum highlighted in the previous section thus seems to currently be the most appropriate description of industrial policy in South Africa.

- A serious 'self-discovery' process that aims to identify the constraints and opportunities in the sector. The self-discovery processes can take many forms, but essentially involves a robust consultation between the firms in a sector, government, labour, civil society and other relevant stakeholders. The process should be informed by extensive sector research and analysis.
- An analysis of the viability and sustainability of the sector in the medium to long term.
- An economic cost-benefit analysis of the alternative policy responses available to address identified constraints and opportunities within the sector.
- An assessment of institutional arrangements that impact on both the sector's ability to engage with government and assist in implementing policy measures, and government's capacity to implement policy measures in the relevant sector.

Based on the criteria listed above, the NIPF advocates the prioritisation of about five 'high-impact priority sectors' to focus on within every MTEF period (DTI 2007: 34-35). Emphasis should also be placed on sectors that can support South Africa's structural transition to a 'technology sophisticated and knowledge-driven economy, have made significant progress in 'self-discovery' and have sufficient information available to craft effective policies.

4. Synergies between carbon pricing and industrial policy

Climate change was not addressed in the NIPF or the original IPAP. Putting a price on carbon is likely to have a significant impact on industrial policy initiatives. There are a number of areas where a price on carbon may support the objectives of industrial policy in South Africa, and these are considered below.

4.1 Structural change in the South African economy

Hausmann, Rodrik and Sabel (2008: 2) refer to the process through which firms identify the markets which they are (or may be) able to serve as 'self-discovery'. They suggest that self-discovery externalities are ubiquitous in emerging markets. The process of learning how to produce new products profitably is under-supplied in most emerging economies since it is a risky endeavour and the social value of success exceeds the private return. By forcing the private sector to consider the implications on their activities of having to pay for their GHG emissions, carbon pricing can assist the 'self-discovery' process that is one of the cornerstones of industrial policy in South Africa. Firms will need to evaluate new production techniques and technologies to either reduce their GHG emissions, or to increase the efficiency of other areas of their production process to try and offset the increase in their production costs as a result of carbon pricing. This may lead to the development of new technologies, processes or products which that could eventually become part of the firm's product mix.

In a relatively new area like climate change the potential social value (and the potential for private returns) of successful self-discovery is very high, given that the development of new global markets for environmental goods and services[2] is likely to offer

2 Environmental goods and services 'measure, prevent, limit, minimise or correct environmental damage', and include activities as diverse as renewable energy generation, environmental consulting, environmentally friendly construction techniques and energy efficiency (European Commission 2008: 9).

significant opportunities for growth (Demailly 2009; DTI 2007a). Becker and Shadbegian (2009) find that environmental products manufacturing firms in the US are more likely to be exporters than general manufacturers, indicating the international nature of these markets. Countries and firms that identify and act upon these opportunities quickly will have a significant first-mover advantage. This could lead to a strong competitive advantage which may prove highly lucrative since these markets are expected to grow significantly in the medium-to-long term (Demailly 2008; DTI 2007a; MEDS 2007). As international commitments to reduce GHG emissions start to become more onerous, and developing countries are party to these commitments (as happened recently with the signing of the Copenhagen Accord) a first-mover advantage in environmental goods and services linked to climate change is expected to increasingly translate into a competitive advantage.

Blueprint (2006) identifies climate change as one of the key factors expected to drive growth in the environmental goods and services sector in South Africa, and identifies three main areas of opportunity linked to climate change, namely analytical and consulting services (eg. data generation and interpretation); commercialisation of new technologies (eg. carbon capture and storage technologies); and renewable energy (eg. wind farm and solar energy). One possible outcome of climate change measures may be to incentivise the creation of new areas of low-carbon competitive advantage within the economy based on local resource endowments (Winkler & Marquard 2007). One potential such area of competitive advantage in South Africa may be the solar energy industry, given that South Africa has some of the best conditions for solar energy generation in the world.

By favouring less energy- and carbon-intensive sectors, climate change policy will assist in diversifying the South African economy away from its historical reliance on energy- and capital-intensive upstream resource-based manufacturing (DTI 2007a; Winkler & Marquard 2007). This will support the NIPF objective of moving the South African economy towards non-traditional tradable goods and services and potentially diversifying exports.

4.2 Continued access to export markets

Credible carbon pricing will play an important role in supporting industrial development by facilitating continued access to South Africa's current export markets (DTI 2007a). Developed countries implementing (or considering implementing) relatively stringent climate change policies are increasingly concerned that putting a price on carbon my lead to 'carbon leakage'. Carbon leakage refers to a relocation of production activities to jurisdictions with less stringent climate change policies as a result of, for instance, a shift in consumption of carbon-intensive goods from local production to cheaper imported products (Van Asselt et al 2009). Carbon leakage thus refers to a situation where the competitiveness of firms is reduced as a result of a price on carbon existing in some countries, but not in others (Garnaut 2008).

Carbon leakage can be addressed in a number of ways. Countries where a price of carbon exists may consider implementing border adjustment measures. Border adjustment measures aim to remove the cost advantage of imported goods produced under less stringent climate change policies by levying a tariff on imported goods equal to the differential between the local price of carbon and the price on carbon in the country where the imports originated. Alternatively, importers may be required to surrender permits or certificates equal to the value of the carbon embodied in imports, which will then in turn lead them to require exporters to provide the required permits/certificates so as to not impact on their margins (Frankel 2009; Van Asselt et al 2009). Given that there is a precedent of allowing trade measures to combat global externalities (trade restrictions relating to products linked to CFC emissions under the Montreal Protocol, for instance), Frankel (2009) and Bordoff (2009) believe that border adjustment measures linked to GHGs may well be WTO compliant, depending on how they are designed and implemented. Frankel and Bordoff, however, both mention the possibility that border adjustment measures may be implemented as protectionist tools given the discretion that individual governments will have to define: whether trade partners are meeting their carbon responsibilities; how to measure the carbon content of manufactures; what sectors are susceptible to border adjustment measures; etc. Another way to combat carbon leakage is to use labelling and product specifications to allow local consumers to differentiate between more and less environmentally damaging goods. The US is currently considering the implementation of broad border adjustment measures (potentially covering energy-intensive products and all other final products), while the EU is in favour of sub-sector-specific trade measures to address carbon leakage (targeting energy-intensive products) (Van Asselt et al 2009). The EU has already adopted environmental labelling regulations and minimum requirements on energy-related products. (European Commission 2008).

If a realistic local price on carbon is not in place and border adjustment measures are applied to South African goods, it could significantly affect the ability of South Africa to grow (or even sustain) exports to its main export markets, namely the EU and US. The situation will be exacerbated if a combination of labelling requirements and consumer preferences in export markets lead to a reduction in demand for relatively high carbon South African goods.

4.3 Knowledge-based industrialisation

The imposition of a price on carbon may offer significant opportunities for technology development, innovation and adoption as firms attempt to reduce their carbon liabilities. The European Commission (2008: 2) states that efforts to increase sustainability and global pressures to increase resource efficiency 'could become an important source of innovation and ... an asset for industry's competitiveness'. The extent of the opportunity is highlighted by the fact that MEDS (2007) places climate change mitigation and adaption at the centre of the Western Cape's innovation strategy. An environment that incentivises low-carbon production technologies (by placing a price on carbon, for example) may also lead to significant technology spill-over effects as new low-carbon technologies available internationally are adopted and adapted locally (Demailly 2008).

Knowledge industries are often established in response to market forces that increase the returns on new technologies and innovation (a price on carbon would increase the monetary value of carbon abated through a reduction in carbon costs) and other incentives like government support for specific technologies and their implementation (MEDS 2007). A regulatory environment where climate change considerations are incorporated into investment and policy decisions through a price on carbon, underpinned by appropriate public sector support programmes, should thus create the right incentives for private sector players to exploit the opportunities offered by climate change (MEDS 2007; Winkler & Marquard 2007). Winkler and Marquard (2007) believe that, with the right support measures, South Africa could become a 'world leader' in solar thermal energy in a similar way that Denmark became the leading developer and exporter of wind technology. In addition to solar energy, DEAT (2009) believes investment in research and development related to electric and hybrid vehicles, carbon capture and storage, and clean coal technologies should be prioritised.

An opportunity to secure international funding for the development of new environmental goods and services, and to facilitate technological spill-over effects, which has been underutilised in South Africa, is the Kyoto Protocol's Clean Development Mechanism (CDM) (Sangena Investments, 2004). In 2006 the value of trade in CDM credits was €6bn while only 12 out of the 839 CDM projects registered internationally, were registered in South Africa (Van den Berg 2008). According to the UNFCCC CDM registry (http: //cdm.unfccc.int), as at the 12th of November 2009, only 17 out of a total of 1895 (0.9%) CDM projects were registered in South Africa. In contrast, 165 projects were registered in Brazil, 467 in India and 663 in China. The CDM is only available to South African firms for a limited period of time (until South Africa enters into binding international commitments to reduce its GHG emissions), and measures should thus be put in place speedily to assist South African firms to make the most of this opportunity while it is still available (Sangena Investments 2004; Van den Berg 2008). The Environmental Finance function that was established in the wood, paper and other strategic business unit of the Industrial Development Corporation during 2009 to specialise in the funding of CDM projects, and the Africa Carbon Asset Development (ACAD) Facility that was launched by the United Nations Environment Programme (UNEP) and Standard Bank in October 2009, should help to provide much needed impetus to the development of CDM projects in South Africa (IDC 2009; Standard Bank 2009).

4.4 Labour-intensive and broad-based industrialisation

A move towards a low-carbon economy facilitated by a price on carbon has the potential to create a number of 'green jobs'.[3] Winkler (2007b) mentions that energy efficiency measures generate significant employment opportunities. Not only are people employed directly in energy efficiency initiatives, but savings on energy expenditures enables greater expenditure on non-energy goods and services (the production of which is generally more labour-intensive than the energy sector) which leads to employment gains throughout the economy (Geller et al 1992; UNEP 2008, Winkler 2007b). UNEP (2009) mentions that opportunities for employment creation linked to energy efficiency are particularly significant in developing countries as a result of large stocks of energy inefficient buildings that will require retrofitting.[4] The European Trade Union Confederation (EUTC 2007) believes that on the whole climate change mitigation actions will have a modest positive impact on employment. Locally, the Minister of Energy recently commented that the programme to roll out a million solar water heaters locally within the next 5 years has the potential to create up to 100 000 jobs across the value chain including installation and maintenance (van der Merwe 2009a). In addition, Winkler (2007a) mentions that renewable energy technologies are more labour intensive than non-renewal technologies. AGAMA (2003) calculated that adding renewable energy to the generation mix to meet energy demand in 2020 (70% of the estimated 62TWh additional supply provided from renewable sources) will lead to an 21% increase in the number of direct

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3 UNEP (2008: 3) defines 'green jobs as work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute substantially to preserving or restoring environmental quality'.

4 For a discussion of employment creation linked to energy efficiency initiatives, see UNEP (2008).

jobs created in the electricity supply industry compared to a situation where all additional capacity is generated from coal-fired power stations (52 000 new jobs versus 43 000).[5]

Not only will the additional jobs include a significant number of unskilled and semi-skilled workers[6] (mainly in the biofuels, biogas and solar water heaters sectors), but the distribution of jobs will also support the NIPF's stated objective of creating employment in marginalised regions. The jobs created by renewable sources will be more decentralised than will be the case with gas, nuclear and coal generation and will largely be located in rural areas (AGAMA 2003). The provision of off-grid electricity to remote areas could also stimulate rural economic activity (AGAMA 2003).

4.5 Continued access to financing

One of the cross-cutting themes addressed in the NIPF is ensuring that sufficient developmental industrial financing is available to finance new industries (DTI 2007a and 2007b). The NIPF mentions that industrial financing should target new activities and should include explicit 'sunset clauses' that limit the period for which it is extended to firms, while the IPAP states that industrial financing has an important role to play in leveraging private sector investment. Industrial financing should thus serve as seed capital to initiate new activities or sector with a high potential to achieve industrial policy objectives. Once these areas are established, private sector funding and investment should drive its further development.

Financial institutions have the greatest impact on GHG emissions via their lending and investment portfolios (RiskMetrics Group 2009). The impact of carbon pricing on the profitability of creditors and investment projects could thus have a serious impact on the performance of the loan portfolios of financial institutions. In addition to measuring emissions resulting from their investment and financing activities, RiskMetrics Group (2009) recommends that financial institutions in emerging markets should begin to factor carbon costs into their financing and investment decisions. They mention that this is particularly important for energy-intensive projects which embody potential financial risks as a result of the implementation of more widespread (and more substantial) policies to reduce GHG emissions internationally. Cogan (2008) finds that out of a sample of 40 of the world's largest banks, 14 banks have adopted lending procedures or risk management policies that systematically address climate change. Cogan adds that a 'small but growing number of banks also are formally calculating carbon risk in their loan portfolios'. These banks include Citi, Mitsubishi UFJ Financial Group Mitsubishi UFJ Financial Group, Mizuho Financial Group, Royal Bank of Canada and Wells Fargo. In addition, Bank of America has announced a target to reduce the GHG emissions associated with its utility corporate finance portfolio.

Locally, Nedbank has recently indicated that it 'may make calls on whether or not to finance projects and businesses based on their carbon emissions and their willingness to make environmentally-friendly choices' (Shumacher 2009: 1). A number of financial institutions also indicated concerns that financing to emissions-intensive indus-

5 The results of this study are consistent with that of the European Commission's MITRE project. The project found that employment creation in the renewable energy sector more than compensates for employment losses elsewhere in an economy, and that 'pro-active encouragement of renewables give rise to significant net employment gains' (EC 2004: 13).

6 For a detailed assessment of the types of skills required for individual renewable energy technologies, see AGAMA (2003).

tries by be regulated in future (NBI 2009). The emissions intensity of industries and projects could thus potentially affect their ability to raise financing in future, and a price on carbon that incentivises industries to reduce their emissions intensity could thus play an important role in facilitating continued access to funds for industrial policy focus sectors in future.

5. Carbon pricing and industrial competitiveness

There is, however, one area where carbon pricing may undermine industrial policy objectives: the potential impact of a price of carbon on industrial competitiveness.

5.1 Overview

In addition to the potential opportunities available to firms from climate change mentioned above, carbon pricing may lead to increased competitiveness as firms are forced to audit their production process for unexploited efficiencies (MEDS 2007; Demailly 2008). The use of the instruments of industrial policy, particularly mechanisms to support investment in updated machinery and equipment to replace ageing capital stock and more general support for industrial upgrading to deepen manufacturing capacity (DTI 2007), could be used to further leverage unexploited efficiencies. There are, however, concerns that having to internalise the cost of GHG emissions may reduce the international competitiveness of firms relative to countries with less strict carbon policies and lower carbon production processes. This may lead to a reduction in employment and tax revenues (Demailly 2008; Neuhoff 2008).

Different sectors typically have different comparative advantages, and are often faced with divergent regulatory regimes – often even within the same country. In terms of international competitiveness, the emphasis should thus be on the sectors or even firms within countries that compete in international markets, rather than the competitiveness of a country (Krugman 1994). Climate change policies will reduce the competitiveness of carbon-intensive sectors relative to less carbon-intensive sectors within an economy. They may also reduce the competiveness of-carbon-intensive sectors in a country relative to carbon-intensive sectors in countries with less stringent climate change polices (Demailly 2008). Only the relative competitiveness of tradable sectors in countries with different levels of climate change policies in place will be affected (Demailly 2008). In practice, however, climate change (and other environmental) policies are only one of many factors influencing competitiveness.

The impact of climate change policies on industrial activities have to-date been relatively small, and are currently dwarfed by factors like trade barriers, transport costs, exchange rate fluctuations, investment climate factors, etc for most sectors (Desmailly 2008; Oikonomou et al 2006; Neuhoff & Mathes, 2008;). This may, however, largely be a function of carbon commitments internationally being relatively modest to-date. As international commitments become more onerous and widespread, the impact of carbon costs on industrial competitiveness may become more pronounced.

Factors like sunk costs and regulatory requirements (like limits on foreign ownership of enterprises) also limit the ability of firms to relocate (Desmailly 2008). Firms that wish to relocate also run the risk that a price on carbon may be implemented (or become more significant) in the jurisdiction that they are contemplating relocating to during the pay-back period on their new investment (Neuhoff & Mathes, 2008). As a result of international pressure, border adjustment measures in export markets etc this scenario is quite likely– particularly for projects/investments with long pay-back periods. Sijm et al (2006), based on a survey of the empirical literature, and Barker et al (2007: 20), based on an econometric assessment of carbon leakage within the European union, both find that environmental policy to date has not generally had a significant effect on the competitiveness or the investment and relocation decisions of firms in energy-intensive industries. The reason for the relatively insignificant leakage impact in practice is that carbon leakage effects have largely been offset by technology diffusion and spillover effects (Desmailly, 2008; Barket et al 2007).

The cost impacts of climate change policies do however vary widely between sectors, and there are usually a minority of sectors in a country that are significantly affected by climate change policies like carbon pricing (Neuhoff & Mathes, 2008). Figure 1 shows the sectors in the UK which are expected to experience an increase of more than 2% in their production costs (relative to gross value added [GVA] – this measure is referred to as 'value at stake') as a result of a carbon price of €20/t and a €10/MWh increase in the price of electricity (Houcade et al 2008). Sectors accounting for slightly more than 1% of economic activity in the UK will experience an increase of 2% or more. These sectors contribute 11% of the UK's total GHG emissions and 0.5% of its employment.

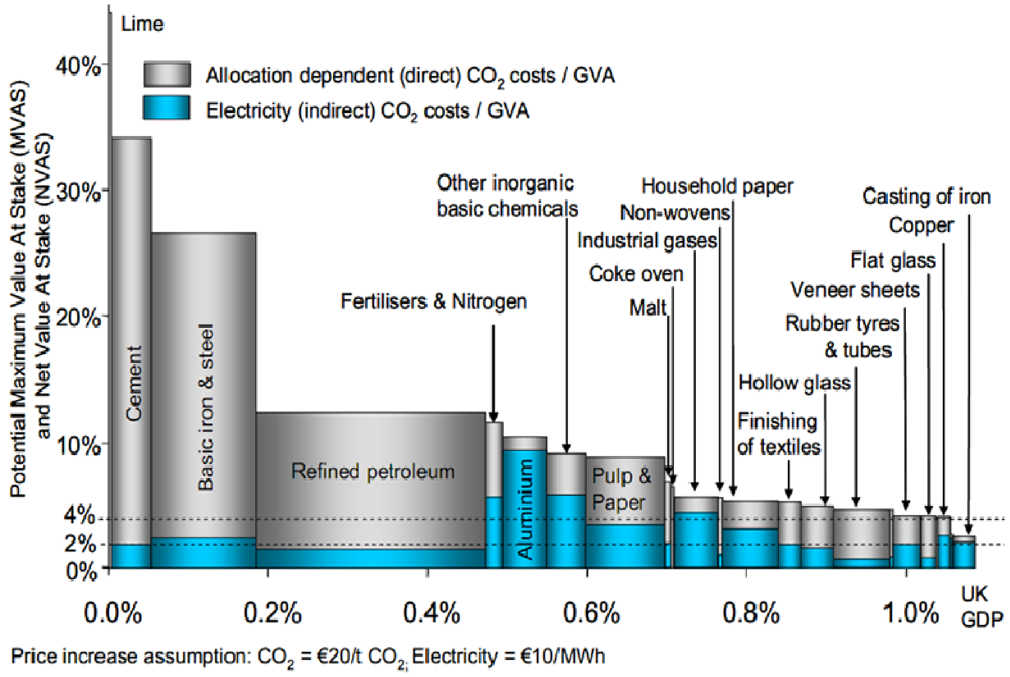

Figure 1: Sectors potentially exposed to significant CO_2 price effects (UK 2004 data)

Source: Houcade et al *(2008)*

Neuhoff and Mathes (2008) believe that the results shown in Figure 1 are very similar to results from other studies dealing with OECD countries. Figure 2 shows the emission intensity of the Australian economy. Five Australian traded goods and services sectors stand out as very emissions-intensive in comparison with the rest of the economy, namely: aluminium, beef cattle; cement and lime; sheep; and dairy cattle. The 10 industries with the highest emissions intensity accounted for a combined 37% of Australia's total emissions, around 4% of GDP, 3% of total employment and 15% of total exports in 2001-2002. For the five most emissions intensive industries, a carbon price in the vicinity of \$20/t CO_2 would increase production costs by 10–15%. Sectors that would experience production cost increases of 4% or more contributed 25% of Australia's national emissions, and around 2% of GDP and employment in 2001-2002 (Australian Government 2008).

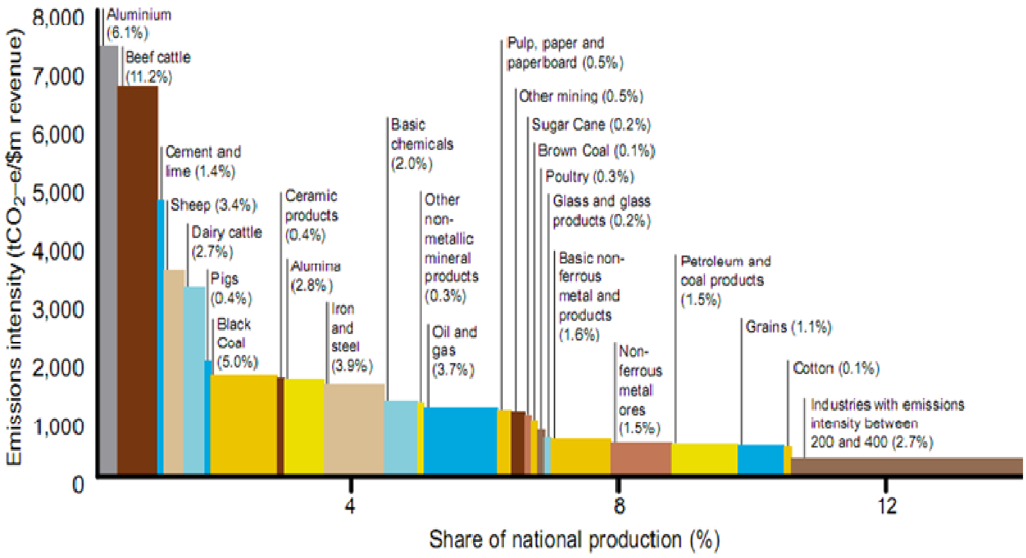

Figure 2: Emission intensity of traded sectors in the Australian economy (2001-2002)

Source: Australian Government (2008)

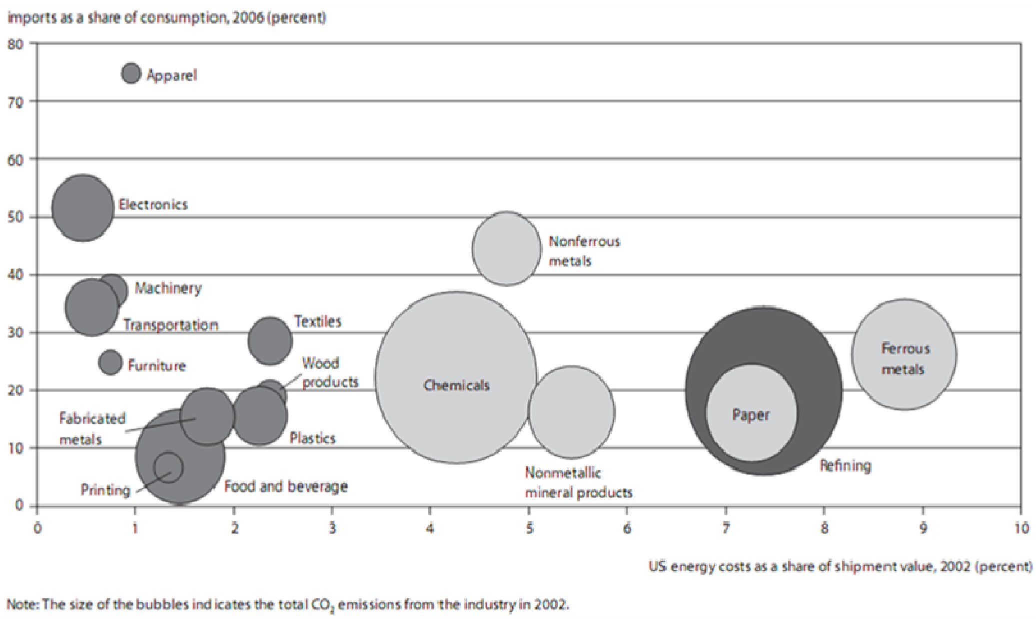

Figure 3: Assessing vulnerability of US sectors to carbon price based on trade and energy intensity

Source: WRI (2008)

Figure 3 shows imports as a share of local consumption (as a proxy for the tradability of a sector and thus also the ability of firms to pass on cost increase) relative to the energy intensity (as a proxy for carbon intensity) for a number of US sectors (WRI 2008). The figure indicates that the most energy-intensive sectors in the US are relatively shielded from international cost pressures in the form of imports, non-ferrous metals being a notable exception. The non-ferrous metals sector is thus likely to be much more constrained in its ability to pass on carbon costs than a sector like, for instance, ferrous metals, and is likely to be relatively vulnerable to competitiveness impacts as a result of a price on carbon. This analysis does however not take into account the availability and cost of abatement options available to the non-ferrous metal industry in the US. If there are a number of low-cost and low-risk abatement options available to the non-ferrous metals sector in the US, it may be less vulnerable to competitiveness impacts than indicated in Figure 3.

5.2 Addressing competitiveness concerns

Neuhoff and Mathes (2008) state that potential negative competitiveness concerns tend to be concentrated in upstream sectors, and particularly in sub-sectors that utilise energy and emission-intensive processes to produce low value-added products. Hourcade et al (2008) mention that potentially highly affected sectors contribute relatively small shares of GDP and employment within a given country. They believe that this provides the opportunity to focus on a few specific subsectors of limited size, which in turn allows for the development of customised technical solutions to address valid competitiveness and leakage concerns. Governments can thus craft interventions that support robust economic performance while addressing climate change concerns. Addressing valid carbon leakage concerns in specific sectors is also important since these sectors may play an important role in supplying downstream sectors. It is also important to consider political economy considerations. Determined opposition by highly affected industries, particularly if they are provide significant employment, may be sufficient to prevent credible climate policies from being implemented.

The socio-economic challenges facing South Africa mean that climate change mitigation must be balanced with the need for sustained economic growth and employment creation (DEAT 2009). Industrial policy in South Africa aims to diversify the South African economy away from its current over-reliance on energy- and capital-intensive upstream resource-based manufacturing. Based on international experience, these areas are likely to include the sectors that will be most vulnerable to climate change policies and may find it hard to compete in a carbon-constrained world. So while this goal makes sense from a climate change perspective as well, it should be borne in mind that these sectors are currently core to South Africa's international competitiveness. Energy-intensive upstream resource-based manufacturing currently constitutes a large part of the economy, attracts significant local and foreign investment, and contributes disproportionately to exports (Winkler & Marquard, 2007). Given the energy- intensive (and more importantly emissions- intensive) nature of the South African economy as a result of mispriced energy prices in the past, these industries are expected to face significant adjustment costs to be able to compete in a carbon-constrained world. It is thus important that carbon leakage concerns in these sectors be adequately addressed and that these sectors are assisted to transition as effectively as possible to a low (or at least lower) carbon production path.

6. Aligning industrial and climate change policies: conclusions and recommendations

To facilitate the transition of South Africa to a low-carbon growth path, industrial policy needs to start favouring less GHG emissions intensive industries (DEAT 2009). Climate change considerations need to be included in the overarching framework that guides the implementation of industrial policy in South African (future IPAPs and any revisions of the NIPF) to ensure that industries are supported that will be sustainable in a world with a universal price on carbon. This can be done in the ways given below.

6.1 Climate change considerations should inform sector targeting

Climate change considerations should inform the selection and prioritisation of sectors for support. Customised sector programmes, or whatever instruments form the basis for the implementation of industrial policy in future, should include a mandatory climate change section to provide baseline information on GHG emissions to inform sector prioritisation. This will also facilitate self-discovery with respect to climate change opportunities and the range and cost of mitigation technologies available to sectors. The provision of information about a firm's carbon footprint should become a necessary step to qualify for any form of government support (MEDS 2007). Considering the emissions-intensity of production reduces the risk that chosen sectors will not be able to remain competitive in a carbon-constrained world.

6.2 Generate information to assist policy formation

It is important that detailed emissions profiles are created for all South African sectors to identify sectors and subsectors that are at risk of experiencing significant competitiveness issues, and to be able to calculate the impact and effectiveness of climate policies on individual sectors. It is thus important to generate emissions data in a form that is useful for the analysis of individual sectors, for instance according to Statistics South Africa's Standard Industrial Classification (SIC) of all economic activities. The requirement that GHG emissions data is generated as a prerequisite to be considered for government support would create a powerful incentive to generate the data required to implement effective climate change policies.

6.3 Incorporate climate change into the implementation of industrial policy

Climate change considerations need to inform all industrial policy actions to instil a mindset that moves away from defining competitive advantage in terms of energy-intensive sectors and cheap electricity (DEAT 2009). The climate change implications of every industrial policy project supported needs to be considered (Winkler & Marquard, 2007). This should include not only general incentive programmes, but also industrial financing by the IDC, industrial upgrading and 'hidden industrial policy' in the form of support provided by departments other than the DTI. Where there are trade-offs between environmental and growth objectives, these trade-offs should be considered explicitly (MEDS 2007). The recently published draft regulations relating to tax incentives for large industrial projects include energy efficiency criteria in the qualifying criteria and are a useful example in this context. Environmental and energy efficiency standards should now be applied to all incentives.

During the implementation of cross-cutting aspects of industrial policy in South Africa, like industrial upgrading, support for research, development and innovation etc, special attention should be paid to financial and technical support for the adoption and adaptation of GHG mitigation technologies.

The implications of government's strategy to focus on high value-added products through the beneficiation of natural resources and ways to effectively fast-track this strategy should be considered. If additional value-add can outweigh additional energy use or carbon emissions, this will help to reduce the energy- and carbon-intensity of the economy as a whole (Winkler & Marquard, 2007).

Public procurement is considered as a tool to support industrial policy in South Africa. The European Union's example should be followed. South Africa should move to a 'Green Public Procurement' paradigm where energy efficiency and environmental standards for public procurement are specified to help support the development of carbon-efficient products (European Commission 2008: 7).

6.4 Exploit climate change opportunities

Climate change opportunities should be exploited directly and environmental goods and services should be prioritised as a sector for development. The European Union is currently undertaking a comprehensive screening of regulatory barriers and market failures in environmental industries that hamper their uptake and competitiveness as a precursor to public support (European Commission 2008). The self-discovery process will assist in the identification of potential new areas of advantage in 'climate-friendly' technologies locally. Government should seek to support firms to build new low-carbon competitive advantages in identified areas and become market leaders in promising new technologies (like solar energy or carbon capture and storage) that leverage local resources (DEAT 2009; Winkler & Marquard). Given the overlap with current industrial policy objectives identified earlier, the renewable energy sector should be identified as a key growth sub-sector within environmental goods and services (DEAT 2009).

6.5 Address valid carbon leakage concerns

It is important to identify the extent to which particular sectors are exposed to competitiveness issues as a result of carbon pricing.[7] In order to reduce the adjustment costs to the South African economy of moving towards a more environmentally sustainable growth path (built around higher value-added and knowledge-based production), vulnerable sectors should receive transitional support to move towards more carbon-friendly production processes. Support should be linked to technical measures to reduce the carbon emissions of firms or sectors to prevent interference with the overall structural adjustment path of the economy. This is consistent with the NIPF's view that interventions should focus on 'addressing specific constraints and opportunities ... [r]ather than generically subsidising a particular sector or activity' (DTI 2007a: 17). Specific measures will differ from industry to industry and depend on factors like the abatement technologies and options available to the industry, but in general should include measures linked to support for research and development, industrial upgrading, the adoption of new technologies, energy efficiency etc. These measures overlap with many of the cross-cutting issues already included in the NIPF

7 See Cloete et al (forthcoming) for a detailed methodology, applied to a number of local sectors, for identifying South African sectors that could potentially be vulnerable to negative competitiveness impacts as a result of a carbon pricing.

and should thus be relatively easy to implement within the current industrial policy framework in South Africa.

Reinaud (2009), however, highlights that it is important to design measures to address short-term competitiveness concerns as a result of carbon pricing in a way that does not over-compensate firms. Measures to address carbon leakage should not be used to compensate for other factors that may impact on the competitiveness of a sector like exchange rate movements, demand conditions, labour productivity etc. Policymakers should guard against the risk of 'using climate policy as a tool for industrial policy and undermining the effectiveness of climate policy' (Reinaud 2009: 10). The purpose of measures to address carbon leakage is thus to reduce the short to medium term adjustment cost of moving to a low-carbon growth path. They should thus be implemented as a tool to reduce the potential short-term negative impact of carbon pricing on industrial competitiveness, not as a tool of industrial policy that promotes industrial development at the expense of climate change mitigation.

6.6 Allow structural changes to the economy

Reinaud (2008) emphasises that carbon leakage refers only to the artificial competitiveness disadvantage experienced by industries in countries where carbon is priced into the production process relative to carbon 'unconstrained' producers in countries where carbon does not have a price. Gradual changes in the comparative advantage of countries as the cost of carbon is being internalised into the production process should thus not be viewed as carbon leakage.

In the long run, it is quite possible that the introduction of a price on carbon emissions will mean that some industrial activities will no longer be viable in South Africa. These activities should be allowed to migrate to other parts of the world. The best example of an industry that may be unviable in South Africa in a carbon-constrained world is aluminium smelting. Winkler and Marquard (2007) mention that the aluminium smelting industry is based in South Africa primarily as a result of electricity prices that have been very low historically. The industry imports its feedstock and exports most of its production. This stands in contrast to other mineral beneficiation industries like coal, iron and steel, ferrochrome etc, that beneficiate minerals that are mined locally and of which a large proportion of production is consumed locally. Winkler and Marquard (2007: 20) contend that 'aluminium smelting in South Africa is thus really another form of coal beneficiation or electricity export'. In a world where the cost of carbon is fully priced into the production of goods and services, it is likely that the production of aluminium will be concentrated in countries like Canada, where on average 200g of CO_2 is emitted per kilowatt-hour of electricity generated, rather than South Africa, where on average 960g of CO_2 is emitted per kilowatt-hour of electricity generated (Winkler 2008).

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THEME 2: QUANTITATIVE ANALYSES OF CARBON PRICING

What is fair? Meeting a national emission reduction target in an experimental setting

Kerri Brick and Martine Visser

Abstract
In this paper, we use a one-shot public goods framework with heterogeneous groups and a climate change framing to analyse the public good-dichotomy between social welfare and individual incentives. Using a variant of the standard Voluntary Contribution Mechanism (VCM), we examine the cooperative behaviour of different player-types in meeting a national emission reduction target when players can invest in mitigation or continue with business-as-usual. The experiment consists of four treatments: the standard VCM, a VCM with communication opportunities and two VCM variants which specify minimum contributions to the public good and sanction free-riding. We find that voluntary cooperation results in insufficient cooperation in the context of meeting a national target. With the introduction of communication, cooperation is significantly improved, indicating that stakeholder participation is important in facilitating compliance. With the introduction of taxation, cooperation in the context of meeting the target is near universal. Importantly, we find that tax crowds out contributions in excess of the target.

Keywords: climate change, national target, public good, communication, tax

1. Introduction

Given that mitigation is a public good, climate change poses the ultimate social dilemma: curtailing greenhouse gas emissions entails a private cost while the benefits are shared equally by all – creating an incentive for individuals to free-ride, ultimately emitting more green-house gases than is optimal (Brekke & Johansson-Stenman 2008). In this paper, we use a one-shot public goods framework with heterogeneous groups and a climate change framing to analyse this public good-dichotomy between social welfare and individual incentives.

While the dominant strategy in linear public good games is for each player to contribute nothing, subjects make positive but suboptimal contributions to public good provision (Cherry & Kroll 2005). Similarly, in the application to mitigation as a public good, despite no *individual* incentive to do so, governments, businesses and individuals around the world are taking steps to reduce greenhouse gas emissions. As Irwin (2009) notes, this attempt at reducing greenhouse gas emissions certainly does not imply that emission levels will be reduced to optimal levels, but it suggests that potential for cooperation exists. In this paper, we use behavioural economics to offer insights into the potential for cooperation in the context of this social dilemma.

When faced with a social dilemma, an institutional structure to enforce a cooperative norm in a group or society can be imposed exogenously; conversely, the institutional structure may emerge endogenously as the outcome of a social choice process (Noussair & Tan 2009). In this paper, we use evidence from the lab to consider the effectiveness of different exogenously imposed institutions in fostering cooperation among asymmetric agents.[1]

Using a variant of the standard Voluntary Contribution Mechanism (VCM), we examine the cooperative behaviour of different player-types in meeting a national emission reduction target when players can invest in mitigation or continue with business-as-usual. The experiment consists of four treatments: the standard VCM, a VCM with communication opportunities and two VCM variants which specify minimum contributions to the public good and sanction free-riding.

The significant reduction in greenhouse gases needed to avoid catastrophic climate change requires a great degree of cooperation among asymmetric agents. For example, the Kyoto Protocol requires countries with large income and historical emission disparities to reach consensus on individual targets for the reduction of emissions. On a national scale, so too does meeting a national abatement target require collective action from asymmetric individuals. In the literature, asymmetry has been introduced into the public good framework by varying subjects' participation fees (Anderson et al 2004), endowments (Rappoport & Suleiman 1993, Bagnoli & McKee 1991, Cherry et al 2005, Chan et al 1996, Buckley & Croson 2006, Hofmeyr et al 2007, Isaac & Walker 1988, Chan et al 1999), marginal per capital returns (MPCRs) (Fisher et al 1995, Tan 2008) and private account valuations (Palfrey & Prisbrey 1997). While the impact of heterogeneity on cooperative behaviour has been examined using a variety of methods and game settings, results from the literature are mixed. Various authors report that heterogeneity improves group contribution levels (Chan et al 1999, Chan et al 1996), while others find the opposite effect (Anderson et al 2004, Rappoport and Suleiman 1993, Cherry et al 2005, Isaac & Walker 1988).

The experimental evidence from public good games with symmetric players and sanctioning reflect the norm of equal contributions (Reuben & Riedl 2009). For example, Fehr and Gächter (2000), Fehr and Gächter (2002) and Anderson and Putterman (2006) find that punishment increases as the differential between individual contributions and average group contributions widens, while Gächter et al (2008) conclude that deviations from the punisher's contribution are sanctioned. Conversely, few studies report on the effect of heterogeneity on individual contributions. In this context of individual contributions among asymmetric players, it is not evident what contribution norm will arise in a public good context. Fisher et al (1995), who

[1] Brick and Visser (forthcoming) test whether endogenous institutional choice enhances public good provision by allowing subjects to endogenously select an institution (through a voting process).

examine the impact of asymmetric MPCRs in a linear public good setting, find that low-MPCR players contribute less to public good provision relative to high-MPCR players. In terms of the impact of endowment heterogeneity on individual contributions, Chan et al (1996) find that low income players over-contribute in terms of public good provision while high income players under-contribute, Buckley and Croson (2006) report that low income players contribute a higher proportion of income to the public account relative to high income players and Hofmeyr et al (2007) conclude that wealthy players contribute the same percent of income to the public account as their wealthier counterparts. In this paper, we examine whether different contributions norms emerge across different player types.

In this paper, we introduce heterogeneity by varying subjects' marginal contributions to the public good. As high-types have lower marginal costs of abatement relative to low-types, one token invested in mitigation (public good) translates into more units of emissions reduced relative to low-types. We denote each additional token invested by high-types in mitigation as making a larger marginal contribution to the public good relative to an additional token invested by low-types. To the best of our knowledge this is the first paper to introduce heterogeneity in such a manner. The impact of heterogeneity on cooperation is particularly significant in the context of mitigation given that suboptimal levels of cooperation will not subvert the potentially catastrophic effects of climate change, and optimal reduction of greenhouse gas emissions will require significant feats of cooperation.

As international climate talks revolve around the question of how to distribute an abatement burden, equity and distributive fairness considerations have become important subtexts in global climate change negotiations (Dannenberg et al 2007). The United Nations Framework Convention on Climate Change (UNFCCC) underscores the need for 'common but differentiated responsibilities' (UNFCC 1992; 1998), while climate negotiators subscribe to a number of equity arguments including polluter-pays, equal percentage reduction and equal per-capita emissions (Lange et al 2007). Discussion on the role of equity considerations in global climate talks and the importance of fairness for sustaining international cooperation is extensive: Cazorla and Toman (2000); Lange et al (2007a, 2007b); Ringius et al (1998, 2001); Torvanger and Ringius (2002); Dannenberg et al (2007), Winkler et al (2001), Posner and Sunstein (2007). Conversely, on a national scale, despite the fact that reducing a national greenhouse gas inventory will require a change of behaviour from industry and individuals (Vandenberg and Ackerly 2007), the literature addressing equity issues in a domestic context is far more limited.

The paper proceeds as follows: Section 2 reviews the experimental literature on heterogeneity. Section 3 introduces the experimental framing while the experiment design, procedures and parameters are discussed in Section 4. The experimental results are examined in Section 5. Section 6 concludes with a discussion of the possible policy implications.

2. Experimental evidence

A number of studies examine the impact of heterogeneity on *group* contribution levels. Anderson et al (2004) introduce inequality by varying subjects' participation fees. The authors find that when information is complete and subjects are made aware of the unequal payment distribution, cooperation is decreased.

When examining the effect of asymmetric endowments in a threshold public good setting with incomplete information, Rappoport and Suleiman (1993) report heterogeneous groups to be less successful in meeting the threshold relative to homogenous groups, while Bagnoli and McKee (1991) find heterogeneous groups acting in an environment of complete information to be just as capable. Cherry et al (2005) examine the impact of endowment heterogeneity and origin on cooperation. Their results indicate that endowment heterogeneity significantly reduces group contribution levels. Using a linear public good setting with asymmetric endowments, incomplete information and communication, Isaac and Walker (1988) find that contribution levels are lower under conditions of heterogeneity. Chan et al (1999) analyse the impact of asymmetric endowments and preferences on group contribution levels in a non-linear public good environment with communication and incomplete information. The authors find that heterogeneity increases cooperation.

Turning the discussion to literature reporting the effect of heterogeneity on individual contribution levels, Fisher et al (1995) examine the impact of asymmetric marginal per-capita returns (MPCRs) in a linear public good setting with symmetric endowments. While subjects were told not to assume that all participants have the same MPCR, subjects were not explicitly told that within-group MPCRs differed. The authors conclude that contributions to the public good are strongly incentivised by the MPCR, with low-MPCR players contributing less relative to high-MPCR players.

Chan et al (1996) find that (known) endowment heterogeneity results in high group contribution levels; however, in terms of individual contributions, low income players over-contribute in terms of public good provision while high income players under-contribute.

Buckley and Croson (2006) examine the impact of (known) income heterogeneity in a linear public good setting. In contrast to theories of inequality-aversion and altruism, low income players are found to contribute a higher proportion (same absolute amount) of income to the public account relative to high income players. Hofmeyr et al (2007), who also analyse the effect of endowment asymmetry in a linear public good game, find no significant effects from endowment heterogeneity on contributions. Furthermore, as consistent with reciprocity models, less wealthy players contribute the same percent of income to the public account as their wealthier counterparts.

3. Experiment framing

In the environmental economics sub-class of the experimental economics literature, the use of framed lab experiments is common in the areas of emissions trading (Bohm and Carlén 2002, Wråke et al 2008, Croson et al 2005, Klaassen et al 2005) and green certificate trading (Schaeffer and Sonnemans 2000). While framed public good games are not as prevalent, ours is not the first experiment to utilise an environmental (climate change) framing: using a linear public good setting, Millinski et al (2006, 2007) examine whether subjects would cooperate so as to prevent dangerous climate change. Subjects could invest €0, €2 or €4 in a climate account, where the sum total of contributions would be used to publish the experiment results and information on climate change in a local newspaper. Hasson et al (2009) used a framed lab experiment to examine the trade-off between country investments in mitigation versus adaptation. Subjects were asked to consider themselves as their respective country's principle climate practitioner. Participants had to decide whether to invest their entire climate budget in mitigation versus adaptation.

We now turn to the experimental framing used in this experiment. Upon entering the lab, participants were allocated a factor of production and told to think of themselves as representing either capital or labour. It was explained that government has set a national emission reduction target[2] in line with its multilateral obligations and that the experiment investigates how the responsibility of meeting this target could be divided between different sectors of society (capital or labour).

Subjects had to decide how much of their endowment to invest in the environment (public account), where, investing in the environment is synonymous with investing in mitigation. Players earn a return from investing in mitigation. Given that this study assumes the setting of the national target is part of a multilateral voluntary commitment to reduce emissions, the return from mitigation includes a decrease in the risks related to climate change (such as environmental disaster). At a local level, a focus on demand-side management by the local utility, to reduce peak-time consumption, will benefit consumers by reducing the probability of costly black-outs. Because the environment is a public good, and no one can be excluded from deriving these benefits, each member of the group receives the same income from the public account – irrespective of his or her contribution level. Thus the MPCR from investing in mitigation is the same for all players.[3]

Alternatively subjects could invest in other income generating activities by directing their endowment towards the private account. The private account represents investment opportunities other than investing in mitigation. Because capital can more easily invest in productive (income-generating) activities as compared to labour, capital earns a higher return from money invested in the private account relative to labour.[4]

The total sum of tokens in the public account represents the emission reduction of each group. We assume that capital (firms) have lower marginal costs of abatement relative to labour (households). Intuitively, because capital emits more pollution relative to labour (is dirtier), it is *relatively* cheaper for capital to reduce a unit of emissions. This means that capital is able to reduce more emissions with one token relative to labour. We therefore denote each additional token invested by capital in

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2 As discussed in Section 4, the target was binding in only two of the treatments. However, throughout the experiment, players were told that government is committed to meeting this target and asks capital and labour players to ensure that the target is met.

3 Note that this differs from studies that have varied the MPCR. Ruben and Riedl (2009) implement a linear public good game where group members differ in terms of the marginal benefit from public good provision. Specifically high-type players derive a marginal benefit from the public good of 0.75 while low-types have a marginal benefit of 0.50. Fisher et al (1995) vary MPCR *between* groups, where high and low groups have a MPCR of 0.75 and 0.30, respectively. Tan (2008) introduces the notion of *productivity heterogeneity*, whereby subjects within a group have asymmetric impacts on the public good. Players have different MPCRs *to* the public good – with high and low types having a MPCR of 0.9 and 0.3 respectively. This work is similar in specification to our study in that subjects, irrespective of type, benefit equally from contributions to the public good. Income for player i is denoted as:

$$I_i = 10 - C_i + 0.9 \times \sum_{h=1}^{2} C_h + 0.3 \times \sum_{l=1}^{2} C_l \quad .$$

Thus, player *i*'s income from the public account is calculated as 90% of the contributions of high types plus 30% of the contributions of low types. The same experimental specification is used in Noussair and Tan (2009).

4 The parameters used in the experiment are outlined in Section 4.

mitigation as making a larger marginal contribution to the public good relative to an additional token invested by labour.

4. Experiment design and parameters

The game was played in groups of four that were randomised at the start of each treatment. Each group consisted of two capital and two labour players.

In the standard VCM (the baseline treatment), participants, who are either representing capital or labour, are endowed with 10 tokens which must be allocated between a private and public account. Players are aware of a national emissions reduction target and are told that, while government is committed to meeting the target, players will not be penalised if the target is not met. Communication is prohibited. Subjects' payoffs are given by

$$\pi_{K_i}=12(10-c_i)+0.25\left(20\times\sum_{i=1}^{2}c_{K_i}+10\times\sum_{i=1}^{2}c_{L_i}\right) \quad (1)$$

$$\pi_{L_i}=6(10-c_i)+0.25\left(20\times\sum_{i=1}^{2}c_{K_i}+10\times\sum_{i=1}^{2}c_{L_i}\right) \quad (2)$$

where c_i reflects investments in the public good.

As evident from Equations 1 and 2, each token contributed to the private account generates a private return of 12 and 6 tokens for capital and labour, respectively.

Capital and labour's contributions to the public account are multiplied by 20 and 10, respectively. As such, capital is able to contribute more to emissions reductions relative to labour, at the same personal cost. This is reflected in Table 1, which tabulates emissions reductions, per token invested in the public account, for both player types. Note that the cumulative sum of contributions to the public account denotes the units of emissions reduced.

In terms of the returns from investing in mitigation, one token invested in the public account by capital generates a return for each group member of 5 tokens; similarly, one token invested in the public account by labour generates a return for each group member of 2.5 tokens.[5]

As usual, the dominant strategy is for players to contribute nothing to the public account whereas the social optimum is achieved when all players contribute their full endowment to the public account; this is reflected in the symmetric payoff tables reproduced in Appendix A.

An explicit national emission reduction target of 240 units was specified. Table 1 illustrates that the target can be met via Capital and Labour contributing different combinations of tokens to the public good.

[5] For both capital and labour, the ratio between the marginal value of a token invested in the public account and the marginal value of a token invested in the private account (the MPCR) is 0.42.

Table 1. Emissions reductions, per token invested in the public account

Tokens	*Units emissions reduced*	
	K	*L*
0	0	0
1	20	10
2	40	20
3	60	30
4	80	40
5	100	50
6	120	60
7	140	70
8	160	80
9	180	90
10	200	100

We extend this standard VCM by way of four experimental variants which are outlined below:

Variant 1. Introduce the possibility of communication with group members. The communication treatment is identical to the baseline treatment except that subjects were able to communicate with each other via an online chat program in order to decide, as a group, how best to meet the target. However, players were informed that the group decision was not binding and that players were still free to decide on their own contribution. In this treatment we are obviously examining the role of stakeholder participation in promoting cooperation.

Variant 2. Specify minimum contributions to the public good and sanction free-riding. Capital players must each contribute a minimum of 3 tokens to the public account whereas labour players must each contribute a minimum of 6 tokens. Capital and labour players each reduce emissions by 60 units. This treatment is hereafter referred to as Tax36.

In the Tax36 treatment, all sectors in the economy reduce emissions equally, irrespective of the difference in the cost of abatement. In this treatment, players are taxed on the quantity of emissions; the implied contribution norm is that capital and labour players each reduce emissions by the same quantity. If capital and labour must meet the target of reducing emissions by 240 units and reduce emissions by the same quantity, then all four players must reduce emissions by 60 units each. This is equivalent to each capital player contributing 3 tokens to the public account and each labour player contributing 6 tokens (Table 1). In the advent that a subject contributes less than the minimum contribution, he or she is taxed.

Subjects' payoffs are given by:

$$\pi_{K_i}=12(10\text{-}c_i)+0.25\left(20\times\sum_{i=1}^{2}c_{K_i}+10\times\sum_{i=1}^{2}c_{L_i}\right)\text{ if }c_{iK}\geq 3 \quad (3)$$

$$\pi_{K_i}=12(10\text{-}c_i)+0.25\left(20\times\sum_{i=1}^{2}c_{K_i}+10\times\sum_{i=1}^{2}c_{L_i}\right)\text{-}(10\times(3\text{-}c_{iK})\text{if }c_{iK}<3 \quad (4)$$

$$\pi_{L_i}=6(10\text{-}c_i)+0.25\left(20\times\sum_{i=1}^{2}c_{K_i}+10\times\sum_{i=1}^{2}c_{L_i}\right)\text{ if }c_{iK}\geq 6 \quad (5)$$

$$\pi_{K_i} = 6(10 - c_i) + 0.25\,(20 \times \sum_{i=1}^{2} c_{K_i} + 10 \times \sum_{i=1}^{2} c_{L_i}) - (10 \times (6 - c_{iK})\text{ if } c_{iK} < 6 \quad (6)$$

The corresponding payoff tables are replicated in Appendix B. As evident from these tables in Appendix B, the Nash Equilibrium is moved inwards to (3,6) for (capital, labour), respectively.

Variant 3. Specify minimum contributions to the public good and sanction free-riding. Capital and labour players must each contribute a minimum of 4 tokens to the public account. Capital and labour players each reduce emissions by 80 and 40 units, respectively. This treatment is referred to as Tax44.

In the tax44 treatment, capital and labour are taxed on their monetary contribution to emissions reduction. Capital and Labour can reduce emissions by different quantities as long as they are contributing the same amount in tokens. If each capital and labour player contributes 4 tokens, each group will collectively meet the emission reduction target (see Table 1). In this case, capital players must reduce emissions by 80 units each, while labour players must reduce emissions by 40 units each. If subjects contribute less than 4 tokens to the Public Account they are taxed. Subjects' payoffs are given below.

$$\pi_{K_i} = 12(10 - c_i) + 0.25\,(20 \times \sum_{i=1}^{2} c_{K_i} + 10 \times \sum_{i=1}^{2} c_{L_i})\text{ if } c_{iK} \geq 4 \quad (7)$$

$$\pi_{K_i} = 12(10 - c_i) + 0.25\,(20 \times \sum_{i=1}^{2} c_{K_i} + 10 \times \sum_{i=1}^{2} c_{L_i}) - (10 \times (3 - c_{iK})\text{ if } c_{iK} < 4 \quad (8)$$

$$\pi_{L_i} = 6(10 - c_i) + 0.25\,(20 \times \sum_{i=1}^{2} c_{K_i} + 10 \times \sum_{i=1}^{2} c_{L_i})\text{ if } c_{iK} \geq 4 \quad (9)$$

$$\pi_{K_i} = 6(10 - c_i) + 0.25\,(20 \times \sum_{i=1}^{2} c_{K_i} + 10 \times \sum_{i=1}^{2} c_{L_i}) - (10 \times (6 - c_{iK})\text{ if } c_{iK} < 4 \quad (10)$$

The reader is referred to Appendix C for the corresponding payoff tables. As evident from the tables in Appendix C, the Nash Equilibrium is moved inwards to (4,4) for (capital, labour), respectively.

4.1 Procedures

The experiment was conducted with 204 students recruited from the University of Cape Town (UCT) in the Western Cape of South Africa. The reader is referred to Table 2 for a summary of sample statistics. On average, subjects were 21 years old. Over 60% of subjects were male. Around three-quarters of participants classified themselves as Black, while the remaining subjects classified themselves as Coloured, White and Indian. Around 30% of subjects' classified their family's financial situation as lower income, while 67% classified their family as middle income. Subjects were recruited via announcements made in lecture theatres and posted on the course sites of an online UCT student administration system. Students from a broad spectrum of faculties were targeted for participation including commerce, humanities and the built environment.

Table 2. Sample statistics

	Subjects *n=204*
Gender	
• Male	0.63
• Female	0.37
Race	
• Black	0.78
• Coloured	0.07
• Indian	0.05
• White	0.07
• Other	0.02
Schooling	
• Public	0.65
• Private	0.35
Nationality	
• South African	0.69
• Other	0.31
Age	20.92 (1.76)
Household size	5.56 (2.55)
Family's financial situation	
• Upper income	0.05
• Middle income	0.67
• Lower income	0.28

Note: Standard deviations in parenthesis

The mechanics of the experiment are outlined in Table 3. The experiment consisted of three different sequences. Sequence 1 merely consisted of the baseline treatments and acts as a control. Sequence 2 and 3 consisted of the baseline, communication and tax treatments, and differed only in the ordering of the treatments.[6] Each session was completed over 2 sessions.

The experiments were performed manually. Upon entering the laboratory, each participant randomly drew an experiment number and factor of production. It was explained that, unless told otherwise, communication was prohibited with anyone except the experimenter.

While subjects were aware that each group consisted of two capital and two labour players, the identities of their group members were never revealed. Information relating to their group members' individual contributions was also not made available. During the communication treatment, group members chatted with one an-

6 All experiment sessions commenced with treatment 1 (baseline treatment) given that it was crucial for subjects to understand the context of the experiment and the fairness issues at play.

other via an online chat program. Participants were assigned to new groups at the start of each treatment.

In each experiment session, the instructions for the 5 different treatments were sealed in separate envelopes. At the start of a treatment, subjects opened the envelope corresponding with that treatment. The instructions were read aloud by the experimenter while the subjects followed on their own hard copies. As such, payoffs were common knowledge. An exchange rate for the conversion of experimental tokens into South African rands was specified at the beginning of the session (1 token = R0.2).

During each treatment, subjects recorded their contributions on a decision-making sheet which was collected by enumerators who calculated each groups' total contribution to the public good and each players' payoff.

While the experiment had a climate change framing, the instructions were neutrally-worded in relation to issues around distributive justice: words such as equity, equality and fair were never referenced. In addition, language referring to capital and labour remained neutral: subjects were simply told to think of capital as representing firms and labour as representing households. No mention was made of historical responsibility for the current inventory of emissions or to the differential emission levels of dirty industry versus households.

Table 3. Experiment overview

Treatment	*Sequence 1*	*Sequence 2*	*Sequence 3*
Treatment 1	Baseline 1	Baseline	Baseline
Treatment 2	Baseline 2	Comm.	Tax44
Treatment 3	Baseline 3	Tax36	Tax36
Treatment 4	Baseline 4	Tax44	Comm.
Sessions	2	2	2
Sample	68	68	68

Apart from the instructions, students were provided with summary sheets and payoff tables to assist them in making their decisions. Before commencing with the experiment, examples were conducted with the participants. In addition, an excel-spreadsheet calculator was provided to students for use during the experiment; this meant that students were not preoccupied with the mathematical component of calculating their payoffs. An example of the calculator is provided in Appendix D. Each experimental session lasted less than three hours (including payment). At the end of the experiment, participants filled out a post-experiment questionnaire.

Mann-Whitney tests can't reject the null hypothesis that the contributions in Session 1 and 2 (for each sequence) are drawn from the same distribution ($p > 0.110$ for all sequences) (See Appendix E). As such, when discussing the experimental results for each treatment, mean contributions are averaged across Session 1 and 2 for each sequence. In addition, like-treatments in Sequence 2 and 3 will be pooled given that Mann-Whitney tests do not find them to be significantly different (Appendix E).

5. Experimental results

Average earnings for participating in the experiment (including the R20 show-up fee) were approximately R132 (S$17, at an exchange rate of R1 = $7.70 as per 1 March 2010). Capital players fared better at R152 (US$20) while Labour players averaged R111 (US$14).

5.1 Contribution levels and norms

Table 4 reflects the average contributions of players across the various treatments.

5.1.1 Baseline (Sequence 1)

As reflected in Table 4, average contribution levels (across player-types) range between 22 – 29 percent for the 4 treatments in Sequence 1 (Baseline). These contribution rates undershoot those typically seen in the literature, where, in one shot public good games, contributions to the public good generally range between 40-60 percent of endowments (Ledyard 1995). Contribution levels are more in line with those seen in repeated play, where contributions decay over time (Hermann et al 2008) but remain between 15-25 percent of individual endowments in the final round (Isaac and Walker 1988). While the Spearman rank-order correlation between mean contributions and treatments is negative but insignificant $(\rho = -0.073, p > 0.100)$, the decreasing pattern for the first three treatments is significant at the 10 percent level $(\rho = -0.121, p = 0.084)$.

Observation 1. Player heterogeneity has no significant impact on contributions to the public good

As a token contributed by capital has a greater marginal impact on the public good relative to labour, we would expect capital contributions to be higher. Figure 1 presents a plot of the average contributions of both player-types in each of the 5 treatments *in* Sequence 1 (Baseline). There is little difference in the average contribution levels of capital and labour across the four treatments. Specifically, the average contribution of labour players in the first treatment of the experiment is 3.1 tokens, decreasing to 2.3 tokens in the final treatment. In contrast, capital players contribute an average of 2.7 tokens in treatment 1, reducing contributions to 2.4 tokens in the final treatment. Mann-Whitney tests confirm there to be no significant difference between Capital and Labour contributions in each treatment (p>0.080 for all four treatments). Kruskall-Wallis tests comparing the contributions of each player-type across all treatments cannot be rejected (capital: $p = 0.457$; labour: $p = 0.341$), indicating there to be no statistically significant difference in contributions among the different treatments.

Table 4. Average contributions

Panel A: average contributions, by Sequence

	Seq. 1 n=68				Seq. 2 n=68				Seq. 3 n=68		
	Avg.	*K*	*L*		*Avg.*	*K*	*L*		*Avg.*	*K*	*L*
Baseline 1	2.9	2.7	3.1	*Baseline*	2.8[2;3]	2.9[2;3]	2.7[2;3]	*Baseline*	3.6[1;2;3]	4.0[1]	3.3[2;3]
Baseline 2	2.3[f]	1.8[a;f]	2.9[f]	*Comm.*	3.8	3.6[a]	4.1	*Tax44*	4.6[3;f]	4.3[f]	5.0[3;f]
Baseline 3	2.2[c;d]	2.3[c;d]	2.1[c;d]	*Tax36*	5.2[2;c]	3.7[2;c]	6.7[2;c]	*Tax36*	5.3[2; d]	4.2[d]	6.4[2; d]
Baseline 4	2.4[b;e]	2.4[b;e]	2.3[e]	*Tax44*	4.8[3;e]	4.5[3;e]	5.1[3;e]	*Comm.*	5.1[1;b]	5.9[1;b]	4.2

Wilcoxon signed-rank test

[1] Significant difference between Baseline and Comm. ($p < 0.05$)

[2] Significant difference between Baseline and Tax36 ($p < 0.05$)

[3] Significant difference between Baseline and Tax44 ($p < 0.05$)

Mann-Whitney test

[a] Significant difference between Baseline2 and Comm. ($p < 0.05$)

[b] Significant difference between Baseline4 and Comm. ($p < 0.01$)

[c] Significant difference between Baseline3 and Tax36 ($p < 0.05$)

[d] Significant difference between Baseline3 and Tax36 ($p < 0.05$)

[e] Significant difference between Baseline4 and Tax44 ($p < 0.01$)

[f] Significant difference between Baseline2 and Tax44 ($p < 0.01$)

Panel B: average pooled contributions (Sequence 2 and 3)

	Pooled Seq. 2 and 3		
	Avg.	*K.*	*L*
Baseline	3.2[1;2;3]	3.4[1;3]	3.0[1;2;3]
Comm.	4.4[1]	4.8[1]	4.1[1]
Tax36	5.3[2]	3.9	6.6[2]
Tax44	4.7[3]	4.4[3]	5.0[3]

Wilcoxon signed-rank test

[1] Significant difference between Baseline and Comm. ($p < 0.01$)

[2] Significant difference between Baseline and Tax36 ($p < 0.01$)

[3] Significant difference between Baseline and Tax44 ($p < 0.01$)

Observation 2. Free-riding emerges as the contribution norm – irrespective of player heterogeneity

We have found no significant difference in the average contributions of capital and labour players. Figure 2 illustrates the distribution of capital and labour contributions, by treatment, in Sequence 1. The figure suggests that the most apparent contribution norm, irrespective of player-type, is to contribute zero tokens (free-ride).

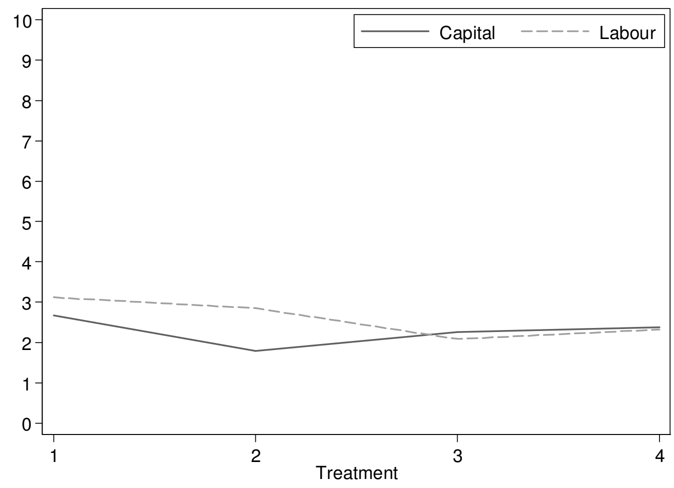
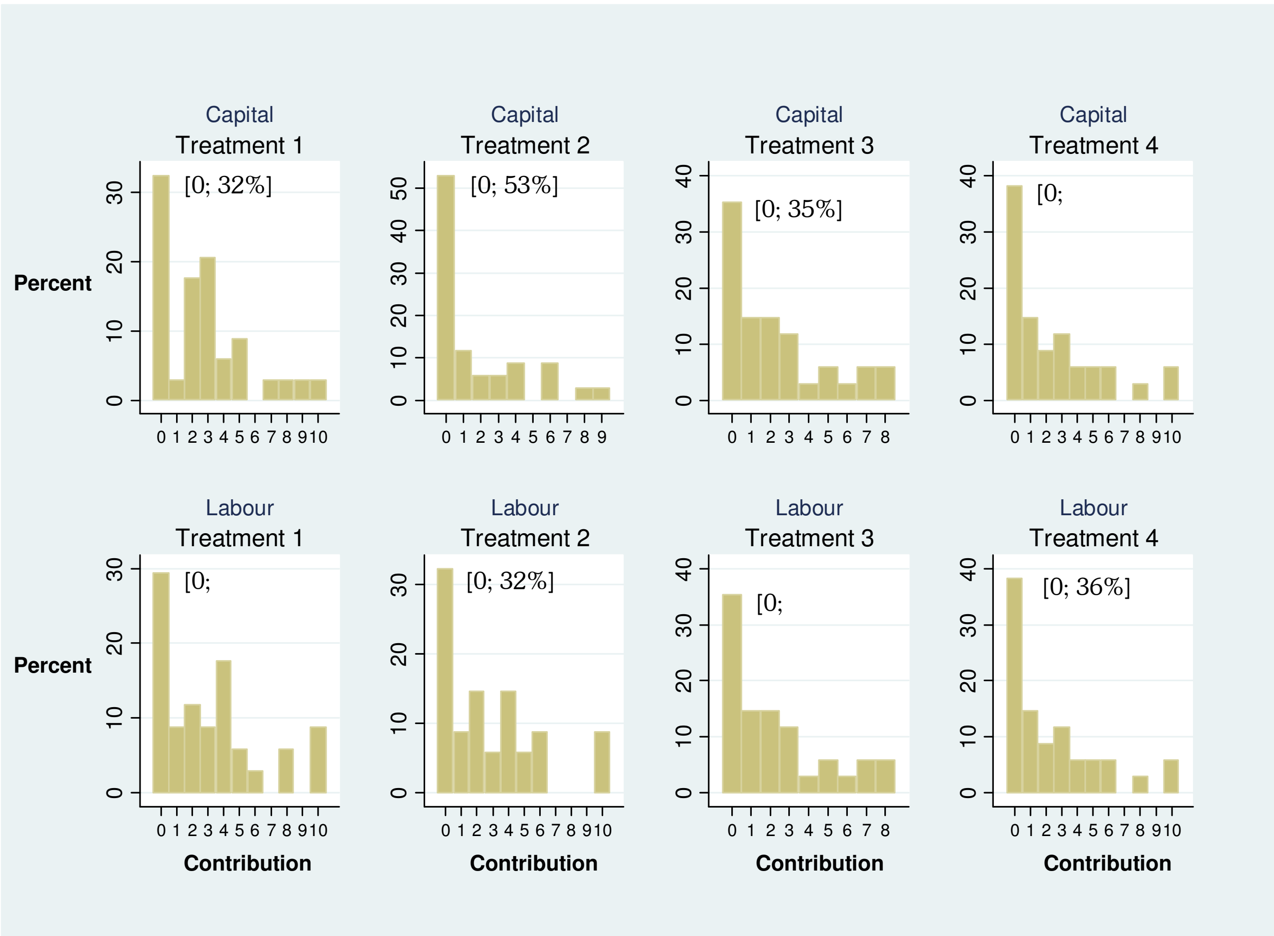


Figure 1. Average contribution to public account



Note: Sequence 1; percent free-riding indicated in square brackets

Figure 2. Subject contributions, by player-type and treatment, Sequence 1 (baseline)

The predilection towards free-riding is likely explained by the high opportunity cost associated with investing in mitigation. For capital, 1 token invested in the private account returns 12 tokens, outpacing the public account return of 5. Likewise, for labour, the private account return of 5 exceeds the return of 2.5 from investing in the environment. As such, in an approximation of reality, the *individual* return to mitigation, for both player-types, is less than the return earned on alternate investment opportunities.

5.1.2 Communication

Observation 3. Communication significantly increases cooperative behaviour

Communication significantly (but unremarkably) increases *average* contributions across both player-types (Wilcoxon signed-rank test: $p < 0.01$ for pooled data; Table 4). As evident from the *pooled* data in Table 4, average contributions across player-types increased by 1.2 tokens to 4.4 tokens when compared to the Baseline treatment. Capital increased contributions on average by 1.4 tokens; this is comparably similar to that of labour where contributions increased by an average 1.1 tokens. Again, while expecting capital to contribute more towards the public good, a Mann-Whitney test indicates there to be no significant difference between capital and labour contributions (pooled data; Table 4; $p < 0.01$) .

An examination of individual (as opposed to mean) contribution rates yields some interesting observations. Table 5 reflects the frequency of contributions at each possible contribution level for the Baseline and Communication treatments, by player-type. It is evident that the opportunity to communicate increases the frequency of plays of ten tokens (full-cooperation) as well as the frequency of plays of zero tokens (free-riding). A plot of the frequency distributions in Appendix F confirms that the presence of communication polarises contribution levels at 0 and 10 tokens.

To examine whether the presence of communication makes free-riding and full-cooperation more likely, we collapse the data in Table 2 into 3 categories of 0, 1-9 and 10 tokens. For capital, the corresponding frequencies for the Baseline treatment are 0.21, 0.74 and 0.06, as compared to 0.27, 0.42 and 0.31 for the communication treatment. A statistically significant goodness of fit test confirms that these two frequencies do in fact differ from one another ($X^2_{[2]}=82.25, p<0.01$). Likewise, a comparison of the frequency of plays of 10 tokens between the Baseline and Communication treatments is significant at the 1 percent level[7] confirming that communication encourages cooperative behaviour. Conversely, a comparison of the frequency of plays of zero tokens between the two treatments is insignificant ($X^2_{[1]}=0.654, p=0.419$).

[7] We use a Fisher exact test given that the frequency of plays of ten tokens in the baseline treatment is less than 5.

Table 5: Frequency distribution of contributions to the public good, by treatment and player-type

Treatment	*Contribution*										
	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Capital (n=68)											
Baseline	0.206	0.103	0.059	0.191	0.162	0.074	0.059	0.029	0.059	0.000	0.059
Comm.	0.265	0.044	0.074	0.074	0.074	0.088	0.029	0.029	0.015	0.000	0.309
Labour (n=68)											
Baseline	0.338	0.074	0.088	0.059	0.132	0.132	0.074	0.015	0.029	0.000	0.059
Comm.	0.456	0.029	0.029	0.000	0.044	0.029	0.044	0.029	0.044	0.044	0.250

Note: Sequence 2 and 3

In the case of labour, in the baseline treatment, figures for the same three categories are 0.34, 0.60 and 0.06 versus 0.46, 0.29 and 0.25 in the communication treatment. This difference is significant at the 1 percent level ($X^2_{[2]}=55.82, p<0.01$). Likewise, a comparison of the frequency of plays of 10 tokens between the Baseline and Communication treatments is highly significant ($p < 0.01$)[8], while a comparison of the frequency of plays of zero tokens between the two treatments is insignificant ($X^2_{[1]}=1.966, p=0.161$). We can therefore draw the same conclusion that communication encourages cooperative behaviour in labour.

As reflected in Table 6, the absolute spend on the public good increased in the communication treatment to 604 tokens relative to 436 tokens in the pooled baseline treatments.

Table 6: Absolute spend on the public good

Sequence 1 (17 groups)		*Baseline* (34 groups)*	*Comm.* (34 groups)*	*Tax36* (34 groups)*	*Tax44* (34 groups)*
Baseline 1	197	436	604	714	642
Baseline 2	158				
Baseline 3	148				
Baseline 4	160				
Max. spend per treatment: 680 tokens		*Max. spend per treatment: 1360 tokens*			
Note: * Sequence 2 and 3					

Observation 4. Labour free-rides significantly more than capital

We now consider whether contributions differ *by player-type*. The frequency of plays of zero tokens in the baseline treatment is 21% for capital as compared to 34% for labour. This difference is significant at the 10% level ($X^2_{[1]}=3.007, p=0.083$). A similar

8 We use a Fisher exact test given that the frequency of full-cooperators in the baseline treatment is less than 5.

comparison for the communication treatment reveals that labour free-rides significantly more than capital ($X^2_{[1]}$=5.392, p=0.020).

The frequency of plays of ten tokens in the in the baseline treatment is 6% for both capital and labour. In the communication treatment, capital plays ten tokens 31% of the time as compared to 25% for labour. This difference is not significant ($X^2_{[1]}$=0.584, p=0.445).

5.1.3 Taxation

The emission reduction target of 240 can be met through capital and labour players contributing different combinations of tokens towards public good provision (Table 7). In the context of a homogonous group-setting, where equal contributions to the public good would imply equal emissions reductions and earnings, a reasonable contribution norm would dictate that all players contribute the same amount in tokens (Ruben and Riedl 2009), however, in the context of heterogeneous groups such as ours, it is not immediately clear what allocation principle should apply.

Table 7. Emissions reductions, per token invested in the public account

Tokens	*Units emissions reduced*	
	K	*L*
0	0	0
1	20	10
2	40	20
3	60	30
4	80	40
5	100	50
6	120	60
7	140	70
8	160	80
9	180	90
10	200	100

We implement two different taxation schemes: Tax36, where players reduce emissions by equal quantities, and Tax44, where players reduce emissions in proportion to their relative abatement costs and split the cost of reducing emissions equally.

In determining an allocation rule, we use an application of the general fairness concepts of *equity* and equality developed by Konow (2000; 2003; 2009).

Equality refers to an equal share of some outcome (such as income). An allocation principle based on equality would entail subjects' sharing the burden equally. In this instance, each player reduces emissions by 60 units (Table 7). This is more costly for Labour given his higher marginal cost; this burden sharing formula implies a cost of 3 tokens to each Capital player and a cost of 6 tokens to each Labour player. The climate justice and fairness implications are obvious: while ensuring that emissions reductions are commensurate with the target, this tax does not promote social equality.

The concept of equity is derived from the accountability principle which states that a fair allocation is one which is proportional to factors within an individual's sphere of influence (such as effort). A discretionary variable is one that the individual can influence and which affects production. Conversely, an exogenous variable, while affecting production, is outside the individual's locus of control. An individual's entitlement (or fair allocation) is proportionate to the discretionary variables within his control.[9] We use the accountability principle to characterize the fair distribution of the abatement burden. Note that we assume marginal cost to be an exogenous variable: it was assigned during the experiment by the experimenter and, although it affects the outcome, it is unrelated to any actions or decisions that the subjects could take. In terms of equity, no subject must benefit or be punished for an exogenous variable. As such, under equality, emission reduction must be proportionate to the marginal cost of abatement; as such each capital player must reduce twice as many units of emissions relative to each labour player – given that Capital's marginal contribution to public good provision is double that of labour. So each capital player must reduce emissions by 80 units while each labour player must reduce emissions by 40 units. This will cost both player-types 4 tokens. Such a scheme promotes social equality.

Observation 5. Taxation reduces the frequency of contributions below the specified contribution rate

In the baseline treatment, the Nash equilibrium was (0, 0) for both capital and labour players. In the case of the Tax36 treatment, the Nash is moved inwards to (3, 6) for capital and labour, respectively. Likewise, in the Tax44 treatment, the Nash becomes (4, 4) for capital and labour, respectively.[10]

From Table 4 (pooled data), average contributions across-player types increase significantly from 3.2 tokens in the Baseline treatment to 5.3 tokens in the Tax36 treatment (Wilcoxon signed-rank test: $p < 0.01$). By player-type: capital contributes an average 3.9 tokens while labour contributes an average of 6.6 tokens. In the tax44 treatment, average contributions increased significantly to 4.7 tokens relative to the baseline treatment (Wilcoxon signed-rank test: $p < 0.01$); capital contributed 4.4 tokens on average as compared to an average contribution of 5.0 for labour.

Table 8 reflects the frequency of contributions for capital and labour players, by treatment. The baseline and communication treatments have been replicated in Table 8 for ease of reference. In the Tax36 treatment, 65% of capital players contribute 3 tokens while 74% of labour players contribute 6 tokens. In the Tax44 treatment, 56% of capital and labour players contribute 4 tokens.

We consider whether the introduction of taxation reduces the frequency of contributions *below* the specified contribution, relative to previous treatments.

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9 Konow (1996) gives the example of two island castaways who collect bananas. If one of the castaways worked twice as hard as the other, he would deserve twice the number of bananas. However, none of the castaways are rewarded or punished for any exogenous variables that may affect output. For example, if one of the castaways has a disability that saw him collect fewer bananas than his counterpart despite the fact that he worked twice as hard, as he is only accountable for the factors that he can influence, he is deserving of an equal number of bananas.

10 The Nash equilibrium become (3,6) and (4,4) in the Tax36 and Tax44 treatments, respectively, as capital and labour can never do better than contributing their corresponding amounts since contributing less when faced with a tax will result in losses.

Capital contributes between 0-2 tokens 4% of the time in the Tax36 treatment, versus 37% and 38% in the baseline and communication treatments, respectively. A comparison of the frequency of plays of 0-2 tokens between the tax and baseline treatments ($X^2_{[1]}=9.905, p=0.002$) and tax and communication (Fisher exact, $p = 0.000$) is highly significant. In terms of the implications for full free-riding, the frequency of plays of zero tokens in the Tax36 treatment are 1.5% as compared to 21% and 27% in the baseline and communication treatments, respectively, a comparison of these frequencies confirms that taxation significantly reduces the frequency of free-riding (Tax36 compared to Baseline: $X^2_{[1]}=3.194, p<0.5$; Tax36 compared to communication: $X^2_{[1]}=9.511, p<0.01$).

Table 8. Frequency distribution of contributions to the public good, by treatment and player-type

Treatment	*Contribution*										
	0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Capital (n=68)											
Baseline	0.206	0.103	0.059	0.191	0.162	0.074	0.059	0.029	0.059	0.000	0.059
Communication	0.265	0.044	0.074	0.074	0.074	0.088	0.029	0.029	0.015	0.000	0.309
Tax36	0.015	0.000	0.029	0.647	0.074	0.059	0.074	0.029	0.015	0.000	0.059
Tax44	0.044	0.015	0.000	0.074	0.559	0.132	0.103	0.029	0.000	0.000	0.044
Labour (n=68)											
Baseline	0.338	0.074	0.088	0.059	0.132	0.132	0.074	0.015	0.029	0.000	0.059
Communication	0.456	0.029	0.029	0.000	0.044	0.029	0.044	0.029	0.044	0.044	0.250
Tax36	0.015	0.000	0.000	0.000	0.000	0.000	0.735	0.074	0.059	0.015	0.103
Tax44	0.000	0.000	0.000	0.000	0.559	0.250	0.044	0.044	0.015	0.015	0.074

Note: Sequence 2 and 3

Staying with capital and examining the effect of the Tax44 treatment: the frequency of plays between 0-3 reduces to 13% in the Tax44 treatment versus 56% in the baseline case and 46% with communication; the difference in these frequencies is highly significant ($p < 0.01$) . The frequency of free-riding reduces to 4% in the same treatment. A comparison of the frequency of free-riding in the tax treatment relative to the baseline (Fisher exact, $p < 0.01$) and communication (Fisher exact, $p < 0.01$) treatments is once again significant.

We now examine the implications for labour. The frequency of plays between 0-5 reduces to around 2% in the Tax36 treatment versus 82% in the baseline case and 62% with communication. A comparison of the frequency of plays of 0-5 tokens between the tax and baseline treatments ($X^2_{[1]}=22.483, p<0.01$) and tax and communication (Fisher exact, $p < 0.01$) is highly significant. The frequency of free-riding declines to 1.5% in the Tax36 treatment from 34% and 46% in the baseline and communication treatments, respectively. A comparison of the frequency of free-riding in the Tax36 treatment relative to the baseline ($X^2_{[1]}=6.675, p<0.01$) and communication ($X^2_{[1]}=24.702, p<0.01$) treatments is also significant.

Staying with labour, the frequency of plays between 0-3 reduces to around 0% in the Tax44 treatment versus 57% and 51% in the baseline and communication treatments, respectively; this difference in frequencies between the tax and baseline treatment (Fisher exact, $p < 0.01$) and the tax and communication treatment (Fisher exact, $p < 0.01$) is significant. A comparison of the frequency of free-riding in the Tax36 treatment (or the absence thereof) relative to the baseline (Fisher exact, $p < 0.01$) and communication (Fisher exact, $p < 0.01$) treatments is also significant.

After this discussion it is clear that the tax discourages contributions below the specified floor and that free-riding in particular is significantly reduced. This was to be expected given that the interior Nash equilibrium in both tax treatments forces cooperation. These results serve to confirm that subjects fully understood the payoffs associated with the experiment.

5.1.3.1 Crowding out of voluntary contributions[11]

Observation 6. Taxation discourages contributions in excess of the Nash equilibrium for capital players

While the presence of taxes certainly reduces free-riding, it is necessary to examine whether the introduction of a tax reduces the likelihood of subjects contributing *in excess of* the regulated floor.

Capital contributed 4 or more tokens 31% of the time in the Tax36 treatment as compared to 44% in the baseline treatment ($X^2_{[1]}=5.128, p<0.05$) and 54% in the communication treatment ($X^2_{[1]}=7.696, p<0.01$); the fact that these differences are highly significant indicates that the presence of the tax discourages cooperative behaviour. Likewise, capital plays 5 or more tokens 31% of the time in the Tax44 treatment as compared to 28% in the baseline treatment and 47% ($X^2_{[1]}=3.7409, p=0.053$); the introduction of the tax discouraged cooperative behaviour relative to the communication treatment.

Labour contributes 7 or more tokens 25% of the time in the Tax36 treatment, as compared to 10% for the baseline treatment and 37% for the communication treatment. Comparison of the tax treatment with the baseline treatment yields a statistically significant result ($X^2_{[1]}=5.396, p<0.05$), while comparison with communication is only significant at the 15% level. Relative to the baseline treatment, the presence of a tax encourages cooperative behaviour! Finally, capital contributes 5 or more tokens 44% of the time in the Tax44 treatment, versus 31% in the baseline case and 44% in the presence of communication. A comparison between the tax and baseline frequencies is significant at the 11% level ($X^2_{[1]}=2.541$).

The effect of the tax thus differs according to player-type. Taxation discourages contributions in excess of the Nash equilibrium for capital. Conversely, in the case of labour, taxation encourages cooperative behaviour beyond the Nash equilibrium.

[11] A pre-requisite for complete crowding-out is that the pre and post-taxation Nash equilibrium is an interior solution. As we are testing for the frequency of free-riding, in our design, the Nash equilibrium before taxation is for each subject to contribute zero to the public good. Thus, we simply comment on the degree to which rising taxes partially crowd out voluntary contributions.

Observation 7. Taxation crowds out voluntary contributions
We test the significance of the different tax schedules on contributions more formally by performing a pooled OLS regression using the pooled data from the baseline and tax treatments in Sequence 2 and 3. The regression is run separately for capital and labour. Following Benzing and Andrews (2004) the model is specified as:

$$H = \alpha + \beta_1 D_1 + \beta_2 D_2 + \epsilon$$

where H signifies the contribution *in excess* of the specified tax rate.

Note, this analysis differs from the analysis above – where we considered the implications of different tax schedules on the frequency of contributions above the contribution floor. In this case we consider the implications of the tax schedules on voluntary contributions, starting with the baseline treatment as an example of lump-sum tax of zero. As such, the constant term, α , signifies (voluntary) average contributions when the tax is 0 (in the advent of a tax of zero, any contribution greater or equal to one is voluntary). For capital, D_1 = 1 if the tax is 4 and 0 otherwise, while D_2 = 1 if the tax is 3 and 0 otherwise. For labour, D_1 = 1 if the tax is 4 and 0 otherwise, while D_2 = 1 if the tax is 6 and 0 otherwise. The results from the regression are replicated in Table 9.

Table 9: Estimates of crowding-out

	Capital		*Labour*	
	Value	S.E.	Value	S.E.
α	3.426*	0.346	2.985*	0.360
β_1	-2.735*	0.311	-1.941*	0.308
β_2	-2.412*	0.294	-2.338*	0.321
F(2, 67)	40.40		26.51	
R^2	0.248		0.191	
Observations	204		204	

Notes: Standard errors are adjusted for clustering; significant at the 1% level; inclusion of control variables such as treatment, sequence and session are insignificant.*

The expected values of H for the three different taxation specifications are reported in Table 10.

The results indicate that the voluntary contribution levels decline as the burden of the tax rises. As average voluntary contributions decline as the tax increases, there is crowding out. In a seminal paper, Andreoni (1993), using a linear public good game, finds evidence of incomplete crowding out.

Table 10: Expected voluntary contribution[12]

Capital			Labour		
Category	*Expected value = E(H)*	*Exp. vol. contribution*	*Category*	*Expected value = E(H)*	*Exp. vol. contribution*
0	α	3.426	0	α	2.985
3	$\alpha+\beta_2$	1.014	4	$\alpha+\beta_1$	1.044
4	$\alpha+\beta_1$	0.691	6	$\alpha+\beta_2$	0.647

5.2 Public good provision

Observation 8. Communication and taxation increase compliance with the target

Table 11 reflects the percentage of *groups* that met the target across the various treatments. With respect to *Sequence 1*: in treatments 1 and 2, respectively, only 24 percent of the groups met the emission reduction target; this percent decreased to a meagre 12 in the final two treatments.

With respect to the pooled data (Sequence 2 and 3), 35% of groups in the baseline treatment met the target. With the introduction of communication, 50% of groups met the target. While an improvement, in the context of climate change, 50% compliance would not be sufficient to subvert catastrophic climate change. Compliance with the target increases markedly with the introduction of taxation.

Table 11: Percentage of groups that met the emission reduction target

	Sequence 1 (17 groups)	*Baseline[1] (34 groups)*	*Comm.[1] (34 groups)*	*Tax36[1] (34 groups)*	*Tax44[1] (34 groups)*
Baseline 1	0.24	0.35	0.50	0.91	0.88
Baseline 2	0.24				
Baseline 3	0.12				
Baseline 4	0.12				
Note: [1]Sequence 2 and 3					

Table 12 indicates the total emissions reduction from each treatment (emissions reductions summed across groups). The greatest reduction occurred in the tax treatments, followed by the communication treatment.

12 Note that Benzing and Andrews (2004) attribute differences between the expected voluntary contribution and actual reported contributions (in our case the estimates reported in Table 4) to the error term ϵ .

Table 12: Total emissions reduction

Sequence 1 (17 groups)		Baseline[1] (34 groups)	Comm.[1] (34 groups)	Tax36[1] (34 groups)	Tax44[1] (34 groups)
Baseline 1	2880	6690	9270	9820	9410
Baseline 2	2190				
Baseline 3	2250				
Baseline 4	2410				
Max. emission reduction per treatment: 10 200 units		*Max. emission reduction per treatment: 20 400 units*			

Note: [1]Sequence 2 and 3

6. Discussion

With reference to meeting an emissions reduction target, the results indicate that voluntary cooperation may not be sufficient to reach a national target and subvert catastrophic climate change. In the Baseline treatment, only 35% of groups met the target. Furthermore, free-riding emerges as the singular contribution norm for both player-types. The baseline treatments in Sequence 1 confirm that voluntary cooperation decays over time. With the introduction of communication, cooperation is significantly improved. Specifically, the percent of groups that reach the target increase to 50%. This result emphasises that stakeholder participation plays an important role in facilitating compliance. Two contribution norms emerged when players were able to communicate: free-riding and full-cooperation, with free-riding being the prevalent behaviour for labour relative to capital.

Regulated cooperation results in near universal compliance with the target. With the introduction of taxation (both treatments), around 90% of groups met the target. Taxation significantly reduces the frequency of free-riding and the frequency of contributions below the tax floor. Thus regulation could be a useful way to promote compliance with the target. Importantly, taxation crowds out contributions *in excess* of the target.

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Appendices

A: Standard VCM – symmetric payoff tables

Labour contribution		***Capital total payoff***										
		Capital contribution										
		0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
	0	120	118	116	114	112	110	108	106	104	102	100
	1	125	123	121	119	117	115	113	111	109	107	105
	2	130	128	126	124	122	120	118	116	114	112	110
	3	135	133	131	129	127	125	123	121	119	117	115
	4	140	138	136	134	132	130	128	126	124	122	120
	5	145	143	141	139	137	135	133	131	129	127	125
	6	150	148	146	144	142	140	138	136	134	132	130
	7	155	153	151	149	147	145	143	141	139	137	135
	8	160	158	156	154	152	150	148	146	144	142	140
	9	165	163	161	159	157	155	153	151	149	147	145
	10	170	168	166	164	162	160	158	156	154	152	150

Capital contribution		***Labour total payoff***										
		Labour contribution										
		0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
	0	60	59	58	57	56	55	54	53	52	51	50
	1	70	69	68	67	66	65	64	63	62	61	60
	2	80	79	78	77	76	75	74	73	72	71	70
	3	90	89	88	87	86	85	84	83	82	81	80
	4	100	99	98	97	96	95	94	93	92	91	90
	5	110	109	108	107	106	105	104	103	102	101	100
	6	120	119	118	117	116	115	114	113	112	111	110
	7	130	129	128	127	126	125	124	123	122	121	120
	8	140	139	138	137	136	135	134	133	132	131	130
	9	150	149	148	147	146	145	144	143	142	141	140
	10	160	159	158	157	156	155	154	153	152	151	150

B: Treatment tax36 – symmetric payoff tables

Labour contribution		**Capital Total Payoff**										
		Capital contribution										
		0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
	0	90	98	106	114	112	110	108	106	104	102	100
	1	95	103	111	119	117	115	113	111	109	107	105
	2	100	108	116	124	122	120	118	116	114	112	110
	3	105	113	121	129	127	125	123	121	119	117	115
	4	110	118	126	134	132	130	128	126	124	122	120
	5	115	123	131	139	137	135	133	131	129	127	125
	6	120	128	136	144	142	140	138	136	134	132	130
	7	125	133	141	149	147	145	143	141	139	137	135
	8	130	138	146	154	152	150	148	146	144	142	140
	9	135	143	151	159	157	155	153	151	149	147	145
	10	140	148	156	164	162	160	158	156	154	152	150

Capital contribution		**Labour Total Payoff**										
		Labour contribution										
		0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
	0	0	9	18	27	36	45	54	53	52	51	50
	1	10	19	28	37	46	55	64	63	62	61	60
	2	20	29	38	47	56	65	74	73	72	71	70
	3	30	39	48	57	66	75	84	83	82	81	80
	4	40	49	58	67	76	85	94	93	92	91	90
	5	50	59	68	77	86	95	104	103	102	101	100
	6	60	69	78	87	96	105	114	113	112	111	110
	7	70	79	88	97	106	115	124	123	122	121	120
	8	80	89	98	107	116	125	134	133	132	131	130
	9	90	99	108	117	126	135	144	143	142	141	140
	10	100	109	118	127	136	145	154	153	152	151	150

C: Treatment tax44 – symmetric payoff tables

Labour contribution		***Capital total payoff***										
		Capital contribution										
		0	1	2	3	4	5	6	7	8	9	10
	0	80	88	96	104	112	110	108	106	104	102	100
	1	85	93	101	109	117	115	113	111	109	107	105
	2	90	98	106	114	122	120	118	116	114	112	110
	3	95	103	111	119	127	125	123	121	119	117	115
	4	100	108	116	124	132	130	128	126	124	122	120
	5	105	113	121	129	137	135	133	131	129	127	125
	6	110	118	126	134	142	140	138	136	134	132	130
	7	115	123	131	139	147	145	143	141	139	137	135
	8	120	128	136	144	152	150	148	146	144	142	140
	9	125	133	141	149	157	155	153	151	149	147	145
	10	130	138	146	154	162	160	158	156	154	152	150

Capital contribution		***Labour Total Payoff***										
		Labour contribution										
		0	1	2	3	4	5	6	7	8	9	10
	0	20	29	38	47	56	55	54	53	52	51	50
	1	30	39	48	57	66	65	64	63	62	61	60
	2	40	49	58	67	76	75	74	73	72	71	70
	3	50	59	68	77	86	85	84	83	82	81	80
	4	60	69	78	87	96	95	94	93	92	91	90
	5	70	79	88	97	106	105	104	103	102	101	100
	6	80	89	98	107	116	115	114	113	112	111	110
	7	90	99	108	117	126	125	124	123	122	121	120
	8	100	109	118	127	136	135	134	133	132	131	130
	9	110	119	128	137	146	145	144	143	142	141	140
	10	120	129	138	147	156	155	154	153	152	151	150

D: Calculator

Capital's calculator

The National Emission Reduction Target is 240.
Capital must contribute 3 tokens to the Public Account
Labour must contribute 6 tokens to the Public Account

	Contribution to Public Account
YOU (Capital)	2
Other Capital	2
Labour 1	2
Labour 2	2

Income from Private Account	96	
Emission Reduction	120	
Income from Public Account	30	
Tokens deducted	10	
Total Payoff (Tokens)	116	(Including tax)
Total Payoff (Rand)	23	(Including tax)

Labour's calculator

The National Emission Reduction Target is 240.
Capital must contribute 3 tokens to the Public Account
Labour must contribute 6 tokens to the Public Account

	Contribution to Public Account
YOU (Labour)	2
Other Labour	2
Capital 1	2
Capital 2	2

Income from Private Account	48	
Emission Reduction	120	
Income from Public Account	30	
Tokens deducted	40	
Total Payoff (Tokens)	38	(Including tax)
Total Payoff (Rand)	8	(Including tax)

E: Mann-Whitney test

Mann-Whitney test

$H_0: t_x(Session\ 1) = t_x(Session\ 2)$

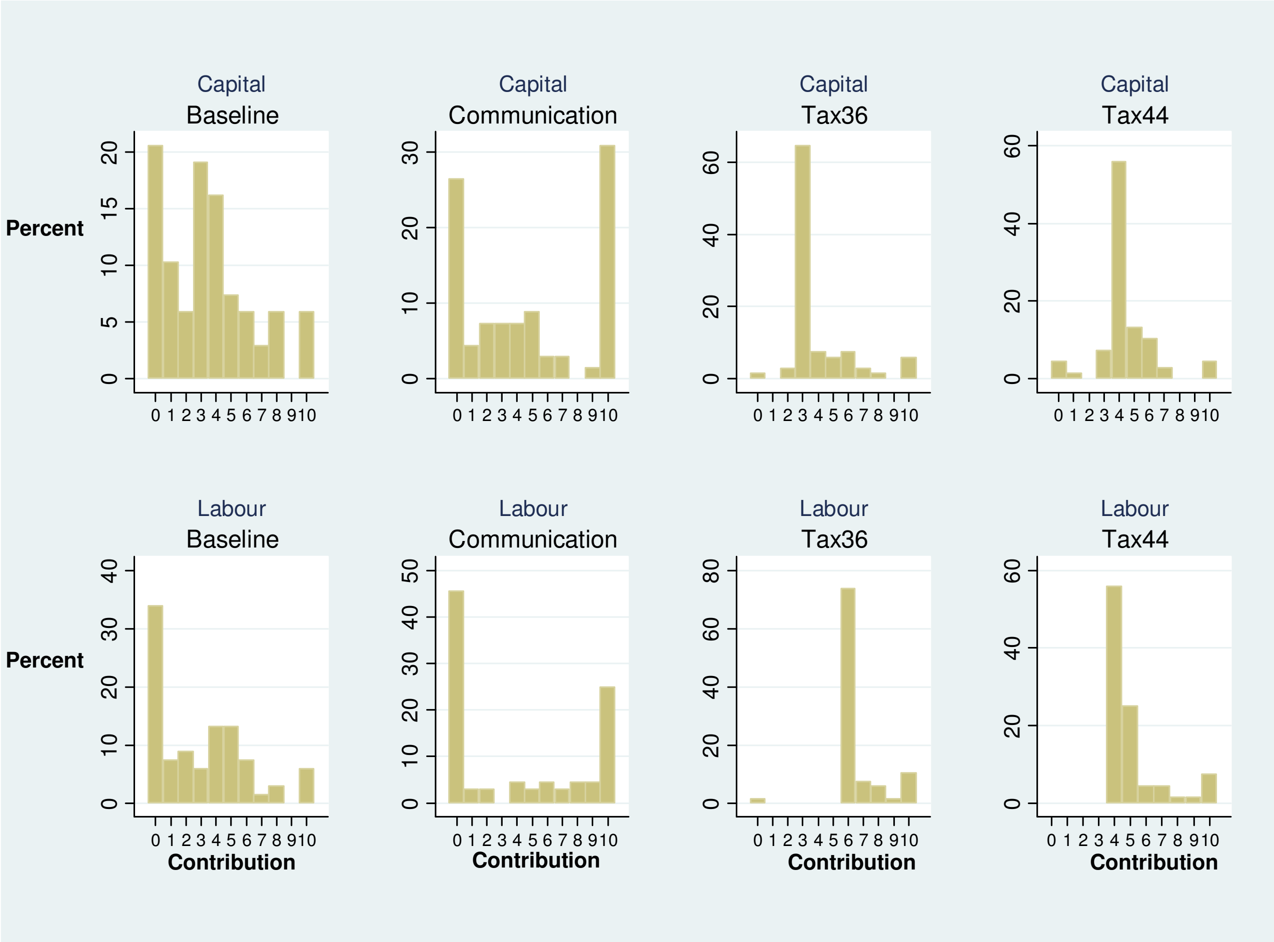
	Sequence 1	*Sequence 2*	*Sequence 3*
Treatment 1	$p = 0.354$	$p = 0.975$	$p = 0.131$
Treatment 2	$p = 0.113$	$p = 0.689$	$p = 0.613$
Treatment 3	$p = 0.376$	$p = 0.455$	$p = 0.298$
Treatment 4	$p = 0.830$	$p = 0.375$	$p = 0.160$

Mann-Whitney test

$H_0: t_x(Sequence\ 2) = t_x(Sequence\ 3)$

Baseline	$p = 0.1624$
Communication	$p = 0.127$
Tax36	$p = 0.931$
Tax44	$p = 0.939$

F: Frequency distributions, by player-type and treatment



Note: Sequence 2 and 3; n=136

Estimating the demand elasticity for electricity by sector in South Africa

Roula Inglesi and James Blignaut

Abstract
This paper analyses electricity consumption patterns in South Africa in an attempt to understand and to identify the roots of the current electricity supply crisis. This is done by investigating various economic sectors' responses to price changes using panel data for the period 1993-2004. Positive and significant price elasticities over this period were found for the transport (rail) and commercial sectors while there are positive but small responses to price changes in the agriculture and mining sectors. Only the industrial sector responded to changes in electricity prices according to theory, namely illustrating negative demand elasticities. These results explain, in part, the current electricity crisis. Given the historic low level of electricity prices in conjunction with a real price decline, i.e. price increases lower than the inflation rate, there was no incentive to reduce electricity consumption and/or to be efficient. This result supports the notion that prices do have an important signalling effect in the economy. Hence, they should be considered not only from an economic growth or social vantage point, but also from a supply and technocratic perspective, that includes environmental factors such as CO_2 emissions. Prices cannot be determined without considering the system-wide implications thereof.

Keywords: Sectoral electricity consumption, price elasticity, energy economics

1. Introduction

How sensitive has the demand for electricity been to changes in electricity prices in South Africa? This study seeks to answer this question based on the hypothesis that the demand elasticity for electricity explains, at least in part, the current mismatch between the demand for and supply of electricity.

Investigating the demand response sensitivity in the electricity sector is becoming a global trend. Internationally there has been increasing interest in analysing the trend of electricity consumption on an aggregate and industrial level. Special attention has also been paid to developing economies. Ghaderi et al (2006), for instance, investigated the electricity demand function of the industrial sector in Iran. A similar sectoral analysis on Russian industries was conducted by Egorova and Volchkova (2004), who found that the electricity prices were a factor of energy consumption –although other factors such as the output of the industries proved more significant. Studies were also carried out for developed countries, by, for example, Lundberg (2009), who derived a demand function of Swedish industrial electricity use as well as the changes in demand trends over time. By dividing the sample into two periods (1960-1992 and 1993-2002), his findings showed that output was a more significant factor in the first period while price had become more significant in the second. A possible explanation for this change was the more efficient use of energy in the latter period.

Locally, Blignaut and de Wet (2001) examined the manufacturing sector's electricity consumption with regard to the price by estimating the price elasticities for the various industrial sectors between 1976 and 1996. They found weak relationships between electricity price and consumption, some of them positive. Ziramba (2008) analysed residential electricity demand, showing that price did not have a significant impact on the residential sector for the period 1978-2005; instead, income was an important determinant of electricity demand. These results, however, are challenged by Inglesi (2010) who showed, for 1980-2005, that price is a significant factor of total electricity demand, but at an aggregate level.

Given the conflicting evidence, this paper attempts to expand the work done by Blignaut and de Wet (2001) and Inglesi (2010). The electricity consumption of the main industrial sectors and their responses to price changes may be considered among the factors contributing to the current electricity crisis. This was done by employing panel data for the period 1993-2004 to determine the sectoral price elasticities and electricity intensity levels. The rest of the paper is structured as follows: the next section describes the situation of South African electricity consumption and electricity prices, in its entirety and per sector. The succeeding section presents the research method and data to be used in the analysis, while the empirical results are presented and discussed thereafter. Finally, the conclusions and policy implications of the findings are discussed.

2. Background

2.1 Electricity consumption

Electricity is a low value yet necessary good within any economy and is one of the pillars of development (Blignaut 2009). The generation, supply and distribution of electricity, and access to it, have the potential to unlock economic development. South Africa, with almost 50 million residents, has about 39 000MW of installed electricity capacity. Nigeria, in contrast, has an installed capacity of 4 000MW serving 150 million. This comparison indicates a key reason why South Africa could develop in the way it has, while Nigeria, despite its natural resources, climate and arable land, could not.

Electricity consumption in South Africa has increased significantly over the past decade: 11.96% between 1995 and 2000, and 33.79% between 2000 and 2005. This unprecedented rise has created serious concerns regarding the environmental effects, including higher CO_2 emissions as a result of the increased combustion of coal. This matter is, however, not elaborated further here, but it is sufficient to say that there is a direct link between the demand elasticity for electricity and CO_2 emissions and that one possibly effective mechanism to reduce CO_2 emissions is to reduce the demand for electricity by strengthening the demand response or demand elasticity for electricity. But has the electricity sector been responsive to price changes in the past? This question is investigated in this study.

Every year, the National Department of Energy in South Africa releases an Aggregate Energy Balance of the country, which includes the electricity consumption by sectors in MWh. Electricity consumption for the years 1995, 2000 and 2005 by sector as well as by the sector's share to total consumption are presented in Table 1. It shows that the industrial sector has been the largest consumer of electricity for all the years. The industrial sub-sectors that showed the strongest growth through the years were 'Chemical and Petrochemical' and 'Non-metallic Minerals'. The 'Construction' sector, although not a big consumer in its own right, has almost doubled its electricity consumption over the period, an indication of the growth in the sector in the 2000s. The residential sector's electricity consumption has also increased, while keeping its share to total consumption fairly constant at about 17%. Moreover, the residential sector was the single largest consumer of electricity in 2005. The electricity consumption of 'Commerce and Public Services' rose in 2005. In comparison to other sectors, 'Commerce and Public Services' share however, remained at 12%.

Table 1: Sectoral electricity consumption in South Africa: 1995, 2000 and 2005

Source: DME (1995; 2000; 2005)

	1995		*2000*		*2005*	
	MWh	*%*	*MWh*	*%*	*MWh*	*%*
Total consumption	**143 172 628**	**100**	**160 299 858**	**100**	**214 464 369**	**100**
Industry sector	**80 657 330**	**56.336**	**99 702 977**	**62.198**	**113 028 378**	**52.703**
Iron and steel	16 250 811	11.351	20 913 350	13.046	21 341 990	9.951
Chemical and petrochemical	3 602 879	2.516	2 640 440	1.647	10 081 160	4.701
Non-ferrous metals	6 956 009	4.858	15 037 710	9.381	18 640 120	8.691
Non-metallic minerals	1 190 263	0.831	1 153 690	0.720	2 604 680	1.215
Transport equipment	8 590	0.006	69 250	0.043	92 350	0.043
Machinery	104 087	0.073	53 170	0.033	41 800	0.019
Mining and quarrying	33 176 049	23.172	29 038 108	18.115	31 506 930	14.691
Food and tobacco	454 207	0.317	639 090	0.399	760 440	0.355
Paper pulp and print	975 054	0.681	1 493 630	0.932	1 753 580	0.818
Wood and wood products	534 173	0.373	412 370	0.257	296 580	0.138
Construction	13 805	0.010	34 010	0.021	52 350	0.024
Textile and leather	475 421	0.332	376 340	0.235	518 960	0.242
Non-specified (industry)	16 915 982	11.815	27 841 819	17.369	25 337 438	11.814

	1995		*2000*		*2005*	
	MWh	*%*	*MWh*	*%*	*MWh*	*%*
Transport sector	**4 297 357**	**3.002**	**5 411 009**	**3.376**	**5 544 622**	**2.585**
Domestic air transport	6 803	0.005	31 280	0.020	49 970	0.023
Road	6 795	0.005	33 740	0.021	19 210	0.009
Rail	3 456 076	2.414	3 433 160	2.142	3 279 980	1.529
Pipeline transport	56 251	0.039	62 260	0.039	78 890	0.037
Internal navigation	0	0.000	6 190	0.004	50 220	0.023
Non-specified (transport)	771 432	0.539	1 844 379	1.151	2 066 352	0.963
Other sectors	**58 217 941**	**40.663**	**55 185 872**	**34.427**	**95 891 369**	**44.712**
Agriculture	5 301 173	3.703	3 954 372	2.467	5 519 706	2.574
Commerce and public services	17 306 899	12.088	17 164 007	10.707	27 103 280	12.638
Residential	24 369 099	17.021	28 680 001	17.891	36 970 239	17.238
Non-specified (other)	11 240 770	7.851	5 387 492	3.361	26 298 144	12.262

2.2 Electricity prices

The real prices of electricity for the years 1995, 2000 and 2004 are shown in Table 2. The increases from 2000 to 2004 were very low, even negative, in most instances.

Table 2: Average electricity prices in South Africa in 1995, 2000 and 2004

Source: DME (2005)

	Real prices (c/kWh)					
	Industry	*Mining*	*Transport*	*Agriculture*	*Commerce*	*Average*
1995	14.36	14.67	20.23	30.37	25.76	15.4
2000	11.94	12.91	15.35	28.88	22.65	13.23
2004	11.28	12.41	15.65	24.9	17.67	12.96
	Real prices (% annual change)					
1995	7.405	-3.296	-5.776	-4.226	-1.529	0.000
2000	7.278	-2.786	-4.063	3.143	-3.453	0.915
2004	-2.759	0.567	0.708	4.315	4.618	-1.370

With its historically low electricity prices, South Africa offers no means of predicting what would be the demand response to price increases such as those proposed by Eskom in September 2009. With specific focus on future effects of changes in electricity prices, van Heerden et al (2008) estimated the effect of a 10% increase in electricity prices on main economic indicators, keeping the elasticities constant.

Under such a scenario, the economic consequences would be alarming in the long run, with an estimated reduction of investment by 0.37%, a decrease of 0.16% of GDP, and a rise in the CPI of 0.5%. In addition, Inglesi (2010) forecast the behaviour of total electricity consumption to 2030, assuming that the electricity price would double over the period 2008-2011 and then remain constant until 2030: her findings showed that electricity demand decreased substantially after the implementation of higher prices (-24%, assuming average economic growth of 4% over the period 2009-2030; -27%, assuming average economic growth of 6% over the same period). She assumed, however, that the price elasticity remained constant at -0.56 on electricity consumption until 2030.

In summary, before implementing any type of policies or changes in price regimes, the price sensitivity of each of the sectors should be taken into consideration because each of the sectors responded differently in the period when the prices were kept low (mainly until 2004-05).

3. Method and data

To apply modern panel data techniques for the analysis, local sources of data were used. Sectoral electricity consumption is derived from the *Energy Balances* of the DME (DME 1993 to 2004). The series on the sectoral electricity prices is obtained by the *Energy Price Rep*ort, 2005 (DME, 2005); while the data series on gross value added was obtained from the *Quarterly Bulletin* of the South African Reserve Bank (SARB, various issues).

For an investigation of the effects of prices and industrial output on electricity consumption of different economic sectors a balanced panel data of five production sectors for the period 1993-2004 was developed. First, a pooled panel test was employed to investigate the overall relationship between electricity prices and output with electricity consumption. To capture sector specific effects, fixed effects analysis was employed to account for cross-section dynamics.

Secondly, to determine how the various sectors respond to electricity price changes, in terms of their own production output, and to describe inter-sectoral dynamics, a seeming unrelated regression (SUR) model is estimated. The equation used is of the following functional form:

$$LCons = \alpha_0 + \alpha_1 \, Lprice_{it} + \alpha_2 \, loutput_{it} \quad (1)$$

Where *cons* is the electricity consumption, *price* is the price of electricity and *output* is the gross value added of the sector *i* at time *t*; all the variables are in their natural logs. The sources for the respective variables are listed in the Appendix (Table A1). The letter L in front of the variable notates that all the variables are linearised. A summary of the variables' descriptive statistics is also presented in Table 3.

Table 3: Data descriptive statistics

	Lcons	*Lprice*	*Loutput*
Mean	16.5517	-4.0346	11.2849
Median	16.7040	-4.1192	11.1958
aximum	18.4361	-3.4287	12.2162
Minimum	14.9495	-4.5153	9.9451
Std. dev.	1.0459	0.3297	0.6994
Skewness	0.0721	0.3072	-0.3986
Kurtosis	1.6018	1.7372	1.9647
Jarque-Bera	4.9392	4.9307	4.2679
Probability	0.0846	0.0850	0.1184
Sum	993.1041	-242.0740	677.0927
Sum sq. dev.	64.5440	6.4118	28.8580
Observations	60	60	60
Cross sections	5	5	5

The univariate characteristics of the variables were tested according to the unit root test proposed by Levin, Lin and Chu (2002). The null hypothesis of both tests is that all series contain a unit root contrary to the alternative that at least one series in the panel contain a unit root. The results of the tests are presented in Table 4.

Table 4: Unit root test of Levin, Lin and Chu (2002)

Variable	*Possible deterministic structure*	*Statistic*	*p-value*	*Level of significance*	*Conclusion*
Lcons	None	2.5175	0.9941		
	Intercept	-0.6123	0.2702		
	Intercept and trend	-1.6379	0.0507	*	Stationary
Lprice	None	1.5857	0.9436		
	Intercept	-3.9083	0.0000	***	Stationary
	Intercept and trend	0.4857	0.6864		
Loutput	None	8.0831	1.0000		
	Intercept	-0.6446	0.2596		stationary
	Intercept and trend	-5.1429	0.0000	***	
Note: *, **, *** denote 1%, 5% and 10% level of significance respectively					

Figures 1-5 below show the behaviour of each of the sectors' electricity consumption in combination with its exclusive electricity prices. From Figure 1 it is clear that the electricity consumption in the industrial sector has a distinct negative relationship with electricity prices. In the commercial sector, the graph indicates a positive relationship between electricity consumption and electricity prices for the sector. The agricultural and mining sectors show an ambiguous relationship: prices had a downward trend while the electricity consumption fluctuated. This is likely due to other factors such as production output. The situation in the transport sector is also ambiguous. The sample was thereafter divided into two smaller ones (1993-1997 in Figure 5a and 1998-2006 in Figure 5b). This exercise showed the existence of a positive relationship in some of the years, namely 1994-1996 and 2001-2004.

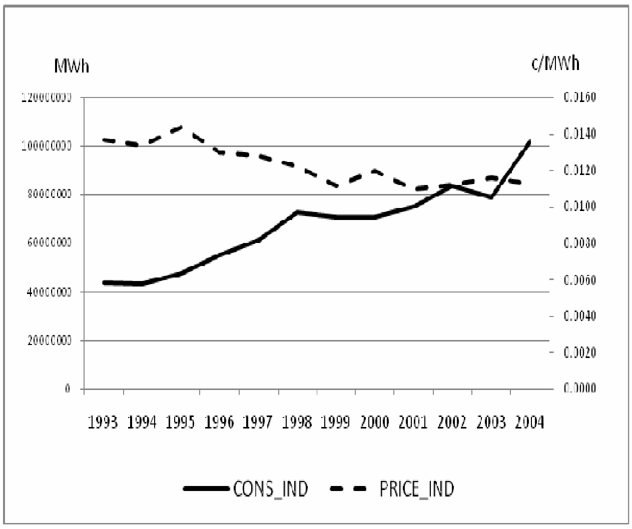


Figure 1: Industrial sector

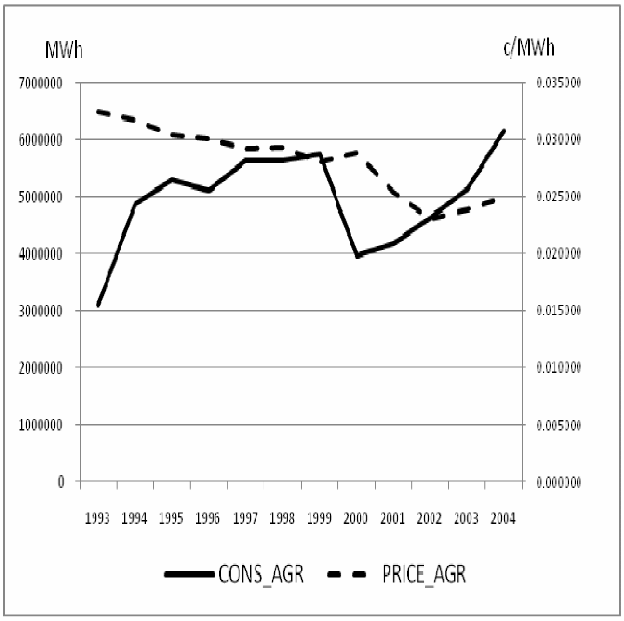


Figure 2: Agricultural sector

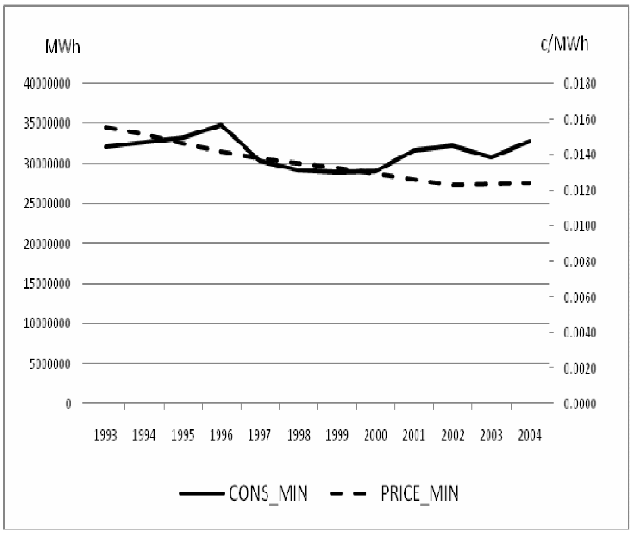


Figure 3: Mining sector

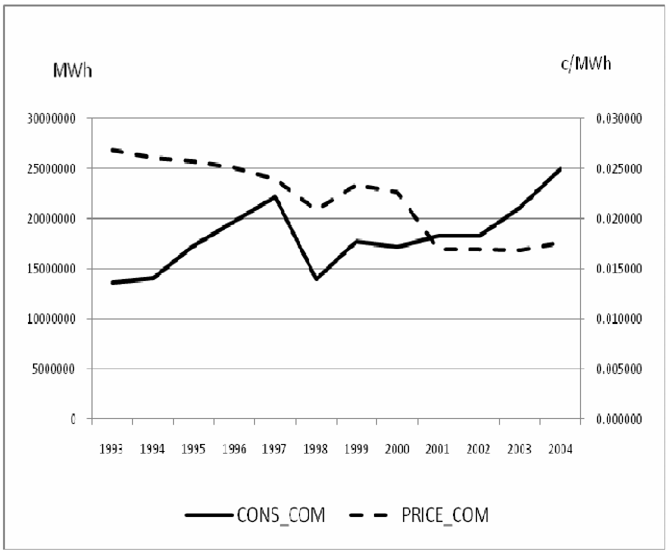


Figure 4: Commercial sector

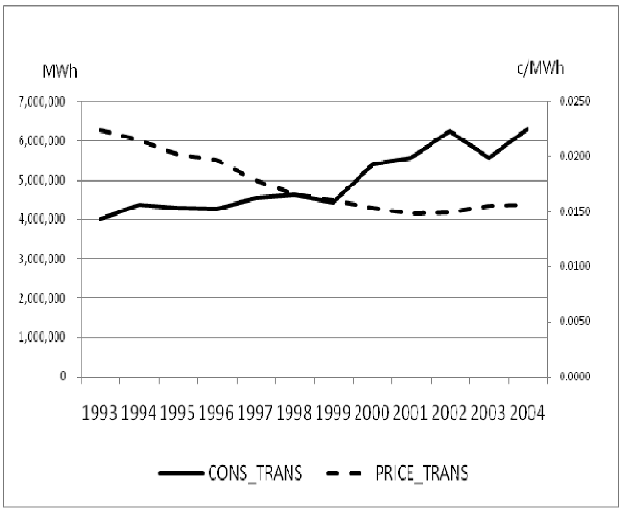


Figure 5: Transport sector

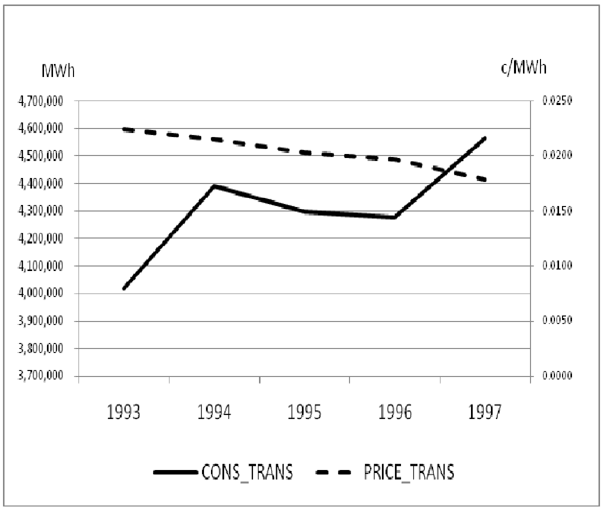


Figure 5a. Transport sector: 1993-1997

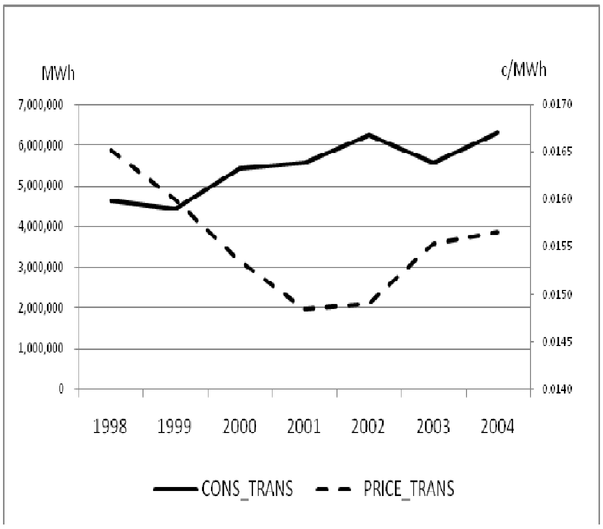


Figure 5b. Transport sector: 1998-2004

4. Empirical results

The results of the pooled and fixed effects are presented in Table 5. The pooled effects model is considered to be limited for a number of applications since it does not take into account any cross section heterogeneity among the sectors. The fixed effects model, on the other hand, does allow for cross-section heterogeneity and assumes a different intercept for each sector. The results show that both price and output of the industries are significant factors of electricity demand in its entirety. Output has a positive impact while an increase in price leads to a decrease in the electricity use. However, when the effects of the different sectors (fixed effects model) are taken into account, the coefficient of electricity prices becomes insignificant while output becomes much more significant.

Table 5: Pooled and fixed effects results

Lcons	*Pooled effects*	*Fixed effects*
Loutput	0.604 (0.000)	0.753 (0.001)
Lprice	-1.568 (0.000)	-0.062 (0.800)
Constant	3.410 (0.000)	
Constant of industrial sector		8.632 (0.000)
Constant of transport sector		6.722 (0.000)
Constant of commercial sector		7.485 (0.000)
Constant of agricultural sector		7.525 (0.000)
Constant of mining sector		8.650 (0.000)
R^2	0.635	0.98
LM (heteroskedasticity)		28.990 (Heteroskedasticity)
Hausman test		1.377 (No misspecification)
LM (serial correlation)		2.863 (No serial correlation)

The p-values are shown in parentheses below the regression coefficients; while the last three rows show the results of tests for misspecification, heteroskedasticity and serial correlation (the conclusions of these tests are indicated in parentheses).

The results of the fixed effects analysis show that inter-sectoral dynamics might be the cause of the insignificance of the electricity prices. Therefore, a SUR model is estimated next to capture the importance of electricity prices in each of the sectors separately and their inter-sectoral dynamics, knowing that the sample is characterised by heterogeneity in their behaviour towards electricity use (see Table 6). White-heteroskedasticity-consistent standard errors and covariances were used to correct for heteroskedasticity, as proposed by Baltagi (2008).

The coefficients of the variable *Lprice* are considered to be the price elasticities of electricity demand for each of the sectors. The results are in accordance with the expectations following a careful study of the graphs (Figures 1-5). The industrial sector has negative price elasticity for the period 1993-2004, the transport and commercial sectors have positive price elasticities and finally, in the agriculture and mining sectors, the price does not play a significant role in the demand for electricity.

In stark contrast, sectoral output is found to be a significant factor that influences electricity consumption of the sectors positively (the coefficients in all the sectors are positive and significant). The results are, for the most part, in conflict with standard economic theory since, according to theory, the price elasticity of goods is expected to be negative since as the price of the good increases (decreases), the quantity demanded will decrease (increase). Some of the plausible reasons for this behaviour are discussed below.

Table 6: SUR model results

Lcons	*Industrial*	*Transport*	*Commercial*	*Agriculture*	*Mining*
Lprice	-1.692 (0.000)	1.667 (0.001)	1.018 (0.000)	0.039 (0.950)	0.099 (0.5581)
Loutput	0.874 (0.000)	1.979 (0.000)	1.729 (0.000)	1.529 (0.000)	1.596 (0.000)
Adj R^2 =0.98					
Total number of observations: 60					
Corrected for heteroskedasticity					

Note: Numbers in brackets show the p-values.

5. Discussion: policy implications

The fact that prices and consumer behaviour follows the path they have as analysed above can be explained in a number of ways. Firstly, in South Africa low prices have caused a lack of behavioural response to price changes. There was a long period during which consumption increased more rapidly than prices due to other factors, such as product demand. Miketa (2001) attributed the positive price elasticities in his analysis to the fact that energy prices were not constructed as an industry specific energy price.

Another reason is that electricity could be considered as a Giffen good. The prerequisites for a good to be characterised as a Giffen good are the following: a) the good is considered inferior; b) lack of close substitute goods; and c) the good must be a significant ratio of the consumer's income but not as much as any of the other normal goods demanded. Although, the existence of Giffen goods is considered a rarity, Bopp (1983) and Abrasmksy (2005) have argued that kerosene and gasoline behave as Giffen goods in some applications. In the case of electricity in South Africa, the income effect from a price change is higher than the substitution effect. Therefore, the price and quantities demanded present the same trend (upward or downward), hence, price elasticity is positive. It would therefore be fair to say that electricity in South Africa, at least historically, can be categorised as resembling the characteristics of Giffen goods.

The price policies followed in the country, in addition to the results of the above analysis on electricity, resulted in an enhancement of electricity consumption as reflected through positive price elasticities in all but the industrial sector. The positive demand elasticity, a rarity in economics, can at least be considered to have been a contributing factor to the current electricity crisis. Moreover, the stronger the demand for electricity, given the electricity supply mix, which is heavily, dominated by coal, the stronger the demand for power and the more the CO_2-emisisons. The positive behavioural response to changes in price, implying that prices and consumption move in the same direction, has not only led to the rapid crowding-out of electricity capacity, but also to a strong increase in CO_2-emissions.

6. Conclusion

The main argument in this study is that in order to address the mismatch between electricity supply and demand such as the one South Africa currently experiences, one must understand, among other things, the underlying behavioural responses due to changes in price. The sector-specific approach employed in this paper clarifies each of the sectors' behaviour to price changes before the recently proposed increases.

Using Panel data, this study examined the price effect on electricity consumption by sector and their respective price elasticities were estimated. The findings of the analysis indicate 'abnormal' behaviour towards price changes in all but the industrial sector, which is the only one in which consumption declined with price increases and vice versa.

According to this analysis, a lack of behavioural responses to price changes was a contributing reason for the insecure and uncertain environment in which the current policy-makers find themselves. In the future, a structural change is expected to be experienced due to the high increases in the electricity tariffs with different sectors turning to more efficient technologies and other – cheaper – forms of energy. More disconcerting, however, is that the positive demand elasticity has also acted as a strong stimulus for the growth in CO_2-emssions. If South Africa wishes to curb the emissions of CO_2 from electricity generation it will do well to induce change that would enhance a behavioural response to price changes.

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Modelling the impact of CO_2 taxes in combination with the Long Term Mitigation Scenarios on emissions in South Africa using a dynamic computable general equilibrium model

Marna Kearney

Abstract
A dynamic computable general equilibrium (CGE) model is used to analyse the impact on the economy of taxes on CO_2 emissions combined with the Long Term Mitigation Scenarios. A sales tax is used to model the impact of a CO_2 tax. The mitigation scenarios modelled include structural shifts (for example switching from coal-fired electricity plants to nuclear power stations), changes in energy efficiency and changes in investment required. The extent of the structural shifts, changes in energy efficiency and investment required differs from scenario to scenario.

The results for the mitigation scenarios indicate that the mitigation scenarios have a positive impact on GDP when investment is large. Although economic activity initially declines due to improved energy efficiency, it is followed by a period of economic expansion as lower prices increases output in most industries – this is especially the case when it is combined with higher investment. When CO_2 taxes are levied the economic impact is again positive if this is combined with either tax relief or reinvestment of the additional tax revenue. The scenarios have varied impact on labour, in general employment for semi- and unskilled labour rise if investment is higher. In most scenarios the demand for energy declines, especially for coal and petroleum. However, the demand for electricity increases if investment rises significantly.

When the mitigation scenarios is combined with a CO_2 tax the results indicate that the CO_2 tax is effective in reducing output of CO_2 producing industries as it changes the relative price of the commodities produced by these industries. However, the sales tax is distortionary as it introduces price wedges in the economy while consumers may end up paying large portions of the tax. A CO_2 tax may not be the most appropriate tool to achieve the desired results considering the economic development objectives of South Africa. However, when combined with the LTMS framework its negative impact is negated by higher investment and GDP growth.

Keywords: CO_2 tax, computable general equilibrium model, economic impact; long term mitigation scenarios

1. Introduction

Under the United Nations Framework Convention on Climate Change and its Kyoto Protocal, South Africa has been exempt from taking mandatory action to reduce emissions. However, South Africa has identified strategies through its Long Term Mitigation Scenarios (LTMS) to reduce emissions. In this process the Department of Environment Affairs and Tourism (DEAT) identified two scenarios, the first being the base scenario against which all other scenarios are compared. This is the Growth without constraint (GWC) scenario, and measures the level of emissions if the economy continues to grow at current trends without any significant attempts to mitigate emissions. The second scenario is the Required by science scenario' (RSS) and estimates the required interventions to mitigate emissions to target levels. Within the RSS four strategies have been identified, namely Start-now, Scale-up, Use-the-market, and Reach the goal. Each of these strategies has different investment and cost implications, technological improvements and tax and other incentive packages in mind. (DEAT 2007). Meeting the rising demand for energy in South Africa poses certain challenges which include (1) investment to increase the capacity to produce energy; (2) switching to more environmentally sustainable sources of energy; and (3) increasing energy efficiency. All of these challenges have an impact on the economy, on production and ultimately on the level of CO_2 emissions produced. This paper focuses on a further challenge, looking at the impact of taxes on CO_2 emissions as an effective means to reduce emission output. The reasoning is that a tax on CO_2 emissions will increase their relative price so that production declines. This is measured within the framework set by the LTMS. A dynamic computable general equilibrium (CGE) model is used to analysie the impact on the economy of taxes on CO_2 emissions combined with the LTMS.

Various authors contributed to this topic in the past, including Van Heerden et al (2006), Paauw (2007), and Devarajan et al (2009); they all attempted to measure the impact of taxes on emissions and/or mitigation strategies in South Africa. The paper by Van Heerden et al focuses on finding double or triple dividends from the revenues raised from energy related taxes if recycled to households and industry by lowering existing taxes, while Paauw focused on the impact of the LTMS scenarios specifically. Devarajan et al, in turn, focused on the economic impact of various taxes aimed at reducing carbon emissions. In all these papers a static CGE model was used to evaluate the impact of the strategies and taxes. This paper attempts to add value to this debate by using a dynamic CGE model to assess the combined impact of the LTMS scenarios and taxes on energy emissions.

The advantages of using a dynamic CGE model compared to a static CGE model include the following:

- Comparative-static CGE models estimate the reaction of the economy to certain policy shocks or economic events at only one point in time. A comparative static approach has limitations when linked to scenarios from energy modeling, which project energy demand and emissions up to 2050. Since the purpose is to understand the economic implication of long-term mitigation scenarios, dynamic effects are particularly relevant. The dynamic CGE model on the other hand can trace the impact of a policy shock or economic event on a period-by-period basis (usually over annual periods).
- A further advantage of the dynamic CGE model is that it captures growth in capital stock and therefore productive capacity over time. Capital accumulation is modeled endogenously so that previous period investment generates

new capital stock for the next period. The allocation of new capital stock across sectors is influenced by the sectors' share in aggregate capital income, the depreciation rate, and on sectoral profit rates from the previous period. Sectoral profit rates may be important in mitigation scenarios, if investment flows to sectors with different levels of capital stock. Sectors with above-average capital returns will receive a larger share of the new capital stock relative to their share in capital income (and *vice versa*). A predetermined macroeconomic forecast is used to determine the benchmark growth path of the model against which policy shocks can be compared. All exogenous variables in the model are updated within the macroeconomic forecast framework.

The dynamic CGE model used in this analysis is based on a model developed by James Thurlow for TIPS (Thurlow 2004). It is an extension of the comparative static CGE model used by the International Food Policy Research Institute (IFPRI). The IFPRI standard model is based on the neoclassical-structural modelling tradition as introduced by Dervis and De Melo (1982). Various adaptations have been made to the dynamic model as developed by Thurlow, including changes to the specification of labour demand and supply, the determination of wages, and the determination of the base growth path in the model. The two main sources of data used in the dynamic CGE model are a social accounting matrix (SAM) and a macroeconomic forecast.

Designing or evaluating environmental policy requires detailed understanding of the relationship between the economy and the environment. Mathematical models provide the quantitative links between economic activity and the environmental impact. These models allow one to quantitatively measure the impact of policies that restructure the economy to achieve emission reductions in a multi-sectoral economy.

2. Methodology

2.1 The model

The model consists of two basic components, namely the *within-the-period* and the *between-the-period* components. In the *within-the-period* component the standard IFPRI model is solved. The standard IFPRI model consists of a set of non-linear equations, which are simultaneously solved. Behaviour is captured by non-linear first order optimality conditions where producers maximise profits and consumers utility. The model makes provision for both goods and factor markets. The institutions included are households, firms, the government, and the rest of the world. The model is in equilibrium when demand is equal to supply. A number of macro constraints are also included to 'close' the model (Lofgren 2002).

In the *between-periods* component the model is updated to capture effect from the static model into the next period or alternatively to capture economic effects outside the model into the next period. The most important effect to be captured in the in-between year updating process is the impact of current investment on future capital stock (Thurlow 2004). If mitigation leads to current investment in some sectors but not others, this would have implications for differences in capital stock in following periods. Other variables that are updated include total factor productivity, factor specific productivity, labour force growth, population growth, real wages, government consumption, investment, and transfers from the government to household.

Most of these are exogenous parameters in the model. These parameters are updated to provide better tracking of a GDP growth path.

2.2 Data

2.2.1 Social accounting matrix

The main source of data used for the CGE modeling is a SAM, which is a comprehensive, economy-wide data framework. It is a square matrix in which each account is represented by a row and a column: each cell shows the payment from its column account to its row account. The CGE model follows the flows captured in the SAM. The SAM used for the modelling was compiled by the Western Cape Department of Agriculture (PROVIDE 2006) and is based on the base-year 2000. The same matrix was used by Pauw (2007), who describes the SAM in his paper.

Table 1: PROVIDE National Accounting Matrix for 2000 (Rm)

		Commod-ities	*Activities*	*Production factors*		*House-holds*	*Enter-prises*	*Government*		*Capital*		*Rest of world*	*TOTAL*
				Capital	*Labour*			*Taxes*	*Expend-iture*	*Invest ment*	*Changes in inventories*		
Commodities			1 088 770			580 802			167348	139 648	7 096	257 011	2 240 675
Activi-ties		1 893 686											1 893 686
Factors	*Capital*		377 770									15 910	393 680
	Labour		442301									2 242	444 543
House-holds				94 883	440299		112 441		29687			260	677 570
Enter-prises				262 865			139 834		51747				454 446
Govt	*Taxes*	117 232	-15155			87 848	33 248						223 173
	Expendi-ture					1 870	9 687	223 173				481	235 211
Capital	*Savings*					6 922	159 156		-20526			1 192	146 744
	Changes in invent-ories									7096			7 096
Rest of the world		229 757		35 932	4244	128	80		6955				277 096
TOTAL		2 240 675	1 893 686	393 680	444543	677 570	454 446	223 173	235 211	146 744	7 096	277 096	

2.2.2 GDP Forecast up to 2050

The dynamic CGE model requires a detailed forecast up to 2050 in order to establish the benchmark growth path of the model against which the alternative scenarios will be compared. A consistent forecast for the real GDP aggregates is required as well as for the level of capital stock in the economy and the size of the labour force. Table 2 shows a summary of the growth forecast.

The growth path for 2001 to 2007 is based on the actual values for the GDP aggregates as published by Statistics South Africa and the SARB. The growth path for 2008, 2009 and 2010 are based on the National Treasury forecast as published in the Budget Review document of 2007. The ASGI-SA growth targets are built into the forecast for the years 2010 to 2014. Thereafter continued growth is forecasted up to the mid 2020s whereafter growth returns to trend of 4.5%.

The growth for final consumption expenditure, government consumption expenditure, investment, changes in inventories and GDP growth is initially imposed exogenously on the model, while imports and exports are solved for endogenously. The growth path is determined accordingly. A range of parameters is then used to maintain the growth path set while variables such as consumption, investment and GDP are made endogenous to the modelling process.

Table 2: Summary of the GDP growth forecast up to 2050

GDP components (R million)	*2001-2005*	*2006-2010*	*2011-2015*	*2016-2020*	*2021-2025*	*2026-2030*	*2031-2040*	*2041-2050*
Real final household consumption								
% change y-o-y	4.2	5.7	5.0	5.8	6.7	6.5	6.5	6.5
% of GDP	63.6	67.3	65.5	63.5	63.0	65.5	66.1	66.1
Real gross fixed capital formation								
% change y-o-y	6.3	13.4	8.6	7.3	2.6	2.4	3.1	3.1
% of GDP	15.9	22.2	28.2	30.2	27.4	23.2	22.9	22.9
Real government consumption								
% change y-o-y	5.1	4.9	5.2	6.0	7.0	6.6	6.5	6.5
% of GDP	18.7	19.1	18.7	18.1	18.1	19.1	19.3	19.3
Real change in inventories								
% of GDP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Statistical discrepancy: Real GDP								
% of GDP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Real exports: Total								
% change y-o-y	1.6	6.6	6.8	6.6	5.6	5.2	5.2	5.2
% of GDP	26.7	27.6	29.4	30.0	29.3	28.9	28.9	28.9
Real imports: Total								
% change y-o-y	7.0	11.3	8.6	7.5	6.2	5.0	5.0	5.0
% of GDP	25.8	36.7	43.0	46.5	46.8	46.4	46.4	46.4
Real GDP								
% change y-o-y	3.6	5.2	5.7	6.7	6.3	4.9	4.5	4.5

2.3 Emissions

The input-output structure within the SAM as used in the CGE model allows one to calculate the emission levels of the various industries according to its use of the different energy sources in their respective production processes. This allows the model to capture the change in emission levels due to structural shifts in production. The present study calculates the change in energy demand for coal, petroleum, and electricity in the economy and uses this as a proxy for emission levels. The changes from intermediate demand and final use are included. The limitation of this is that changes in the composition of demand for coal, petroleum and electricity will have an impact on the emission levels which this approach will not pick up.

2.4 Scenario modelling

The shocks in the various scenarios are modelled as follows:

- *Structural shifts* are modelled by relocating capital stock to the growing sector while keeping the total supply of energy unchanged.
- Improved *energy efficiency* is modelled by reducing the intermediate input use coefficient in the model.
- Changes in *investment required* are modelled by adjusting the investment level in the model. It is assumed that household and firm savings increase to finance the higher investment required.
- A sales tax is used to model the impact of a *CO_2 tax*. Two alternative scenarios are modelled here: It is first assumed that government invests the additional revenue and, second, that government use the additional revenue for tax relief. The tax relief is given to firms and households proportionally to their current tax contribution.

2.4.1 Start-now, Scale-up and Use-the-market scenarios

The mitigation scenarios Start-now (initial wedges), Scale-up (extended wedges), and Use-the-market (economic instruments with increased efficiencies) are modelled using the same approach as applied by Pauw (2007) in the static modelling process. The mitigation scenarios include structural shifts (for example switching from coal-fired electricity plants to nuclear poser stations), changes in energy efficiency and changes in investment required. The extent of the structural shifts, changes in energy efficiency and investment required differs from scenario to scenario. The main impacts of the three scenarios are set out in Table 3.

Table 3: Structural shifts

	Structural shifts in electricity generation	*Structural shifts in petroleum production*
GWC	Electricity from coal remains the most important method for electricity generation. However its importance starts to decline from the early 2020s. Nuclear power becomes more important from the 2030s but is still small. At the end of the period, electricity from coal still constitutes 80% of total output and nuclear about 15%.	Petroleum from oil is and remains the most important production method for petroleum. Its contribution to total petroleum supply increase marginally – in 2050 it accounts for 75% of total petroleum supply. The contribution of the other methods declines somewhat or remains constant.
Start-now	Electricity from coal starts to rapidly decline from 2010 onwards. Its contribution declines to 45% from 2030 onward. Electricity from nuclear and gas becomes more important: each contributes around 25% to electricity generation from 2030 onwards.	The contribution from petroleum from oil declines somewhat to 65% in 2050. The production of petroleum through coal-to-liquid is more important – its contribution increases to around 30% in 2050.
Scale-up	Electricity from coal declines from 2010 onwards. Its contribution is almost 0% in 2050. The contribution of nuclear power increases to about 50% in 2050 with the electricity from gas making up the rest (just below 50%).	The Scale-up picture is very similar to the Start-now picture. The importance of petroleum from oil is marginally lower, while the importance of petroleum from coal-to-liquid is marginally more important.

	Structural shifts in electricity generation	*Structural shifts in petroleum production*
Use-the-market	The contribution of electricity from coal declines faster and reach almost 0% in 2040. Nuclear is more important, but only contributes 25% in 2050. Gas is the most important source for electricity generation (75%).	Petroleum from oil becomes significantly more important. In 2050 it represents 95% of petroleum production.

Table 4: Energy efficiency

	Energy efficiency in electricity use	*Energy efficiency in coal use*	*Energy efficiency in petroleum use*	*Energy efficiency in gas use*
Start-now	The energy efficiency of most industries in the use of electricity improves except for wholesale and retail trade. The industry with the largest improvement is 'other manufacturing' followed by non-metal products.	The energy efficiency in the use of coal improves for all industries.	The energy efficiency in the use of petroleum improves for wholesal and retail trade – there is also a slight improvement in the energy efficiency of services.	Not applicable
Scale-up	The same as Start-now	The same as Start-now	The same as Start-now	Not applicable
Use-the-market	The energy efficiency of most industries in the use of electricity improves except for wholesale and retail trade. The improvement is however much lower compared to Start-now and Scale-up.	Initially the improvement in energy efficiency in the use of coal is lower than when compared to Start-now and Scale-up. However since the mid 2040s there is a sharp increase in the efficiency of coal use.	The same as Start-now and Scale-up	Most industries see a decline in the efficienct use of gas from the mid 2040s onwards.

Required investment

Figure 1 shows the required investment by each of the scenarios. The required model is derived as input from the MARKAL model. The required investment in the Start-now scenario is lower than in the Growth without constraints (GWC) scenario as the improved energy efficiencies demand reduces demand and thus investment. In the Scale-up and Use-the-market scenarios the required investment is higher; it is the highest for the Scale-up scenario.

CO_2 taxes

In the Use-the-market scenario CO_2 taxes are imposed as a sales tax on the use of commodities producing high levels of emission including electricity, coal and petroleum. The purpose of this is to adjust economic behaviour by making the use of electricity, coal and petroleum more expensive. The tax increase rates are derived from the MARKAL model. There is a significant increase in the tax on coal (especially for the generation of electricity), and smaller increases in the tax on crude oil and gas (as seen in). The revenue generated from the CO_2 taxes is modelled using two alternative scenarios: (1) to increase investment or (2) for tax-relief. The approach used to model CO_2 taxes is similar to the approach used by Devarajan et al (2009) where they model the impact of a carbon tax on coal, petroleum, and electricity. The results of Devarajan et al (2009) show that the carbon tax has a welfare loss, but much lower than the other taxes investigated (this includes a sales tax on energy use).

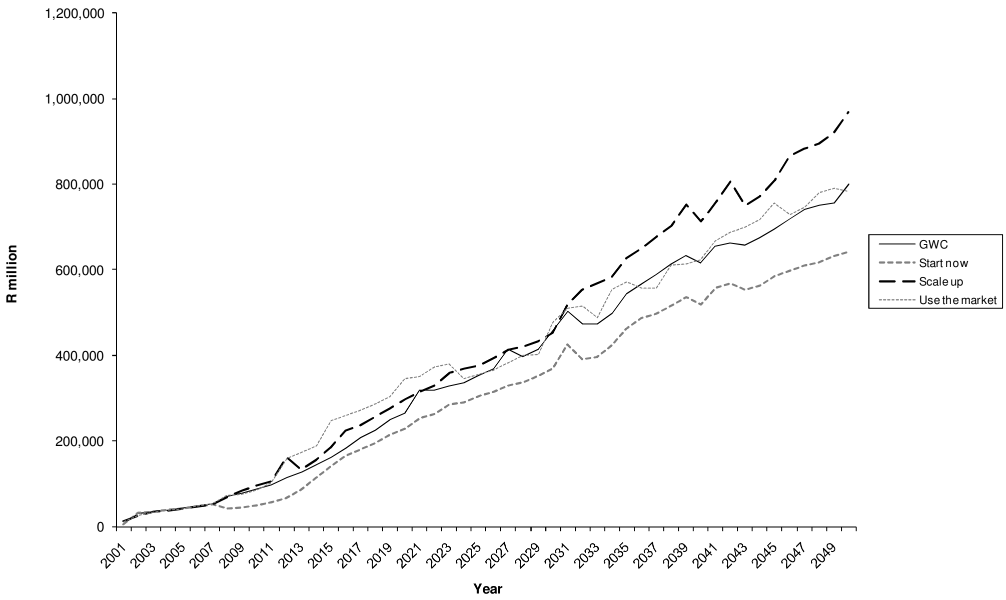

Figure 1: Required investment (in R million)

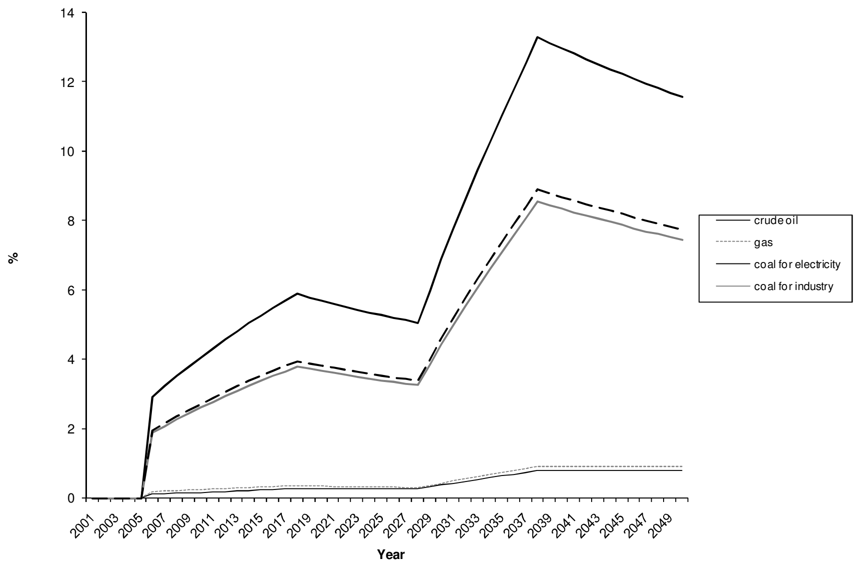

Figure 2: CO_2 taxes imposed in the Use-the-market scenario

2.4.2 Additional scenarios

Two sets of additional scenarios are conducted. The first set of scenarios estimates the impact of an increase in the capacity of the electricity from coal industry versus the electricity from nuclear industry and the electricity from,renewables industry. The purpose of these scenarios is to investigate the economy-wide impact of the three methods in generating electricity and to answer questions such as which is most costly, which industries would be affected, which labour groups would be influenced, and what the welfare impacts and the macro economic effects would be. In these scenarios it is assumed that the capital stock of electricity generation using coal, nuclear and renewables increases by R10 billion in 2010, respectively.

The last scenario conducted investigates the impact of a structural shift in the economy on energy demand and therefore emissions. A structural shift in the economy to a service based economy is imposed, while it is assumed that the contribution of the primary sector in the economy decline. It is assumed that the tertiary sector's productive capacity grow by R2 billion a year, while the productive capacity of the primary sector decline by R2 billion a year.

The impact of the additional scenarios is compared against the GWC scenario.

2.4.3 Closures and assumptions

The closures will be, as far as possible, kept in line with the closures used in the comparative-static modelling. The specific closures used will include the following:

1. The savings rate of households and firms will adjust to finance the higher investment levels.
2. The dynamic model makes provisions for specific levels of labour supply and unemployment for each type of labour. Semi-skilled and unskilled labour are unemployed, while skilled and high-skilled labour are very close to full employment. Employment levels will adjust for all types of labour until full employment is reached, whereafter wages will adjust. For skilled and high-skilled labour, wages will adjust sooner as these types of labour are much closer to full employment (a certain level of natural unemployment is assumed).
3. The exchange rate is flexible with a fixed level of foreign savings (fixed at the base growth path level).

3. Results

3.1 Start-now, Scale-up and Use-the-market Scenarios

GDP impact

The Start-now scenario shows a decline in GDP (compared to GWC) from 2008 until 2024 mainly due to the improved energy efficiency. The improved energy efficiencies lead to a decline in economic activity as the demand for electricity, coal and petroleum declines in intermediate use by industries. From 2024 onwards GDP (compared to GWC) increases, due to the positive impact on prices in the economy stemming from the improvement in energy efficiency. The prices of coal, petroleum, and electricity from nuclear and electricity from gas are lower. This translates into lower prices for most of the commodities in the economy. The commodities that do not see a decline in prices are electricity from coal, electricity from renewables, and commodities that are mostly sold to households (such as wholesale and retail trade, and services). The increase in the price of consumption goods is driven by higher demand. Consumption is higher in the Start-now scenario (compared to the GWC scenario) as investment is lower: households therefore need to save less to finance investment and consumption increase. This is a result of the closure rules used in the model: it is assumed that household savings adjust to finance additional investment and *vice versa*. As can be seen in Table 5 the decrease in GDP is mainly driven by higher consumption (compared to GWC), investment is lower (compared to GWC), while exports and imports decline. Exports decline as the price of exports decline. More goods are therefore sold domestically. Imports also decline as it is assumed that exports are the only source of foreign exchange to pay for the imports (assumed that foreign savings is fixed). Over the entire period average GDP is 0.06% lower when compared to GWC.

The GDP impact of the Scale-up scenario is positive (compared to GWC). The energy efficiencies in the Scale-up scenario are very similar to those in the Start-now scenario and one would have expected the GDP impact to show a decline initially, as was the case in the Start-now scenario. However, investment in the Scale-up scenario is significantly higher, so that the additional economic activity generated through the increase in investment outweighs the decline in economic activity from the improved energy efficiency. The improved energy efficiency and structural changes also result in lower prices for most commodities in the economy. The lower prices in this instance are further driven down by large declines in the price of capital (return on capital) due to higher investment. Some prices in the economy decline to a large extent (coal, petroleum from oil, petroleum from coal-to-liquid, petroleum from biofuels, and electricity from gas) but others, in turn, increase significantly (electricity from coal, electricity from renewables, and electricity from nuclear). Most investment and consumption industries also see an increase in prices. However, over the period the decline in prices outweighs the increase and there is an overall decline in producer prices. Initially consumption by households will fall as savings increase to finance the higher investment. However, consumption soon rises as the lower prices lead to an increase in demand. As can be seen in Table 5, the higher GDP is a result of an increase in consumption and investment. Over the entire period, average GDP is 1.26% higher when compared to GWC.

The GDP impact in the Use-the-market scenarios is the same whether the additional revenue from the CO_2 taxes gets reinvested or whether it is used for tax relief. The macroeconomic effect of the two scenarios is the same due to the assumptions of this model. When the additional revenue is reinvested it results in a decline in the required savings by households and firms, which is equivalent to tax relief extended in the second scenario. Investment levels in both cases remain the same, but the source of investment differs. In the reinvestment case governments invest the additional revenue, while in the tax-relief case the higher investment comes from firms and household who receive the tax relief. The main difference would be in the distributional and welfare impact as the people who save in the economy are not necessarily the same as the taxpayers. According to the SAM used, the high-income household group contributes 67% to total taxes paid by households, and 65% to total savings. The low-income group contributes 8.5% to total taxes paid by households and 8% to savings, while the middle-income groups contribute slightly more to savings compared to taxes (27% and 24%) respectively. Tax relief is therefore expected to benefit higher income households more, while the impact of the reinvestment scenario depends on industry structure.

In the Use-the-market scenarios, GDP increases sharply from 2010 to 2018 due to a sharp increase in investment. Although the GDP impact is still higher compared to GWC it declines from 2018 to 2036 due to a bigger decline in consumption. There is a short period where the GDP impact is lower when compared to GWC, however the GDP impact again rises from 2044 onwards. Over the entire period, average GDP is 0.73% higher compared to GWC, for both the Use-the-market scenarios.

The required investment levels as imposed in the model are somewhat higher than in the GWC scenario. However, the additional revenue generated with the CO_2 taxes results in even higher investment (either from the reinvestment or from tax relief to households and firms). This results in investment being significantly higher compared to GWC. Consumption will therefore decline as households need to save more to finance the increase in investment. Investment increases the capital stock in the model and will therefore increase production capacity in future periods. At the end of the period the taxes levied decline, causing the level of investment to decline. Exports increase initially as domestic prices rise (due to the increase in tax) relative to world export prices and more output is sold domestically. This results in a real depreciation of the exchange rate and a rise in imports. At the end of the period this is reversed due to domestic prices declining.

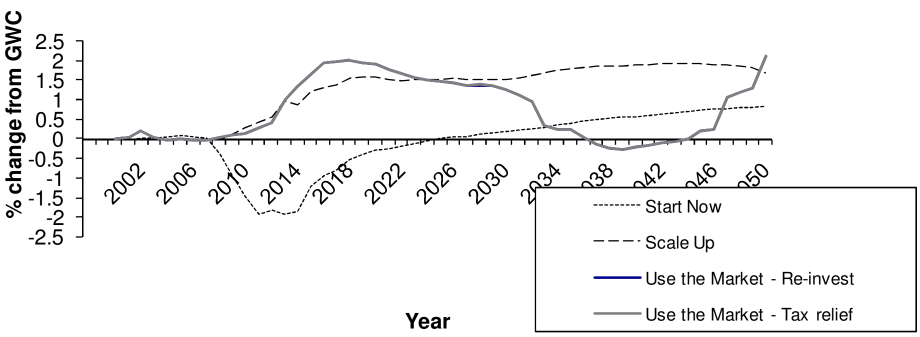

Figure 3: GDP impact (percentage deviation from GWC)

Table 5: GDP components (percentage deviation from GWC)

	2000-2004	2005-2009	2010-2014	2015-2019	2020-2024	2025-2029	2030-2039	2040-2050
Private consumption								
Start-now	-0.03	0.96	0.44	0.38	2.13	2.41	2.55	2.27
Scale-up	0.07	-0.09	-0.51	0.34	1.53	1.67	0.70	0.62
Use-the-market – reinvest	0.07	0.07	-1.37	-1.43	-0.03	-0.68	-1.23	-0.97
Use-the-market – tax relief	0.07	0.07	-1.37	-1.43	-0.03	-0.68	-1.23	-0.97
Gross fixed capital formation								
Start-now	0.19	-3.37	-6.97	-2.85	-3.97	-4.40	-4.96	-5.05
Scale-up	0.13	0.23	3.12	3.32	1.64	1.28	3.83	5.10
Use-the-market – reinvest	0.13	-0.10	4.62	7.67	4.63	5.32	3.68	3.96
Use-the-market – tax relief	0.13	-0.10	4.62	7.67	4.63	5.32	3.68	3.96

	2000-2004	2005-2009	2010-2014	2015-2019	2020-2024	2025-2029	2030-2039	2040-2050
Change in inventories								
Start-now	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scale-up	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Use-the-market – reinvest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Use-the-market – tax relief	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Government consumption								
Start-now	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scale-up	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Use-the-market – reinvest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Use-the-market – tax relief	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exports								
Start-now	0.04	-0.74	-3.80	-2.50	-2.66	-2.58	-2.54	-2.08
Scale-up	0.04	0.04	1.31	1.78	0.57	-0.05	-0.20	-0.43
Use-the-market – reinvest	0.04	0.01	1.75	4.44	2.79	2.13	0.66	-0.54
Use-the-market – tax relief	0.04	0.01	1.75	4.44	2.79	2.13	0.66	-0.54
Imports								
Start-now	0.04	-0.53	-2.64	-1.73	-1.89	-1.93	-2.18	-2.00
Scale-up	0.05	0.03	0.91	1.23	0.40	-0.04	-0.17	-0.41
Use-the-market – reinvest	0.05	0.01	1.21	3.08	1.99	1.59	0.55	-0.52
Use-the-market – tax relief	0.05	0.01	1.21	3.08	1.99	1.59	0.55	-0.52
GDP								
Start-now	0.01	-0.23	-1.79	-0.77	-0.18	0.08	0.37	0.71
Scale-up	0.05	0.01	0.62	1.42	1.54	1.54	1.74	1.89
Use-the-market – reinvest	0.05	0.02	0.62	1.89	1.67	1.40	0.35	0.51
Use-the-market – tax relief	0.05	0.02	0.62	1.89	1.67	1.40	0.35	0.51

GDP industry impact

Table 6 shows the industry impact for the Start-now scenario. Electricity from gas, petroleum from coal-to-liquid, and electricity from nuclear are the industries that benefit the most in the Start-now scenarios. The industry that benefits the least is electricity from renewables, mostly due to the structural shifts imposed in the model. The industry seeing the largest percentage change compared to the GWC scenario is electricity from gas. However, this is mainly because it is from a very low base: electricity from gas is a very small industry.

Table 6: Start-now GDP industry impact (percentage deviation from GWC)

	2000-2009	2010-2019	2020-2029	2030-2039	2040-2050
Best performing industries (excluding electricity and petroleum industries)					
Metal industries	-0.64	-2.68	2.04	3.66	3.52
Water	0.22	-0.82	0.79	0.98	0.86

	2000-2009	2010-2019	2020-2029	2030-2039	2040-2050
Worst performing industries (excluding electricity and petroleum industries)					
Machinery	-1.51	-4.56	-4.34	-4.70	-4.05
Other manufacturing	-0.92	-4.07	-4.09	-4.36	-3.79
Vehicles	-0.54	-3.67	-3.77	-4.17	-3.92
Construction	-1.99	-3.88	-3.38	-3.79	-3.69
Petroleum industries					
Petroleum from oil	-0.10	-6.58	-12.75	-12.70	-10.76
Petroleum from coal-to-liquids	0.01	41.80	242.75	340.73	341.20
Petroleum from gas-to-liquids	-0.65	-6.03	-16.48	-28.30	-37.24
Petroleum from biofuels	-0.16	-5.06	4.14	7.19	1.72
Electricity industries					
Electricity from coal	-0.25	-11.97	-29.05	-33.93	-31.87
Electricity from nuclear	0.10	46.55	57.79	43.40	57.02
Electricity from renewables	1.81	-89.54	-85.08	-69.23	-98.79
Electricity from gas	0.18	589.07	2584.14	3416.93	3516.87

The GDP impact on industries in the Scale-up scenario is shown in Table 7. The industries that benefit the most from this are again electricity from gas, petroleum from coal-to-liquid, and electricity from nuclear. Other industries that are likely to benefit here are investment-oriented ones such as metals and construction, due to the significant increase in investment. Industries that do not benefit include electricity from renewables, electricity from coal, and petroleum from gas-to-liquid. This is again a function of the structural shifts imposed in the model.

Table 7: Scale-up GDP industry impact (percentage deviation from GWC)

	2000-2009	2010-2019	2020-2029	2030-2039	2040-2050
Best performing industries (excluding electricity and petroleum industries)					
Metal industries	0.06	4.25	6.01	5.89	3.79
Construction	0.17	2.90	1.64	3.88	5.53
Machinery	0.05	2.27	-0.07	1.57	2.30
Non metallic products	0.07	1.66	0.35	0.76	0.91
Water	0.02	0.61	1.73	0.94	0.57
Wholesale and retail trade	0.02	0.78	0.60	0.48	0.75
Worst performing industries (excluding electricity and petroleum industries)					
Fertiliser	0.02	-0.29	-3.18	-6.07	-6.02
Vehicles	0.02	1.18	-1.00	-1.63	-2.87
Beverages	0.02	-0.03	-0.98	-2.16	-2.35
Agriculture	0.02	-0.03	-0.53	-1.66	-1.80

	2000-2009	*2010-2019*	*2020-2029*	*2030-2039*	*2040-2050*
Petroleum industries					
Petroleum from oil	0.12	-4.26	-12.66	-13.54	-11.34
Petroleum from coal-to-liquids	0.13	38.87	228.55	352.31	438.95
Petroleum from gas-to-liquids	-1.76	-10.81	-35.44	-56.23	-66.75
Petroleum from bio-fuels	-0.14	-4.90	-5.51	-6.40	-7.79
Electricity industries					
Electricity from coal	-0.19	-10.22	-27.90	-42.91	-75.51
Electricity from nuclear	0.16	50.68	60.96	89.89	278.35
Electricity from renewables	0.02	-92.04	-91.38	-65.35	-98.20
Electricity from gas	0.22	617.85	2589.14	3986.44	8559.62

The industry impact in the Use-the-market scenario is relatively the same as in the Scale-up scenario with the exception that investment industries such as metals, construction, and machinery benefit more from the additional revenue from the reinvestment of CO_2 tax revenue. Industries that benefit include electricity from nuclear, petroleum from coal-to-liquid, and petroleum from biofuels. When compared to the Scale-up scenario, the petroleum from coal-to-liquid industry benefits to a lesser extent. There is still a general move toward petroleum generated through coal-to-liquid processes compared to oil, but due to the higher coal taxes the increase in petroleum from coal-to-liquid is smaller. Petroleum generation through biofuels, however, now increases with more than in the Scale-up scenario as some substitution to this method of petroleum production is less costly in the presence of CO_2 taxes. Industries that do not benefit include electricity from coal, electricity from renewables and petroleum from oil. These industries' GDP is lower compared to the Scale-up industry. The industry results for the Use-the-market Tax Relief scenario are similar.

Table 8: Use-the-market GDP industry impact (percentage deviation from GWC)

	2000-2009	*2010-2019*	*2020-2029*	*2030-2039*	*2040-2050*
Best performing industries (excluding electricity and petroleum industries)					
Metal industries	-0.02	7.18	7.97	7.76	5.32
Construction	-0.04	5.95	5.10	5.55	6.77
Machinery	0.04	4.83	3.33	2.63	2.61
Other manufacturing	-0.02	3.93	3.08	2.90	2.14
Non metallic products	-0.01	3.24	2.46	1.21	0.53
Other services	0.03	-0.23	0.23	0.37	0.45
Worst performing industries (excluding electricity and petroleum industries)					
Fertiliser	-0.03	-1.56	-4.66	-9.57	-9.67
Agriculture	0.03	-0.60	-0.68	-1.94	-2.53
Beverages	0.03	-0.54	-0.75	-1.66	-2.02
Vehicles	0.03	-0.60	-0.68	-1.94	-2.53

	2000-2009	*2010-2019*	*2020-2029*	*2030-2039*	*2040-2050*
Petroleum industries					
Petroleum from oil	0.07	0.41	-3.20	1.95	-1.10
Petroleum from coal-to-liquids	0.30	35.37	136.30	-24.08	136.20
Petroleum from gas-to-liquids	-1.38	-20.73	-47.27	-60.30	-70.86
Petroleum from bio-fuels	-0.01	-5.89	-6.12	18.73	23.21
Electricity industries					
Electricity from coal	-0.31	-12.75	-17.01	-80.31	-93.94
Electricity from nuclear	0.30	12.57	-27.93	146.59	149.72
Electricity from renewables	1.82	-88.36	-79.47	-38.89	-97.75
Electricity from gas	5.46	2047.64	5588.93	19019.63	27932.82

Employment and wages

The combined impact on employment and wages is shown in Table 9. In the Start-now scenario, wage income for high-skilled and skilled categories increases over the entire period (compared to GWC), while factor income for the semi-skilled and unskilled groups decline. This result follows the industry results. Industries that benefits in this scenario (such as petroleum from coal-to-liquid, petroleum from biofuels and electricity from nuclear) use high-skilled and skilled labour most intensively.

In the Scale-up scenario wage income for all labour groups increases even for the semi- skilled and unskilled. The semi-skilled and unskilled benefit in this scenario from the increase in investment. Investment industries such as construction and machinery use semi-skilled and unskilled labour most intensively. The construction industry for example uses 56.4% semi-skilled and unskilled labour in production and contributes 10.4% to total employment of semi-skilled and unskilled labour in the economy.

In the Use-the-market scenario the wage income for all labour categories increases initially. This is due to the additional demand from higher investment or tax relief. At the end of the period the wage income for high-skilled and skilled labour declines. These results also follow the industry results. Industries such as petroleum from gas-to-liquid, electricity from coal, and electricity from renewables employ high-skilled and skilled labour intensively.

Table 9: Employment and wage impact

Average over period (deviation from GWC)			
	Start-now	*Scale-up*	*Use-the-market*
High-skilled labour	*3.6*	*24.1*	*8.4*
Skilled labour	*8.8*	*29.4*	*8.8*
Semi-skilled and unskilled labour	*-11*	*17*	*13.7*

The returns to capital are higher in the Start-now scenario as investment is lower (14.7% on average over the period). In the Scale-up and Use-the-market scenarios the returns to capital are lower as investment is higher (-6.1 and -13.1% on average over the period). In the Scale-up and Use-the-market scenarios the demand for capital increase more. Industries such as petroleum from coal-to-liquid, electricity from nuclear, and the metals industry are capital-intensive and use 74.3%, 81.6% and 60.1% capital in their production respectively.

Household welfare

The equivalent variation measure (as shown in Figure 4) measures the welfare impact of the scenarios by measuring the change in utility for all household groups. The equivalent measure incorporates the welfare impact of changes in income and prices at a household level. In the Start-now scenario welfare for all households (over the entire period and compared to GWC) improves. The high-income household group sees the largest improvement in welfare as their income increased the most over the period. The high-income household group receives a large share of their income from high-skilled and skilled labour (70%). All households are better off due to the decline in prices from higher investment and improved efficiency.

In the Scale-up scenario the highest income group sees a decline in welfare due to lower returns on its capital. This household group receives 18% of its income from capital. In the Scale-up scenario the low-income group is the best off. Low income households receive most of their income (53%) from unskilled labour and are also most intensively employed in investment industries such as construction which benefit in the Scale-up scenario.

In the Use-the-market scenarios all households are better off. The high-income household group is marginally better off. The wage income of the high-income groups is higher, but the returns they receive on capital are lower. Most of the welfare impact for the high-income groups is from lower prices. In the tax-relief scenario high–income households are marginally better off when compared to the reinvestment scenario. This is because the high-income groups pays a larger portion of total taxes and therefore benefits more from the tax relief. In the reinvestment scenario low-income households are marginally better off, as they receive a large portion of their income from semi- and unskilled labour, which factor-income increase the most.

Figure 4: Equivalent variation (deviation from GWC)

Energy demand and emissions

Table 10 shows the changes in energy demand for coal, petroleum and electricity. In the Start-now scenario the demand for coal, petroleum and electricity decline. The demand for coal declines with less compared to the other scenarios, while the demand for petroleum and electricity decline with more. This is due to improved energy efficiency in the use of petroleum and electricity. In the Scale-up scenario the demand for investment is higher (when compared to GWC and Scale-up) which leads to an increase in the demand for petroleum and electricity. Structural changes in the economy (away from coal) lead to a relative large decline in coal demand. In the Use-the-market scenarios the demand for coal decreases significantly mainly due to the demise of the coal industry. The demand for petroleum also decreases. However, in the Use-the-market scenario the demand for electricity increases (especially at the end of the period) due to an increase in demand for electricity from higher investment and exports.

The results are in line with results generated by Pauw (2007). Devarajan et al (2009) found that the impact of the taxes on GDP is negative and that the taxes have negative welfare impacts for most of the taxes investigated, especially when the tax revenue is used for tax relief. The dynamic CGE modeling results shows that when the tax is combined with the mitigating scenarios the net impact on GDP is positive through increased investment. It is also assumed that the tax revenue is channelled to either increased investment, or tax relief. Although the increase in GDP puts pressure on energy demand it is countered with the improved energy efficiencies as well as the CO_2 taxes assumed, so that the demand for coal, petroleum and electricity falls. It is expected that energy emissions will decline.

Table 10: Energy demand

	2000-2004	*2005-2009*	*2010-2014*	*2015-2019*	*2020-2024*	*2025-2029*	*2030-2039*	*2040-2050*
Coal								
Start-now	0.032	-0.474	-3.138	-6.746	-8.476	-10.433	-11.835	-12.240
Scale-up	0.055	-0.041	0.039	-4.559	-7.417	-9.781	-13.028	-19.630
Use-the-market – reinvest	0.054	-1.294	-6.572	-9.268	-10.777	-12.035	-42.922	-64.800
Use-the-market – tax-relief	0.054	-1.299	-6.576	-9.268	-10.777	-12.036	-42.923	-64.802
Petroleum								
Start-now	0.037	-0.150	-1.980	-0.760	-0.552	-0.829	-1.804	-2.976
Scale-up	0.062	-0.037	-0.349	0.008	-1.591	-3.279	-3.970	-2.183
Use-the-market – reinvest	0.062	0.005	0.649	2.067	1.129	0.013	-1.622	-2.587
Use-the-market – tax-relief	0.062	0.002	0.645	2.066	1.129	0.013	-1.623	-2.590
Electricity								
Start-now	0.011	-0.382	-4.343	-5.670	-5.161	-4.746	-5.974	-6.452
Scale-up	0.038	-0.315	-2.348	-3.637	-3.489	-3.536	-5.399	-6.176
Use-the-market – reinvest	0.039	-0.408	-1.341	2.720	9.051	13.599	16.536	12.142
Use-the-market – tax-relief	0.039	-0.415	-1.348	2.720	9.051	13.599	16.534	12.137

When the mitigation scenarios is combined with a CO_2 tax the results indicate that the CO_2 tax is effective in reducing output of CO_2 producing industries as it changes the relative price of the commodities produced by these industries. However, the sales tax is distortionary as it introduces price wedges in the economy while consumers may end up paying large portions of the tax. However, this is negated to some extent if the tax revenue from the carbon tax is allocated to tax relief.

3.2 Additional scenarios

3.2.1 The impact of additional capacity in coal versus nuclear electricity generation

The productive capacity of electricity generation by coal and nuclear is increased by R10 billion in 2010 in each scenario, respectively. The purpose of these scenarios is to see how the distributional impact of the two scenarios differs. The relative impact of the increase in capital stock is largely determined by the structure of the two respective industries. The electricity from coal industry supplies 93% of electricity, while the electricity from nuclear industry supplies 5%. The value added in both industries is very similar; value added in the electricity from coal industry is slightly higher at 55% compared to 54% in electricity from nuclear. The electricity from coal industry uses commodities from more industries in the generation of electricity, with large inputs from coal itself, construction, other manufacturing, electricity, and services. Large inputs into the electricity from nuclear industry are petroleum, construction, other manufacturing, and electricity. The electricity from nuclear industry is more capital-intensive than the electricity from coal industry (81% compared to 78%). High-skilled labour is used more intensively by the electricity from nuclear industry (14% compared to 10%). The electricity from coal industry uses unskilled labour more intensively (8.5% compared to 2.3%).

The macroeconomic impact of the two scenarios is very similar. In 2010 GDP increases by almost 0.25% as a result of the increase in capital stock. The additional capital stock increases the productive capacity of the economy and GDP remains higher than GWC for a time until it returns to GWC levels in the late 2030s. Over the entire period, average GDP is 0.02% higher compared to GWC. The increase in GDP is mainly driven by higher consumption, as the additional capital stock results in an increase in employment and wages and, therefore, disposable income. Lower prices from the increase in the supply of electricity also stimulate consumption. In the electricity from coal scenario the higher consumption is mainly due to lower electricity prices, while in the nuclear scenario it is mainly due to higher wages. Exports also increase as the lower electricity prices lower domestic prices relative to world prices resulting in a real exchange rate depreciation. Imports also increase, as more foreign exchange is available from the higher exports to finance imports. Imports increase with marginally more in the nuclear scenario indicating that electricity from nuclear may be marginally more import-intensive than electricity from coal.

Most industries benefit from the increase in the capacity of the electricity from coal industry, for the following reasons:

- The electricity from coal industry has large backward linkages with other industries. As output here increases it will need more intermediate goods. The industries that supply intermediate goods such as coal, construction, other manufacturing, electricity, and services to the electricity from coal industry, benefit.
- The electricity from coal industry supplies a large portion (93%) of the total electricity supply. The increase in supply of electricity from coal will therefore have a large price impact on the economy. Most industries that use electricity in its production process benefit from this, including metals, mining, pharmaceuticals, electricity from coal, wholesale and retail trade, and services.

The electricity from nuclear industry does not benefit from the increase in the capacity of the electricity from coal industry as there is substitution away from it to the cheaper electricity from coal. The GDP impact on industries from the increase in the capacity of the nuclear industry is similar to that of an increase in the capacity of electricity from coal. The backward linkages between the electricity from nuclear industry and the electricity from coal industry are very similar except for coal used in the 'electricity from coal' industry. The demand for all energy sources increase as the economy expands.

3.3 The impact of a structural shift in the economy from the primary to the tertiary sector

This scenario assumes that there is a structural shift from the primary sector to the tertiary sector in the economy. From 2001 onwards it is assumed that the capital stock of the tertiary sector increases by R2 billion per year, while the capital stock of the primary sector decline by R2 billion per year. The aim of this scenario is to see whether this structural shift in the economy will lead to changes in energy demand and therefore emission levels.

The GDP impact is initially positive as consumption and exports increase. However, from 2024 GDP is lower when compared to the GWC scenario. Over the entire period average GDP is 0.05% higher when compared to the GWC scenario. The increase in production capacity of the tertiary sector leads to an increase in supply, which in turn leads to an increase in employment and income. Prices will also go down as the returns to capital in the tertiary sector fall. The combined impact of higher income and lower prices leads to an increase in consumption. Since the tertiary sector sells more output to households compared to the primary sector, household consumption would therefore not be influenced as much by the rise in prices in the primary sector. The tertiary sector also employs high-skilled and skilled labour more intensively compared to the primary sector. The primary sector combined employs 24.9% and 8.6% high-skilled and skilled labour as a percentage of total factor use, compared to the tertiary sector that employs 59.1 and 31.9%, respectively. The tertiary sector is also a larger employer of high-skilled and skilled labour and employs 80.2% and 87.3% of total high-skilled and skilled labour in the economy. Higher income in the tertiary sector is therefore expected to outweigh the decline in income from the mining industry.

The mining industry is an important earner of foreign exchange in the economy and the decline in mining exports is expected to influence the real exchange rate. Exports of the mining industry in 2000 contributed 33% to total exports in the economy compared to the tertiary sector that contributed 13%. Initially exports increase as the increase in exports in the tertiary sector outweighs the decline in exports from mining. However, mining exports start to decline rapidly as the real exchange rate appreciates and the price of mining commodities relative to international prices increase. This also impacts negatively on tertiary sector exports and from 2024 total exports decline.

Inter-industry linkages influence the impact of this scenario on the various industries. One would have expected agriculture to decline and wholesale and retail trade and services to increase more. The mining industries also show a larger decline than expected. The reasons for this are that (1) agriculture is used intensively in industries such as food and beverages that benefit from the increase in consumption; (2) wholesale and retail trade and services do not benefit as they are used by industries such as petroleum from coal-to-liquid, and petroleum from gas-to-liquid; and (3) the mining industries decline more than expected due to a large decline in exports especially from 2024 onwards. Industries that benefit in this scenario are those that sell mostly to consumption, including food and beverages, industries that supply the inputs into these industries such as machinery, and industries that use services (wholesale and retail trade and other services) intensively in their own production processes. These industries benefit from the lower prices associated with the service industries. Industries that do not benefit are either used intensively in the production of mining commodities or suffer from the real exchange rate appreciation (from 2024 onwards).

Employment and wages increase initially as the tertiary sector is a larger employer than the primary sector. The tertiary sector also employs high-skilled and semi-skilled labour more intensively and these labour groups see a large increase in factor income. The semi-skilled and unskilled labour group benefit more than expected since they are more intensively employed in the primary sector. However, other industries that benefit such as construction and the metals industry also employ semi-skilled and unskilled labour intensively. At the end of the period all labour categories see a decline in wage income as exports declines

The demand for coal, petroleum, and electricity initially rises as the services sector (and the economy) expands. However, with the decline in mining the demand for all these commodities starts to decline. The demand for coal and electricity declines the most, as it is intensively used in the mining industries.

4. Summary and conclusions

The GDP impact in the Start-now scenario is lower when compared to the GWC scenario. This is because the increased energy efficiencies result in a contraction of economic activity as less electricity is used. This is accompanied by a loss of wage income due to lower employment and wages for semi-skilled and unskilled labour. However, most households are better off due to lower prices in the economy from the increased energy efficiencies.

The GDP impact in the Scale-up scenario is higher when compared to the GWC scenario. The impact of the substantial increase in required investment in this scenario outweighs the decline in economic activity associated with the increase in energy efficiency. Wage income for all household groups increases; return on capital is lower due to the increase in investment. This results in higher-income households not benefitting from this as they receive most of their income from capital. The low-income household group benefits the most as they are intensively employed in investment-oriented industries.

The GDP impact in the two Use-the-market scenarios are very similar, as the adjustment mechanisms in the model results in the same macroeconomic impact. The GDP impact is higher compared to the GWC scenario due to the increase in investment. Investment is higher due to firstly, higher required investment and, secondly, higher investment associated with the CO_2 taxes levied. The CO_2 taxes levied are either reinvested or the tax relief extended generates higher savings by firms and households, which in turn generates higher investment. The higher investment again results in a decline in the return on capital. Wage income rises especially for the semi-skilled and unskilled labour groups as they are intensively employed in the investment-oriented industries. There are marginal differences in the distributional impact. In the tax-relief scenario the high-income households are marginally better off, while low-income households are marginally better off in the reinvestment scenario. All household groups are better off, with the high-income households best off when compared to the GWC scenario.

There is a general decline in the demand for coal and petroleum in all the scenarios. The decline in demand for coal is the largest in the Use-the-market scenario. Demand for electricity increase in the Scale-up and Use-the-market scenarios due to the large increase in investment and exports associated with these scenarios.

In conclusion: A CO_2 tax may not be the most appropriate tool to achieve the desired results considering the economic development objectives of South Africa if it leads to higher prices for energy. However, as seen from the results, if the CO_2 tax is combined within the LTMS framework its negative impact is negated through higher investment and GDP growth. The mitigation scenarios have a positive impact on GDP when investment is large as is the case with the Scale-up scenarios. Although economic activity initially declines due to improved energy efficiency, it is followed by a period of economic expansion as lower prices increase output in most industries – this is especially the case when it is combined with higher investment. When CO_2 taxes are levied the economic impact is again positive if this is combined with either tax relief or reinvestment of the additional tax revenue.

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THEME 3: LESSONS FROM THE CDM EXPERIENCE

Innovative environment for enhancing carbon markets and prices

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Abstract
Africa's share in the global market through the Clean Development Mechanism (CDM) is dismally low – standing at 2.42% of total CDM projects in the pipeline as at end of February 2010. Various barriers have been identified, including: CDM expertise, institutional/policy arrangements, awareness and information, and financing. This paper elaborates on Africa's carbon potential, barriers limiting CDM implementation, and a barrier removal strategy. As part of the barrier removal strategy aimed at addressing some of the barriers, in particular financing, the paper proposes an innovative environment for enhancing carbon markets and prices.

Keywords: carbon potential, barriers, barrier removal strategy and innovative financing environment, Africa

1. Background

There are two main types of market-based policy instruments aimed at curbing greenhouse gas (GHG) emissions: price-based and quantity-based ones (UNCTAD TDR 2009). These have generally been used in developed countries and are now being urged on emerging developing countries. Carbon tax is a price-based instrument, because it imposes a direct charge on the use of fossil fuels based on their carbon content. In fact, the carbon tax is equivalent to an emissions tax. In contrast, in a system of tradable permits, the regulator determines the maximum permissible aggregate emission level (the cap), and issues corresponding allowances for emission dischargers. However, in view of several constraints which have limited the application of the Clean Development Mechanism (CDM) in most of sub-Saharan Africa, resulting in African markets being largely bypassed by emerging or rapidly expanding carbon markets, the application of policy instruments is not relevant. What is required, however, is an innovative environment for enhancing carbon markets and prices.

This paper therefore initially investigates Africa's carbon market potential, and identifies various barriers inhibiting its development, including carbon prices, and proposes a barrier removal strategy for the same purpose. To enhance better carbon prices in Africa and financing, the paper proposes an innovative mechanism which requires the establishment of an African Carbon Exchange comprising trading, Africa Carbon Fund, and knowledge hub platforms.

2. Methodology

Some of the results presented in this paper emanate from a study undertaken under the Climate Strategies project aimed at evaluating the record of the CDM to date and to consider ways it might be improved in the future international climate policy regime. The project was coordinated by Oxford Institute for Energy Studies and University of Zurich between mid 2008 and December 2008 (Michaelowa & Muller 2009). The study included analysis from an industrialised country viewpoint on one hand, and from a developing country perspective (covering Africa, India and China) on the other. The concept originating an innovative environment for enhancing carbon markets and prices emerged from discussions between the Centre for Energy, Environment and Engineering Zambia (CEEEZ) and Lloyds Financials of Zambia.

3. Africa's carbon potential

All Parties to the United Nations Framework Convention on Climate Change (UNFCCC), including African countries, are expected, among others things, to undertake measures and programmes to mitigate climate change – taking account of their common but differentiated responsibilities and their specific national and development priorities and circumstance. Thus far the main drivers for the carbon market in Africa and other developing countries are CDM and voluntary markets. There are several constraints that have limited the application of CDM in Africa and, as a consequence, African markets have been largely bypassed by emerging or rapidly expanding carbon markets.

From the African perspective, CDM was meant to allow companies in developing countries to become fully engaged in climate change initiatives and benefit from new investments and transfer of cleaner technologies. At the outset, there were different interpretations of this, one of which was that the private sector from developed countries would actually come and invest in developing countries. However, this did not turn out to be case, since the local private sector has been expected to undertake the investments, while the developed countries only buy carbon credits. The status and performance of CDM in Africa as at February 2010 is illustrated in Table 1. Out of 4 949 projects in the pipeline, Africa has only 120 projects representing only 2.42%. Why such a slow uptake? One of the arguments advanced for this low participation in CDM market in Africa is the existence of a variety of barriers.

Table 10: Status and performance of CDM in Africa

Source: www.uneprisoe.org

Total in CDM Pipeline	*Number*	*%*	*kCERs 2012*	*%*
Latin America	838	16.93	382 704	13.41
Asia & Pacific	3 866	78.12	2 299 867	80.61
Africa	120	2.42	91 735	3.22
Middle East & N Africa	72	1.45	51 726	1.81
LDC	19	0.38	20 122	0.71
LDC Asia & Pacific	34	0.68	6 900	0.24
Total	4 949	100	2 853 054	100

It is expected that total Certified Emission Reduction (CER) potential would reach 740 million tonnes of CO_2-eq per year, more than sub-Saharan Africa's current annual GHG emissions with a value of (US)$4 billion per annum at $5 per CER. There is also great potential through the introduction of energy efficiency management practices in view of the inefficient manner of energy use in most industries in Africa (IPCC 2007: Chapter 7).

Besides the energy sector, there is an enormous potential in the forestry and agriculture sector, which has only been assessed superficially, including: improved agriculture practices (zero tillage conservation, improved agriculture management systems), restoration of cultivated organic soils, improved crop land management (improved grazing land management, restoration of degraded land, livestock management) and sustainable natural resource management (prevent deforestation, intensive management fertilization, increased land- scape carbon stocks), and increase of bioenergy substitution.

A recent study (Walker et al 2008) estimated the area of land available for afforestation in sub-Saharan Africa at 625 million hectares, and this could sequester over 30 billion tCO_2 in a period of 10 years. Methane reduction opportunities in the agricultural and waste management sectors are also significant.

4. Barriers inhibiting CDM

Barriers inhibiting CDM in sub-Saharan Africa are well known (de Gouvello et al 2008; Africa Carbon Forum 2008; IER 2002; Alves 2005; Pemberton 2001) and include CDM expertise, institutional/policy arrangements, awareness and information, and financing. As regards expertise, there is generally a lack of sufficient CDM expertise to undertake technical feasibility studies and development of Project Idea Notes (PINs) and Project Design Document (PDDs), on the one hand. On the other hand, there is still lack of sufficient specialised support service providers among the consulting firms, research institutions, and academia in Africa to work with the private sector to develop PINs and PDDs (IER 2002; Alves 2005).

As part of institutional/policy arrangements, governments are expected to set up Designated National Authorities (DNAs) for approval of CDM projects and provide letters of approval and established sustainable development criteria required for approving CDM projects. Although DNA offices exist in most African countries, they lack resources for infrastructure and capacity development to expand their mandates to include provision of CDM promotional services. However, besides their existence, there is as yet no integrated institutional environment at policy, agency, and corporate levels to mainstream CDM in their vision and development of implementation strategies, investment promotion, and business investment decision processes, respectively.

As for awareness and information, as shown by a recent study (Satnam 2007), the private sector has still not fully woken up to take advantage of CDM Investment opportunities due to various barriers. The study identified barriers including:

(i) a lack of perception of companies about the technical and financial benefits offered by the CDM;

(ii) a lack of model companies to provide some experience for new developers;

(iii) a lack of ability to develop PDDs;

(iv) limited resources for specialised support services for economic and financial analysis of CDM projects;

(v) a lack of awareness about the price of CERs on the international market and therefore uncertainty of the impact of these on project economics;

(vi) a low level of knowledge regarding the legal issues to be considered under the CDM;

(vii) inability to negotiate for a emission reduction purchase agreement (ERPA) and high transaction costs.

It is now a well-recognised fact that lack of financing is the biggest hindrance to CDM project implementation. This is the case since carbon finance alone will not solve the investment financing gap (de Gouvello et al 2008; Africa Carbon Forum 2008). For typical renewable energy projects, including hydro, wind, and biomass, the carbon contribution to financing ranges from 5% to 50% depending on the type of projects (Pfeifer et al 2008). Several project developers, investors and buyers have emphasised that generally unattractive investment frameworks for conventional energy projects are a major obstacle to CDM project development, including access to project finance (Africa Carbon Forum 2008). At the local/regional level, financial institutions perceive energy related projects as risk, and therefore are reluctant to invest in them.

Further, it has been revealed (Pemberton, 2001, Alves, 2005) that there is a weak financial base for local companies to implement CDM projects, non-inclusion of CDM investment of traditional, national/regional financial institutions on their lending portfolio, and lack of institutional set up for performing CDM project cycle functions. The studies also revealed limited awareness as to the availability of international investment sources and of risks associated with CDM project implementation, as well as limited – and sometimes zero – awareness of transaction costs in CDM implementation and impacts of CERs on projects economics.

5. Barrier removal strategy

This section considers barrier removal strategies aimed at removing hindrance to CDM development and implementation in Africa and hence unlocking its great CDM potential. The suggestions are based on the studies mentioned in section 4.

1. *CDM capacity:* Provision of support and resources to develop local expertise in key related CDM services to help project developers prepare business plans, PINs and PDDs. Capacity building activities should involve learning by doing, targeting groups such as engineers, economists and financial analysts from industry, consulting firms, and research organisations and academia. African governments need capacity to promote and encourage CDM and work with the private sector to stimulate project development. African businesses need increased awareness of CDM, its benefits and role in accelerating investment and bringing in new technology.
2. *Awareness and information:* Continued aggressive CDM awareness and information programmes among companies, farmers and project developers on CDM objectives and its project cycle, and on the benefits of CDM in business, especially involving high-level meetings among CEOs. Provision of technical information and key data to the private sector and farmers on technology (renewable energy, energy efficiency etc), characteristics, investment and of the costs, through establishing websites and specialised focal points for widespread dissemination
3. *Financing:* Awareness and sensitising programmes to local financial institutions to remove the perception that renewable energy, energy efficiency and other (afforestation and agriculture) projects carry high risks and transactions costs associated with CDM implementation; and also programmes on the need to formulate an innovative financing arrangement.

6. An innovative environment for enhancing carbon markets and prices

To address the financing barrier requires an innovative environment to enhance carbon markets and prices mechanism under the proposed Africa Carbon Credit Exchange (ACCE). ACCE was developed based on discussions between the Centre for Energy, Environment and Engineering Zambia (CEEEZ) and Lloyds Financials of Zambia. ACCE will manage a market-place which is uniquely designed to facilitate the implementation of carbon reduction projects by unraveling the complexities of carbon markets and addressing the prevailing barriers to carbon market development in Africa. ACCE will further provide innovative services and solutions within existing African and international frameworks to unlock low-carbon Africa and will serve as a one-stop shop for emission reduction or sequestration projects to access the capacity, financing, and linkages required to enable low-carbon development.

It is proposed that the ACCE introduces three platforms, namely: a knowledge hub, the Low-Carbon Africa Fund, and trading platforms. The knowledge hub will build capacity through sensitisation on CDM awareness and will build the technical capacity to develop and implement carbon projects. Once the projects have been assessed and found viable from both business and CDM perspectives, they will be considered for project financing from the Fund. The Fund will draw financial resources from different sources to include pensions, savings and equity entities. The Low-Carbon Africa Fund Portfolio will unlock finance for carbon projects, including green technology development and/or transfer. The Fund will provide debt and/or equity to projects that facilitate sustainable development and reduce emissions versus the business as usual approach. The Fund will also buy African-based carbon credits (CERs and Verified Emission Reductions, VERs). The trading platform will provide the medium for transactions, and supporting structures in the form of brokers and local partners throughout Africa. The platform will further provide a need to build greater supply for today's market by exchanging services that address current constraints in Africa. A summary of the proposed innovative environment for enhancing carbon markets and prices mechanism under ACCE is shown in Figure 1.

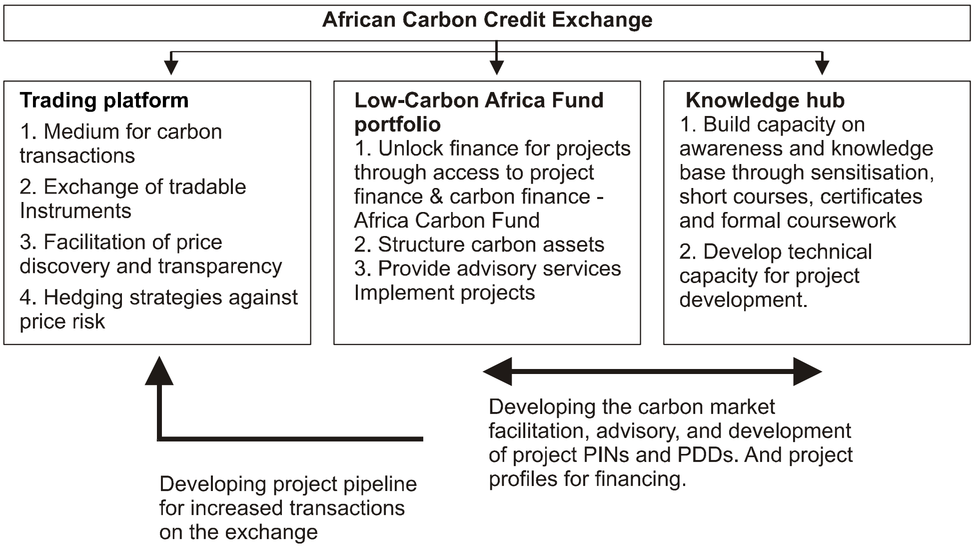

Figure 1: Summary of the proposed innovative environment for enhancing carbon markets and prices mechanism under ACCE

7. Conclusions

Africa has a great potential for CDM projects, and therefore stands to benefit if various issues (CDM reform, barrier removal strategy, and financing) are articulated and implemented as far as possible. Implementation of the proposed Africa Carbon Credit Exchange ACCE will go a long way in addressing barriers currently inhibiting CDM implementation in Africa through increased project pipeline and better carbon prices.

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A comparative analysis of CDM in South Africa and China

Redefining the role of CDM in the quest for putting a price on carbon in South Africa

John Fay, Farai Kapfudzaruwa and Lin Na

Abstract

Both South Africa and China are emergent economies heavily dependent on fossil-fuel based energy sources, and the potential to leverage the Clean Development Mechanism (CDM) is significant in both countries. However, experience to date with CDM indicates South Africa has significantly lagged behind China in the uptake of the CDM, accounting for only 0.9% of the worldwide registered annual Certified Emission Reductions (CERs) while China has dominated the market, generating over 54% of the annual worldwide CERs. Thus, an opportunity exists to redefine the role of CDM in South Africa to better incentivise a lower carbon development trajectory. This paper provides a comparative analysis of the CDM experience in China and South Africa in order to identify the underlying drivers and obstacles to CDM in both countries. It is the authors' objective to analyse the lessons learnt from market-leading China and laggard South Africa to better understand the structures and policies necessary within host CDM countries to unlock the potential of CDM in a post 2012 regime.

1. Introduction

The Clean Development Mechanism (CDM) is a market-based approach under the Kyoto Protocol, designed to provide financial incentives for developing countries to voluntarily contribute to emission reduction efforts and promote sustainable development (UNFCCC, 2009). China and South Africa both ratified the Kyoto Protocol in 2002, and are eligible to implement CDM projects and to trade the Certified Emission Reduction credits (CERs) through the international compliance carbon market. The fundamental structure of the CDM as a market-based approach causes it to favour low-cost opportunities that generate significant CER volumes, in host countries with political stability, investment security and large 'smokestack' industries (such as heavy engineering, energy production or manufacturing that is heavily dependent on fossil fuels).

Whilst the main emergent economies in developing countries (China, India, Mexico, Brazil and South Africa) inherently meet the favourable CDM country criterion outlined above, in reality the geographical distribution of the projects indicates a significant disparity in CDM uptake between the countries. Of the 4 673 projects in the CDM pipeline as of October 1st 2009, the Asia and Pacific region has dominated the CDM while Africa has under-performed. China has taken the leadership role by supplying 2012 CERs, whereas South Africa, the leading CDM host country in Africa, has played a negligible role thus far (see Table 1).

Table 1: CDM project and CER comparison

Source: UNEP (2009)

Location	*Worldwide*	*China*	*South Africa*
Issued projects	566	144 (25.4%)	4 (0.7%)
Issued kCERs	333 069	153 234 (46%)	1 023 (0.3%)
Registered projects	1 834	626 (34.1%)	16 (0.9%)
Registered 2012 kCERs	1 685 229	912 041 (54.1%)	15 643 (0.9%)
Remaining CDM pipeline projects	2 839	1 205 (42.4%)	12 (0.4%)
Remaining CDM pipeline 2012 kCERs	1 100 520	627 221 (57%)	1 065 (0.1%)
GDP 2008 estimated[1] ($ thousands)	-	4 326 187 000	276 764 000
Total 2012 CERs / GDP ($ thousands)	-	0.39	0.06
Estimated population[2]	-	1 338 613 000	49 052 000
Total 2012 CERs /population	-	1.26	0.36
Total emissions (thousand tons CO_2)[3]		6 017 690	443 580
Total 2012 CERs / Est. total emissions		0.28	0.04

Notes:

1. World Bank 2008 GDP.
2. CIA World Factbook 2009.
3. Energy Information Agency 2006 Estimates

As of 1 October 2009, 1 834 projects have been registered by the CDM Executive Board (EB) at the United Nations Framework Convention on Climate Change (UNFCCC), with expected CERs representing 1 685 million tons of carbon dioxide equivalent (tCO_2e) by the end of 2012. Among the registered projects, China has 626 projects, representing 34.6% while South Africa has 16 projects representing less than 0.9% of the total. Even when normalising the significant size difference between China and South Africa, it is further apparent that South Africa has lagged behind (Table 1). China has significantly higher utilisation of CDM in terms of CER per thousand tons of CO_2 emitted (0.28 to 0.04), CER per thousand dollars of GDP (0.39 to 0.06), and pipeline CER per person (1.26 to 0.36).

This article explores the underlying drivers of the Chinese and South African experiences in order to compare and contrast what has supported or hindered CDM uptake in both countries. The paper discusses how a country's regulatory and policy framework need to be aligned with the emission reduction targets and sustainable development criteria for CDM to ensure that the mechanism enhances the social, economic and environmental demands of the country. It is the authors' intent to analyse the experience gained from market leading China to better understand how to leverage the CDM market and to facilitate further development in South Africa. At the same time, the lessons learnt from the Chinese and South African CDM market can guide other developing countries to develop a healthy and mature path for the implementation of CDM and other market-based mechanisms.

2. Methodology

This paper utilised methodological and investigator triangulation as the main research approaches (Denzin 1970; Jick 1979; Kimchi 1991). This approach used conferences, interviews, reports, archival documents and field observations as the main data collection methods. The use of multiple data sources to examine CDM experiences in South Africa and China enhanced the validation process by ensuring that weaknesses inherent in one approach were counterbalanced via strengths in another (Denzin 1970; Jick 1979).

The majority of statistical data was obtained from the UNFCCC website and the UNEP Risøe CDM project pipeline for 1October 2009 (UNEP 2009) which provides an analysis and database for all CDM projects that have been sent for validation. It also contains information pertaining to the Designated Operating Entities (DOEs), project types, number of CERs and several analyses relevant in investigating and comparing the current state and future trends of CDM in China and South Africa. The analysis from UNEP and UNFCCC website also played a significant role in providing background information in designing interview questions. Review of publicly available background documents was also critical in providing contextual information on CDM in South Africa and China. Key documents reviewed included UNFCCC and national CDM regulation; national renewable energy policies and regulation; EB-approved methodologies and project design documents (PDD); reports and criteria provided by the South African and Chinese Designated National Authority (DNA). An extensive literature review on CDM was also conducted as a means of exploring and understanding the current discussions around CDM, both globally and specifically to South Africa and China (e.g. discussion on 'additionality', efficiency of the EB and regulatory aspects of CDM).

To develop a first-hand understanding of the drivers and constraints to CDM uptake in both China and South Africa, structured interviews and unstructured discussions were conducted with relevant CDM stakeholders. A number of observers and stakeholders in the research process also enhanced the reliability of the data by comparing data from different individuals for consistency. The interviews focused on understanding the main drivers and constraints of CDM in China and South Africa in the context of sustainable development, flow of investments, institutional and capacity issues, efficiency of the EB and other CDM management structures and the regulatory framework of the CDM. The interviews largely used open-ended questions to facilitate open discussions with the stakeholder on a wide range of issues related to the CDM (Bryman 1998; Neuman 2006). To identify key informants, a list of key CDM stakeholders in China and South Africa was compiled from CDM association lists, project documents, CDM analysis reports and conference proceedings. Furthermore, asking each contacted interviewee for additional referrals for information rich key informants proved effective (Mason 1996; Welch et al 2002).

For the China research component, 17 interviews with European companies operating in China were drawn upon. In addition, structured interviews were held with four local project developers, two investors, two researchers and two officials representing the DNA (one from the Ministry of Environmental Protection, one from the CDM Project Management Centre). In South Africa, 53 key informants were identified and contacted for structured interviews. Interviews were conducted with one DNA official, eight project developers, two DOEs, four research consultants and three representatives of a financial services firm. Unstructured discussions held with CDM stakeholders during relevant conferences in China and South Africa were also drawn upon.[1] These interactions were important to gather information on key issues affecting CDM (such as new CDM methodologies, policies, and post-2012). Moreover, most of the respondents are influential in the climate change policy realm, so that their input was important in any policy discussions for the post-2012 CDM outlook.

Lastly, previous research on CDM, as well as direct involvement in carbon finance through the implementation of CDM projects in China and Africa by the paper's authors, provided additional insight into understanding the opportunities and challenges in the CDM process. The researchers have been involved in numerous workshops and field observation on CDM in Africa and Asia. These workshops and field observations are an invaluable source of information for policy because they provide interaction and input from individuals who work on CDM on daily basis. The authors have been actively involved with the implementation of the EU-China Facilitation project and the development of the Africa Carbon Credit Exchange.

3. CDM: Current state, opportunities and challenges

As highlighted by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, anthropogenic greenhouse gas (GHG) emissions are 'very likely' the cause of climate change which poses enormous threats to economic stability, public health, national security, as well as to the environment (IPCC 2007). In order to promote climate justice, the Kyoto Protocol recognises that human activity driving GHG emissions has been concentrated in developed countries over the past 150 years and therefore has adopted the principle of 'common but differentiated responsibilities', placing a greater burden to address climate change on the developed countries (UNFCCC 2007; Comim 2008). As a result, all developed nations, aside from the United States, have ratified the Kyoto Protocol and committed to legally binding measures that set a ceiling or cap on allowable emissions released in the atmosphere over a given timeframe. Conversely, developing countries that have ratified the Kyoto Protocol do not have binding emission reduction targets for the first period from 2008 – 2012 (IETA 2009). As one of the mechanisms defined by the Kyoto Protocol, the CDM allows the Annex I countries (developed countries with emission caps) to implement the GHG emission reduction projects in the non-Annex I countries (developing countries without emission caps), providing a flexible alternative for Annex I countries to meet their binding obligations. This approach, as supported by market theory advocates, is perceived to create a cost for emissions while simultaneously creating a market incentive to emit less, either through efficiencies or offsets (Yeoh 2008: 190).

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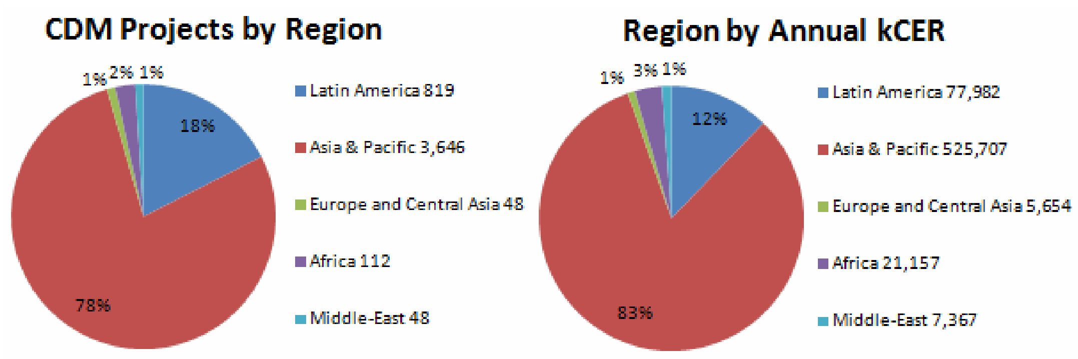
[1] Conferences include UNEP Financial Initiative Conference held October 23-24, 2010 (John Fay, Farai Kapfudzaruwa); The Ecocentric Journey Conference September 15-17 2009 (John Fay, Farai Kapfudzaruwa); The EU China CDM Facilitation Project Final Dissemination Conference held November 19, 2009 (Lin Na); Convention of Parties 15 – attending from Dec 09–17, 2009 (John Fay).

For countries in Africa to fully exploit the economic and environmental benefits of emission trading, CDM also needs to provide an effective medium for transfer technology to these developing countries (Lütken 2009). Other important issues which have been raised include the risks associated with CDM projects hampering development and how these risks can be quantified (Bohringer et al 2007). According to Oleschak and Springer (2007) CDM risks tend to be low for (large) countries with high potentials such as China, India and Brazil. The main reason for countries to be classified as low risks for CDM projects is the fact that the institutions related to the monitoring and implementation of flexible instruments are rated excellent. These countries score high on the following points: DNA in place, participation in capacity-building, memoranda of understanding with potential investors, declaration of policy, and experience with projects (Oleschak & Springer 2007). The regulatory environment which encompasses enforcement of contracts, ease of starting business, and registration of property rights are also an important factor in determining the risks levels of CDM projects (Oleschak & Springer 2007). Youngman et al (2007) complement Oleschak and Springer's findings by critically examining past CDM and JI project portfolios for the extent to which the technology transfer promised to host countries really occurred. Youngman et al (2007) revealed that more than half of 116 CDM and JI projects analysed do indeed involve the transfer of technology hardware from outside the host country, with a total value of €1.3 billion. However, for low- and non-emitting energy technologies (wind, hydro, biomass, energy-efficient devices) the carbon value offered by CDM may not be enough to cover the high upfront investments. Therefore, stimulating specific technologies can be considered an additional policy goal and may require policy instruments in addition to a simple carbon price (Youngman et al 2007). The authors also suggest that options such as programmatic CDM projects need to be supported within the policy realm. These research findings present some important questions that will inform policy decisions, which will be probed in this paper. The comparison of CDM experiences in China and South Africa will provide an opportunity to understand whether additional policies are needed to 'accelerate technology diffusion for long-term climate targets' if technology transfer occurs, but not systematically enough to diffuse new technologies (Bohringer et al 2007).

Despite the dual goals of emission reductions and achieving sustainable development, the emerging CDM project portfolio is shaped almost exclusively by financial incentives for the emission reduction component of projects (apart from the small share of investors that wish to pay a premium for particularly Sustainable development friendly CDM projects) (Ellis et al 2007). As a result many of the current CDM projects represent relatively low-cost emission mitigation opportunities that do not result in investment in new infrastructure. Therefore, the future climate change regime should redesign the CDM to ensure that it exploits the link between sustainable development benefits and mitigation which could be a key to motivating developing countries to take on future mitigation commitments (Ellis et al, 2007). This implies lasting changes in energy infrastructure and demand.

The operation of CDM requires significant institutional arrangement at different levels. At the international level, the EB oversees the CDM activities and policy making, under the authority and guidance of the Conference of the Parties (COP). At the domestic level, the DNA reviews submitted CDM projects and approves or rejects them based on specific international and domestic procedures and regulations. The institutional capacity is important as research has shown host country CDM procedures, specifically evaluation criteria and approvals, are a determinant to CDM investment (Nham, 2007: 553). Since its inception in 2005, the CDM has grown rapidly, with 4 673 projects in the CDM pipeline, which will amount to over 7 416 430 kCERs by 2020 (UNEP 2009). Even though the Asia and Pacific region currently accounts for approximately 80% of the CDM project pipeline and the volume of CERs (Figure 1), countries from Latin America and sub-Saharan Africa have slowly increased their uptake of CDM projects. Within Africa the uptake has remained small, but a group of CDM leaders have emerged, mostly within the wealthiest economies including South Africa, Egypt and Morocco. Each of these



three countries has a handful of large scale CDM projects in the pipeline (UNEP 2009).

Figure 1: CDM Projects and KCERs by region
Source: UNEP (2009)

As a mechanism that gives monetary value to emission reductions, the market searches for the highest volumes at the lowest cost. As such, the CDM has been more effective in achieving one of its main goals of reducing mitigation costs while being less effective in contributing to sustainable development (Figueres & Streck, 2009; Holm Olsen 2007; McGown 2008; Sutter & Parreno 2007; Fenhaan 2008). CDM has been effective in quickly eliminating substantial portions of HFC-23 and N2O industrial gases which experienced early uptake in the market although they contribute little to sustainable development. The exclusion of deforestation leaves the largest emission source of many tropical countries untapped by CDM and misses an opportunity to enhance sustainable land use practices (Figueres & Streck 2009). Since the developing countries are highly vulnerable to the effects of climate change, it is worrying that the CDM has not moved developing countries towards low carbon development paths based on more sustainable energy production and consumption patterns and sustainable forest management (Figueres & Streck 2009; Figueres et al 2005; Wara 2007; Wara & Victor 2008). The complex relationship between social and economic development and climate change, particularly in developing countries, may require CDM to be restructured into a genuinely integrated mechanism which reduces emissions at low costs while improving the livelihoods of vulnerable communities. However, the two objectives imply tradeoffs, since setting a high development objective for CDM projects can slow investment transfers and hamper the flexibility of the mechanism to lower implementation costs (Figueres & Streck 2009). However, increased levels of entrepreneurship combined with innovative financing that leverages CDM can help to simultaneously promote sustainable development through reduced emissions (Gantsho & Karani 2007).

There are certain aspects of the CDM related to its efficiency, sustainability, institutions and structure which need to be restructured to strengthen the effectiveness and transparency of the mechanism (Capoor & Ambrosi 2009). As the EB has worked to maintain CDM credibility through a strict verification process, delays have been problematic and contribute to a recent upsurge of project rejections. Also, the EB's efforts do not sufficiently address the issues 'of re-casting the additionality debate, which is core to the *raison d'être* of the CDM and also the main reason why projects get reviewed for registration' (Capoor & Ambrosi 2009). There has also been mounting criticism about the lack of transparency in the EB's decision-making and lack of predictability (IETA, 2005). Addressing additionality concerns will not only reduce the short-term delays, but also help preserve and expand the credibility of the CDM, so that streamlining the process of registration and issuance is an important immediate objective of CDM reform (Capoor & Ambrosi, 2009). The governance structure of the CDM would have to be reviewed taking into account the need to supervise a rapidly growing market and to include private sector participants that are not represented in the COP ensuring the conditions for fair and predictable decisions (Figueres & Streck, 2009).

4. CDM in China

4.1 Overview

Since commencement in 2006, the number of CDM projects in the global carbon market has experienced tremendous growth. The significant growth of the CDM market in China has made it the largest CDM host country and, consequently, the biggest CER supplier in the international carbon market. As at 1 October 2009, 1 975 Chinese projects have been developed or are currently in the CDM development pipeline, including 626 projects registered at the EB. The expected average annual CERs from the Chinese CDM projects is over 190 million tCO_2e, representing nearly 57% of the worldwide total annual expected CERs (UNEP 2009). China continues to develop CDM projects at a rapid rate; by 10 November 2009 the number of DNA-approved CDM projects jumped to 2 232 (NDRC 2009), with nearly 250 new projects approved in less than six weeks. To put this rapid growth into perspective, at the end of 2006 there were only 138 CDM projects in the pipeline (Eua 2009).

Project scope

As illustrated in Figure 2, current CDM projects in China cover a wide range of industrial type. Renewable energy projects, including small hydro power, wind power and biomass, represent a dominant share of existing CDM projects, in terms of both project number and the quantity of expected annual CERs. Energy efficiency is the second largest area for CDM project development, coming from various industrial sectors including steel, iron and power industries. Furthermore, a majority of the developed and registered energy efficiency CDM projects are for their own power generation, using waste heat recovery or waste gas recovery for power generation. Several new project types have emerged recently, including the solar energy utilisation, perfluorocarbons, SF_6 and transport, which are a result of new methodology development.

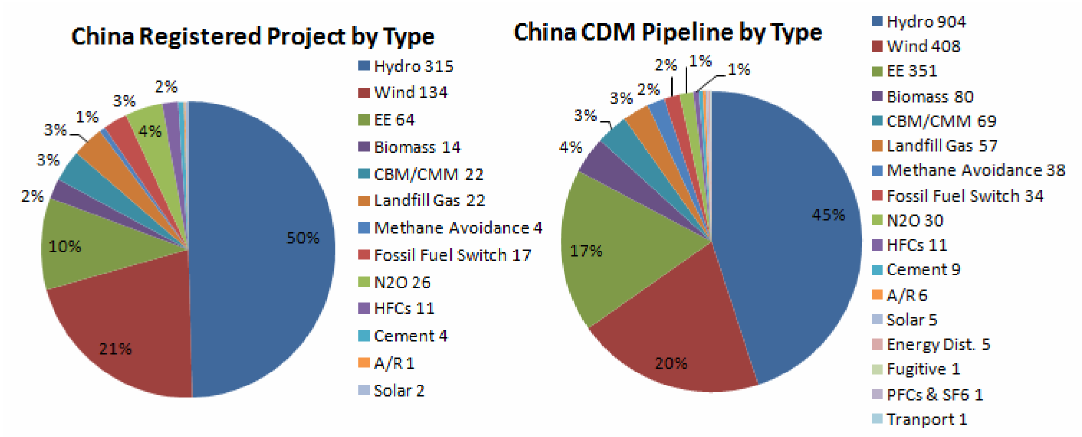


Figure 2: Registered and pipeline projects
Source: UNEP Risø Centre 01-10-09

Early on in the Chinese CDM experience, hydrofluorocarbon (HFC) and N2O projects were considered as 'low-hanging fruits', due to the large amount of CERs from a single project and the relatively low per unit investment. However, from the beginning of 2009, there are no new HFC projects being developed, with the last HFC project registered in April 2009. This is partly because the HFC destruction potential in the Chinese market has largely been exhausted and through an exorbitant 65% taxation charge for HFC projects under the income-sharing CDM management policy (EUb 2009). The growth of N2O projects is also slow, with only two new projects developed in the pipeline in the first nine months of 2009.

CDM management in China

Currently, there are a large number of Chinese governmental authorities directly involved in the management of CDM projects including the National Leading Group on Climate Change (NLGCC), the National CDM Board (NCB), National Development and Reform Commission (NDRC) and the CDM Project Management Centre (CDM-PMC), among which NDRC serves as the DNA for CDM implementation in China (CDM-PMC, 2009). The institutional structure for CDM management is a vertical management system. The NLGCC, consisting of 20 ministries, oversees the national CDM policies, regulation, standards and supervises the National CDM Board. The NCB is responsible for reviewing CDM projects, reporting to the NLGCC on the overall progress of CDM project activities, and making recommendations on amendments to the CDM operation regulations and procedures based on emerging issues (CDM-PMC 2009). China's DNA is part of the NDRC, which is under the supervision of the NCB and responsible for receiving CDM project application documents, implementing the CDM administrative procedure and issuing the Letter of Approval (LoA) for the qualified CDM projects, and implementing specific CDM activities.

In addition, the recently established CDM Fund Management Centre (CDMFMC) is a key institution within the Chinese CDM management structure. It is sponsored by the Ministry of Finance and manages the funds collected from the CER revenue fees charged by the government which will be used as grants to support climate change activities and provided as a seed fund for clean technology investment.

CDM regulation in China

The regulatory framework for CDM implementation is outlined in the Chinese government's *Measures for the Operation and Management of Clean Development Mechanism Projects* (CDM-PMC 2009). This serves as the main legal basis for the CDM implementation in China, including guidance on the eligibility of the projects, the application guidelines, the approval procedure of the DNA, the priority areas of sustainable development, and the CER revenue-sharing policies.

Only Chinese enterprises are eligible to apply for CDM projects because only locally owned (at least 51% ownership) companies are allowed to own CDM projects in China. The Chinese government included this regulation to protect local enterprises' ability to participate in the CDM activities. However, according to a recent survey of European enterprises operating in China's CDM market (CDM-PMC 2009), this eligibility requirement is considered as a major barrier for foreign investment and technology innovation in China.

The CDM project owner is required to submit to the DNA the following documents: the PDD, certification of enterprise status (enterprises licence), general description of projects, the Engineering Feasibility Approval from NDRC, and the Environmental Impact Assessment (EIA) approval from the Environmental Protection Administration (CDM-PMC 2009). The project owner is also required to present the Emissions Reduction Purchase Agreement (ERPA) or purchase intent, and the consultant service contract for review. The CER price agreed to in the ERPA is one of the elements to be reviewed and a minimum price, or pricing floor, is given as a 'guideline'. One argument for the price floor is that the GHG emission reduction resources are considered state-owned in China and in the early stages of CDM the local project owners may not have the capacity to negotiate the appropriate purchase price. Also, it is also argued that clear guidance on CDM pricing in China can have a positive impact stabilising the international carbon market and give project owners clarity on potential CDM revenue streams (personal communications 2009).

Although there is no clear framework to define which type of project will contribute the most to sustainable development in China, priority areas for CDM development include energy efficiency, renewable energy and methane recovery and utilisation, which is consistent with the country's overall climate change and energy policies[2].

Prioritisation of the CDM development is implemented and enforced through the CER revenue-sharing policy. According to the Chinese government, GHG emission reduction resources are owned by the Chinese government and the CER revenues generated from the specific CDM projects shall be jointly owned by the project owner and it (NDRC 2005). This statement allows the government to charge certain percentages of the CER revenue from the different types of CDM projects. According to the different priorities, the government therefore collects fees at different levels from the CER revenues, based on the principles below:

- 65% for projects involving HFC and PFC emission reductions;
- 30% for projects involving N_2O emission reductionl

[2] One of the current research projects under the EU-China CDM Facilitation Project, *The Impact Assessment of CDM Projects in China on Sustainable Development* (August 2009), is trying to develop a suitable methodology to evaluate the contribution to sustainable development from different type of CDM projects.

- 2% for projects in priority areas and forestation projects.

Chinese sustainable development priorities and the CER revenue-sharing scheme appear to have an influence on the current CDM project development trend, in which both the number and the expected annual CERs of renewable energy projects and energy efficiency projects take the biggest share of the pipeline.

4.2 CDM experience in China: Key drivers and obstacles[3]

4.2.1.1 Key drivers

The worldwide CDM pipeline shows China has been a successful player in the CDM market. While there are many factors which have affected CDM development in China, we have found the following points to be particularly salient drivers of CDM development in China:

Firstly, the relatively well-established regulatory framework and procedure from the DNA has facilitated the CDM development. The efficiency of the Chinese DNA has also been improved in recent years, which allows for fast development of a large number of CDM projects.

Secondly, capacity building at the early stage for different stakeholders is commonly viewed as a key driver that has enhanced the local project participants' knowledge and skills, which has significantly facilitated development of the CDM. The engagement and development of local CDM project developers and consultants is also a positive result of different capacity building programmes. There has been numerous capacity building projects and schemes in China targeting the DNA and the local authorities.. The EU-China CDM Facilitation Project, for example, is a large capacity building project funded by the European Commission and jointly implemented by Chinese and European partners. Other European member states have also funded similar projects, such as government of Denmark, the UK government, and the Italian government. The regional CDM centers have actively been involved with capacity building projects and the Chinese government has attached great emphasis to CDM awareness raising and knowledge dissemination. Frequent CDM events organised by the Chinese government and other agencies in China have proven to be an effective platform for information exchange and knowledge sharing for the local CDM stakeholders.

Based on the successful capacity building programmes, local expertise and human capacity have been tapped into and mobilised. There is sufficient human capacity and knowledge base in China to implement CDM projects. The opportunity of a growing market has continuously attracted high quality expertise to the field, creating a virtuous cycle that has propelled forward the CDM market.

Thirdly, the overall socio-economic and policy context in China provides an excellent environment for CDM development. In the socio-economic aspects, China has experienced on average over 10% growth from 2005 to 2008; even with the global economic downturn starting from late 2008, GDP growth in 2009 in China is still expected to exceed 8% (Whelan 2009). The robust economic development in recent years has created huge potential for GHG emission reductions and therefore for CDM projects. The rapidly increasing power generation capacity and the large-scale

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3 The analysis in this section draws significantly draws upon the experience of authors Lin Na and John Fay in implementing the EU-China CDM Facilitation project.

production of cement, steel and iron have provided opportunities for renewable energy and energy-efficiency CDM projects from the power sector and the energy-intensive industries.

Lastly, and possibly most salient, the perspective of overall Chinese governmental policy has been instrumental in enabling CDM. The development of renewable energy and energy conservation is a top priority in China's overall national planning and strategies. In 2006, the Renewable Energy Law was formulated to promote the development of renewable energy. Further, 2007's Medium- and Long-term Development Plan for Renewable Energy has set up specific renewable targets by 2020. Besides the renewable energy policies, the domestic energy conservation and emission reduction programme has intensified, with various energy efficiency projects being launched. As a result, the domestic policy trends have been perfectly matched with a more mature status of CDM to create a booming market and project pipeline in China. This has resulted in significant uptake of CDM by large-scale state-owned enterprises (SOEs) and investment groups which are actively involved in project development, and has profound implications for the enhancement of the CDM (EU 2009a). SOEs are involved in sectors such as power generation, energy-intensive manufacturing industries including cement, steel and iron. In the power generation sector, the big SOEs are highly involved in the development of CDM projects. The five largest power-generating SOEs, China Datang Corporation, China Huaneng Corporation, China Huadian Corporation, China Power Investment Corporation, and China Guodian Corporation, have developed a large number of CDM projects in the pipeline, taking a significant share of the wind and hydro CDM projects (UNEP 2009).

Key obstacles

Although CDM development in China is generally viewed as a success, there are various issues which could be improved upon there and in other developing countries. Firstly, an appropriate guideline to direct CDM towards sustainable development is currently missing in China. As a market-based mechanism, CDM orientation can be focused on the market players' interests to the detriment of sustainable development. The DNA has the responsibility to guide the CDM towards sustainable development of the host countries and should develop comprehensive criteria for sustainable development at the early stage of CDM development. Since the CDM is continuously evolving and is a learn-by-doing process, the CDM guidance should remain flexible in order to address the emerging issues. The Chinese CDM measures which serve as the legal basis for CDM implementation were officially formulated in 2005 and now may require modifications to further enhance the sustainability criteria of CDM in China.

Secondly, due to fast-growing CDM projects in China, the demand for DOE[4] services is increasing but capacity is limited, creating a significant bottleneck in the CDM process. The validation and registration of an individual project is taking longer than in previously years, increasing risks and costs for all other project stakeholders. Capacity building for domestic DOEs in China started much later than for the DNA and project developers, resulting in validating and verification bottlenecks in the CDM

[4] A DOE is a domestic or international legal entity accredited and designated by the EB, which validates the proposed CDM projects and subsequently requests the registration of the project at the EB, and verifies the emission reductions, certifies the CERs and requests the EB to issue the CERs.

process. Until March 2009, the DOEs were only international organisations with no domestic firm accredited by the EB. However, on 25 March 2009 at the EB 46 meeting, two Chinese Applicant Entities (AEs), the China Environmental United Certification Center and China Quality Certification Centre were accredited as DOEs for both verification and verification/certification functions (UNFCCC 2007). Since the domestic DOEs are now accredited, project developers have begun using their services; this has been considered by some to be a faster option due to fewer projects in their working schedule and easier follow-up communication (interview with K Lieberg, 6 November 2009).

Thirdly, apart from the domestic barriers, uncertainty raised from the international climate change negotiations has challenged the healthy operation of the market and is viewed as a significant obstacle to further CDM development in China. Any market-based mechanism like CDM resulting from the policies and politics is generally viewed as highly risky for the market, and lack of clarity in the market serves to exacerbate the risks (interview with S Kwan, 6 November 2009). There needs to be greater certainty in the markets from a regulatory perspective in order to facilitate a healthy and stable market. This is seen as a general limitation of the CDM, applying to all the host countries and CDM stakeholders.

4.3 CDM in South Africa

4.3.1 Overview

Project scope

South Africa affirmed accession to the Kyoto Protocol on July 31 2002, entering the Protocol into force on 16 February 2005 (REEEP 2009). While other emergent economies have successfully harnessed the potential of CDM to varying extends, South Africa has consistently been a laggard since CDM inception. As at October 21, 2009, only 131 CDM projects have been submitted to the South African DNA, consisting of 102 Project Idea Notes (PINs) and 29 PDDs. Of the projects submitted to the DNA, only 33 projects have advanced to validation, representing 17 registered, four issuing CERs and another 12 at various stages in the CDM EB pipeline (DNA 2009). In addition, the trend of project submission to the DNA has not seen a noticeable increase in 2009, considering only 35 projects have been submitted to the DNA as at October 2009, compared to 41 in the whole of 2008.

The project types of all CDM projects submitted to the DNA are illustrated in Figure 3, indicating a high percentage of cogeneration, renewable energy, fuel switch, energy efficiency, waste management and methane recovery and flaring. However, when comparing that to the number of projects that have been moved through the process and corresponding CER potential, the nitrous oxide projects account for a majority of credits, while renewable energy, energy efficiency and waste management have had little success in generating CERs; representing a significantly smaller percentage of total CERs than their percentage of total projects in DNA pipeline.

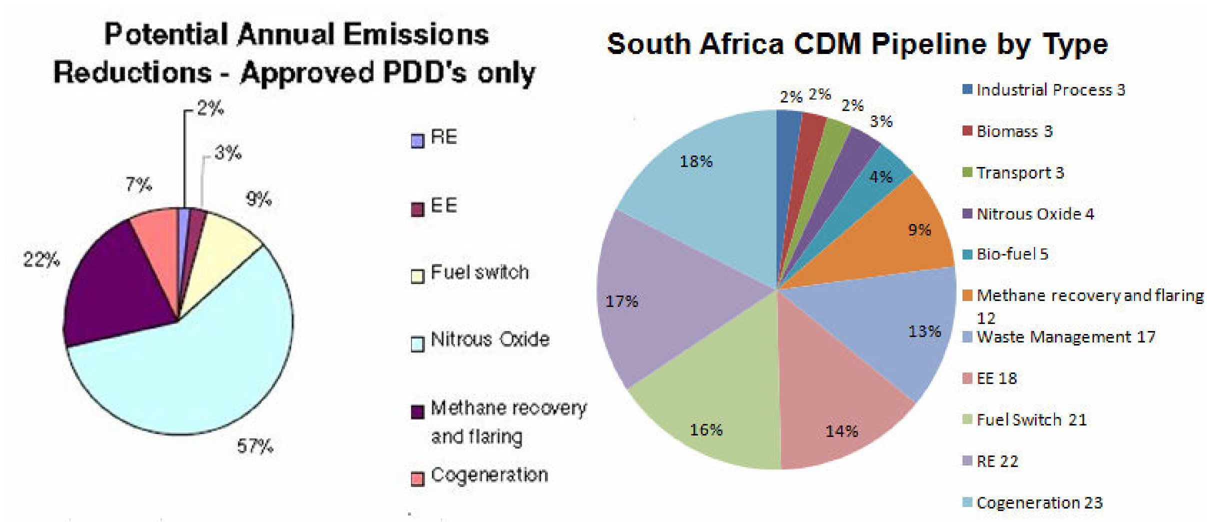

Figure 5: South African annual CERs by approved PDD and CDM pipeline by project type

Source: DNA (2009)

CDM management in South Africa

The DNA, within the Department of Energy, has the legal mandate to oversee the CDM in South Africa under Section 25 of the National Environmental Management Act. Since its inception in 2004, the main task of the DNA has been to assess potential CDM projects, to determine whether they 'assist South Africa in achieving its sustainable development goals and to issue formal host country approval where this is the case' (DNA 2009). However, as a result of the weak institutional and policy framework and lack of capacity the DNA has been playing an important role in providing support to project developers and promoting CDM in South Africa to potential investors. Unfortunately, the private sector and investors in South Africa have been too conservative and not forthcoming to promote CDM (interview with L Chauke, 28 October 2009). To overcome these challenges the South Africa Clean Development Mechanism Industry Association (SACDMIA) was launched in 2007. to provide a platform for CDM industry stakeholders to promote their common interests, that is, 'CDM investment promotion, capacity building, and research or facilitation dialogue with the relevant institutions, civil society and government'; it strives to formulate a common perspective on how to stimulate growth within the energy sector, and streamlining the existing operational environment so that the CDM can act as a vehicle for reducing GHG emissions and driving foreign direct investment (van den Berg 2007). As the lead contributor in the African CDM project pipeline and among the few well-functioning DNAs in Africa, the South African DNA also participates in the DNA Africa Forum to discuss challenges within the CDM process with stakeholders such as DOEs.

The DNA is also mandated to promote the establishment of CDM projects in South Africa 'in cooperation with other government agencies with the same or similar responsibilities' such as the Department of Environment (NEMA section 25 (3)(1)(e)). However, other relevant government agencies have not been active in promoting CDM in South Africa (e.g. the Department of Trade and Industry and the National Treasury which are part of the DNA steering committee), a scenario which has slowed the uptake of CDM projects in the country. A senior Department of Energy official involved with the DNA noted that other government agencies needed to be more proactive in participation of CDM workshops and promoting CDM in the country (interview with L Chauke, 28 October 2009). This is seriously undermining South Africa's performance in the CDM market as there is no coherent structure within government departments to attract investment and manage CDM in South Africa. The DNA requires support from other departments which can leverage investment for CDM more effectively than the Department of Energy.

CDM regulation in South Africa

The regulatory framework for CDM implementation is outlined in a government gazette (section 25(7-8) of the National Environmental Management Act (NEMA). This serves as the main legal basis for the CDM implementation in South Africa, including guidance on the eligibility of the projects, the application guideline, the approval procedure of the DNA and the sustainable development criterion.

Project developers or owners enter the CDM project approval process through voluntary screening or mandatory submissions. The voluntary screening provides the DNA with an opportunity to carry out an initial screening of the project and provide feedback to the developer on the likely performance of the project against approval criteria. This is done via submission of a brief PIN and an application form to the DNA. The mandatory submissions require all projects to submit a detailed description of the project via a PDD and an application form to receive a letter of approval from the DNA. The PDD should already have been validated by the DOE at this stage. The PDD is posted on the DNA website for public consultation for a period of 30 days. The DNA will then provide a recommendation based on the consultation and its evaluation process and then sends them to the DNA steering committee for consideration. Based on the comments from the committee, the DNA makes its final decision on the approval of the project.

Unlike in China, the South African DNA has a set of defined sustainable development criteria which guides the evaluation of the projects. These criteria are guided by the definition of sustainable development in NEMA Section 1 (xxix): 'the integration of social, economic and environmental factors into planning, implementation and decision making so as to ensure that development serves present and future generations'.[5] Despite having this definition and guidelines, a DNA senior official noted that it is difficult to 'measure the social development impact within CDM' (interview with L Chauke, 28 October 2009). Therefore, the DNA encourages the N2O projects in South Africa which have minimal positive impact to social and economic development to invest in other social community projects (ibid). However, the DNA official explained that if the number of N2O projects increases, the DNA will consider imposing a tax on these CDM projects as is the case in China.

4.4 CDM experience in South Africa: Key drivers and obstacles

Key drivers

While CDM in South Africa has not generated a large number of projects to date, there are positive aspects within the structure which could serve as the foundation to

[5] Further information regarding the NEMA sustainable development definition can be found at www.dme.gov.za/dna/dna_susdev.stm.

increase South African CDM uptake. The following points are encouraging elements the research has identified within the South African CDM experience.

Firstly, while the absence of an efficient DNA is often regarded as a hindrance to increasing CDM in Africa, this does not seem to be the case in South Africa (NEPAD, 2009). The South African DNA is well organised and highly regarded both domestically and internationally. Our research has indicated the South African DNA is doing an effective job administering the CDM limited pipeline to date. Stakeholders interviewed consistently regarded the DNA highly, comments including: 'responsive and helpful with a transparent and clear process' (A van Roffet, interviewed 28 October 2009); 'really tried to push CDM and has done a fairly good job' (M Parramon, interviewed 30 October 2009); and 'one of the best functioning DNAs in the world – clear process and committed to timelines … will engage for a solution to work for all on any problems' (H Sa, interviewed, 28 October 2009).

Secondly, the South African economy is based on a high emission structure, providing ample possibilities for CDM projects. The high dependency on coal-based power, and a growing demand for electricity provides an ideal baseline scenario for energy efficiency and renewable energy projects, creating significant potential for CDM projects (du Toit, 2009: 49). While there has been slow uptake to date in these sectors, increasing electricity tariffs and improved technologies are increasingly making renewable energy projects more cost-competitive, thus increasing the likelihood of implementation. In addition, there is great potential for the CDM to support important sustainable development priorities of the South African government, e.g. the Integrated National Electrification Programme, and the White Paper for Renewable Energy target of 10 000 GWh by 2013 (REEEP 2009).

Thirdly, there is a strong base of local project developers with the technical expertise to develop projects in South Africa. While most other countries in the Southern Africa region have few if any local groups with the expertise to successfully develop a CDM project, South Africa has many capable CDM stakeholders and a CDM industry association.

Key obstacles

There is a great deal of hesitancy and uncertainty regarding the perceived risks of CDM in South Africa. Throughout the research, the following issues emerged as recurrent obstacles to greater CDM uptake in South Africa.

First, potential South African projects owners in the public and private sector have a perceived lacked of the vision required to fully harness CDM opportunities. This is compounded by a lack of governmental capacity, public awareness and overall education regarding climate change and CDM (du Toit, 2009:54). The public sector has been hesitant to take on additional responsibilities of developing CDM and the private sector is unwilling to take on the risks associated with investing in CDM (personal communication 2009). The conservative nature of South African business combined with limited regulatory pressure to reduce emissions has resulted in an unwillingness to make sustentative investment into CDM (NEPAD 2009). While local expertise is available in South Africa to navigate the intricacies of the CDM process, organisations that would own the CERs have not possessed the ability to identify quality opportunities and corresponding benefits, resulting in little uptake of potential CDM projects. In addition, the carbon markets are complicated and continually evolving, thus requiring a champion at each stage of the project development cycle in order to implement. Due to the conservative business environment in South Africa, few project champions have emerged to date. As a result, the critical mass required to propel the CDM market forward has not been generated.

Second, the overall complexities of the CDM market have been a disincentive to both public and private entities in South Africa. The uncertainty surrounding the CDM market, including fluctuating market prices and little post-2012 clarity, has created a situation whereby the upfront investment to access the CDM is a major deterrent to moving projects forward. The long approval process and concerns regarding if a project will be registered also contributes to hesitancy of potential project owners to engage in the process. There is also a need for increased flexibility of existing approved methodologies from the EB. If an existing methodology cannot be leveraged, the cost of developing a new methodology was cited during our stakeholder interviews as a prohibitive factor to CDM, and while 'BRIC countries have developed numerous CDM projects, this does not mean that the opportunity automatically extends to South Africa' (DME 2009: 13).

In addition, the high cost of validation and lack of South African DOEs is a major bottleneck to CDM projects. All project developers contacted during our research indicated issues with DOEs as a major problem in South Africa due to cost and availability. Validation costs, varying by project type from an estimated €10 000 to as high as €58 000 for a programmatic CDM validation, represent a significant investment by project developers or owners (interviews, 2009). Additionally, as many DOEs are European organisations, costs are often denominated in euros, adding further uncertainty due to exchange rate risks. The timelines and subsequent overall expense of validation has increased in the past two years, in one project developer's experience from approximately 3-6 months to 8-12, resulting in further expenses for the CDM projects (interveiw with R Spalding, 30 October 2009). This problem was further exacerbated in September, 2009 when DOE SGS United Kingdom Ltd, which has been active in South Africa, was suspended by the EB.[6]

The third main obstacle identified is the underlying financing of CDM projects. Even though an implicit intent of the Kyoto Protocol is to increase FDI for emission reduction projects, CDM experience has shown that the onus 'rests almost entirely on investors in developing countries being willing to put up the financing for the projects, that through the generation of CERs help developed country emitters avoid having to make such investments' (Lütken 2009). Depending on project type, the income from the CERs is usually not sufficient to cover the overall project costs. As a result, there is a need to find debt or equity financing which can be difficult to secure in a reasonable timeframe. This can be extremely difficult as financial return is not guaranteed until the CERs are delivered unless sold ex-ante, often at a significant discount. As a result, CDM financing can easily become an afterthought which can only be leveraged after underlying project finance is organised, which is then further complicated as this can bring into question financial 'additionallity' of the CDM project. Compounding this problem has been the financial crisis; the perceived higher risk of African-based project finance has made funding even more scarce due to the current risk adverse investment climate (Interview with K Reuss, 30 October 2009).

The fourth major obstacle our research has identified is the lack of meaningful governmental or regulatory support for renewable energy and a dependence on high-

6 The UNFCCC list of DOEs indicates SGS as suspended: http://cdm.unfccc.int/DOE/list/index.html, viewed 10 November 2009.

emission coal based power. The South African *White Paper on Renewable Energy* (2003), has set a target to produce 10 000GWh from renewable energy sources (mainly from biomass, wind, solar and small-scale hydro) by 2013; the report also deemed this target to be economically viable through subsidies and carbon financing. To date, only two renewable energy CDM projects have been registered and no subsidies on the scale required to meet the target have been disbursed, leaving South Africa's modest renewable energy target significantly off-track to meet its 2013 goal. This is a significant point of departure for South Africa in comparison to the global CDM experience, where renewable energy projects represent 59% of the overall CDM pipeline (UNEP 2009).

However, in order to reverse this dearth of renewable energy project and support the 2013 renewable energy target, the National Energy Regulator of South Africa (NERSA) released in March 2009 the Renewable Energy Feed-In Tariff (REFIT) regulatory guide (NERSA, 2009). The REFIT guidance document appointed Eskom, the centralised, single energy buyer in South Africa, as the Renewable Energy Purchasing Agency (REPA) and set 2009 tariffs by renewable energy technology (see Table 3).

Table 3: REFIT 2009

Source: Renewable Energy Feed-In Tariff (REFIT)(2009)

Technology	*REFIT (R/kWh)*
Wind	1.25
Small hydro	0.94
Landfill gas	0.90
Concentrated solar	2.10

While the REFIT has the potential to help incentivise CDM development, no power purchase agreements have been signed as of the end of October 2009 because Eskom does not have funds to pay the REFIT, as stated by Eskom's Director of Sustainability (UNEP FI Roundtable, 23 October 2009). Funding for REFIT is to be requested through the 2010 tariff request.

As South Africa's primary energy producer and buyer, Eskom is the key player to lead both renewable energy and energy efficiency projects but has done little to galvanise the renewable or CDM industries. Eskom's Director of Sustainability indicated that initially there was great excitement in 2004 when CDM became available; however, reality around downstream funding and the difficult registration process tempered enthusiasm for CDM. This is confirmed by looking at Eskom's direct CDM experience: the parastatal submitted three PINs to the South African DNA in 2006 and one in 2007, comprising two renewable energy and two energy efficiency projects, of which none have submitted PDDs to the DNA due to lack of underlying funding for the projects (Interview with M Rambakos, interview, 28 October 2009).

With low electricity prices from coal-based generation in South Africa, independent power producers (IPPs) need a stable planning horizon, strong off-taker agreements and a tariff and regulatory framework in place that provides an adequate return to make renewable projects feasible. Without these assurances on the project's financial metrics, renewable energy projects cannot get off the ground, resulting in a missed opportunity for a robust renewable energy CDM pipeline in South Africa. To date, Eskom has not provided off-taker agreements that make projects feasible, slowing the renewable and subsequently the CDM markets. Eskom's lack of willingness to engage directly with CDM or provide a conducive environment for IPPs demonstrates a need for greater coordination between the policy and development framework and key entities such as Eskom

5. Analysis and conclusions

While the uncertainty surrounding the post-2012 climate change regime has adverse implications for all countries developing CDM projects, it also provides an opportunity to address the obstacles to CDM worldwide and within CDM host countries. Ideally the international negotiations will streamline the cumbersome CDM process and deal with difficulties regarding DOEs, permissibility and establishment of applicable methodologies and underlying financing. This is also an ideal time for South Africa to reflect on its overall CDM experience in order to better promote emission reductions and sustainable development. By 'looking East' to understand the drivers of China's effective implementation of CDM, South Africa can explore its own CDM experience to better understand why it has not been fully leveraged.

By comparing the CDM experience of China to South Africa's, it becomes evident that, while there are many influencing factors, the main CDM element which has allowed China to thrive and South Africa to lag behind is the implementation of a robust policy framework and engagement by key governmental and private sector stakeholders. Such a robust policy framework will engage key government, private and public sector stakeholders and provide the underlying incentives required to unlock the potential of CDM. Collaboration and engagement among different stakeholders also paves the way for robust leadership within government and the private sector with a clear understanding of the CDM potential.

The Chinese government and industry decision-makers quickly recognised the opportunity of CDM and developed a policy structure to nurture the nascent industry. Similar to South Africa, China has an increasing demand for power and has prioritised the development of renewable energy and energy efficiency, creating incentives that have enabled these project types to move forward. As a result, renewable energy and energy efficiency projects represent nearly three quarters of the CDM project pipeline in China. In contrast, South Africa has suffered from a lack of leadership around the implementation of emission reductions an integrated part of development strategy. Policy to enable renewable energy in South Africa has been wholly ineffective and stifled by Eskom's unwillingness to leverage CDM as a financial incentive. To better leverage CDM, policy and its implementation needs to prioritise low carbon development approaches and integrate it throughout all development initiatives. Finally, while it is unlikely South Africa will agree to stringent emission caps at international climate change negotiations, considering policies similar to China's efforts to reduce emission intensities has the potential to promote CDM participation.

The South African government also needs to ensure that policies can be realistically implemented in order to avoid cases whereby Eskom is unwilling to sign power purchase agreements for renewable energy due to a lack of funding for the incremental expense mandated in the REFIT. This will only be possible through better communication and collaboration across all relevant governmental departments. Policy-makers need to be continually engaged to be made aware of the evolving CDM opportunities in order to continually align regulation to fully exploit the potential incentives of CDM.

Further, while alignment of overarching polices is important to drive CDM, a greater awareness and understanding of opportunities and benefits of CDM by key public and private sector decision makers at the 'Board' level is needed to better exploit opportunities that have so far been left unharnessed. As exemplified by the Chinese management structure of CDM, significant involvement by many decision-making entities in government and business is required. This is a relevant lesson for South Africa as increased awareness by decision-makers is important to maximise CDM utilisation. While the South African DNA has been running CDM promotion workshops since 2006, the DNA acknowledges low participation from the key decision-makers that own the assets eligible for CDM projects, resulting in a communication gap that can only be bridged through combined efforts with 'other government ministries, trade groups and industry associations' (Interview with L Chauke, 28 October 2009). Through creating greater awareness of the CDM process and aligning with governmental development priorities, potential project owners will have the incentive to move CDM projects forward, and be better informed about the market based incentives available to generate emission reductions by following sound advice, adhering to CDM rules and planning for extended timelines.

To conclude, the Chinese and South African CDM experiences highlight the need for a systematic approach to create a vibrant environment for CDM to thrive in host countries. CDM project potential and technical capacity to work through the intricacies of CDM is not sufficient to harness its full potential. The alignment and implementation of governmental development policy with emission reductions and sustainable development, as defined by each country, is also required to make possible CDM participation and provide the underlying incentive for governmental and private sector asset owners required to unlock the potential of CDM.

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THEME 4: CARBON TAXES AND EMISSIONS TRADING SCHEMES

Structuring approaches to pricing carbon in energy- and trade-intensive sectors: options for South Africa

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and Andrew Marquard

Abstract
This paper explores how energy-intensive (EI) sectors and those that are also trade-intensive (EITI) could be included in the use of economic instruments for mitigation in South Africa. Carbon tax or emissions trading are being considered as part of emerging climate policy. Economic instruments can make a major contribution towards South Africa's goal of a deviation below business-as-usual of 34% by 2020. The paper identifies energy-intensive sectors, trade-intensive ones and compares the two. Reviewing international experience, it explores policy options for application in the SA context.

The rate of a carbon tax could be linked to energy or carbon content, with lower rates subject to an agreement with government on mitigation. If emissions trading were chosen, initial allowances should be auctioned. If permits were allocated administratively to EI or EITI sectors, this should be transitional and allow for an appeals procedure. Recycling of revenue would be desirable under either a tax or auctioning scheme, promoting efficiency, further mitigation and diversification in EITI sectors. Policy favouring EI industry might need to be revised in favour of incentives for climate-friendly programmes. Access to a sectoral crediting mechanism on a no-lose basis deserves re-consideration. Targets for energy- or emissions-intensity could be set for EI and EITI sectors.

Keywords: energy-intensive, trade-intensive, carbon price, emissions trading scheme, carbon tax, South Africa

1. Introduction

In January 2010, the South African government notified the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) that it 'will take nationally appropriate mitigation action to enable a 34% deviation below the 'Business as usual' emissions growth trajectory by 2020 and a 42% deviation below the 'Business as usual' emissions growth trajectory by 2025' (RSA 2010). In pledging this nationally appropriate mitigation action (NAMA), South Africa made clear that the offer was conditional on support for the NAMA in the form of finance, technology and capacity-building and on an ambitious, fair, effective and binding multi-lateral agreement – which is needed to deliver the support. It recalled the commitment made by President Zuma on the 6^{th} of December 2009 (Presidency 2009), and effectively associated itself with the Copenhagen Accord (Leaders of 29 countries 2009). In making this pledge, the letter recalled the study of mitigation potential under the Long-Term Mitigation Scenarios (LTMS) (SBT 2007). The notification concluded that with 'financial, technology and capacity building support from the international community, this level of effort will enable South Africa's green house gas emissions to peak between 2020 and 2025, plateau for approximately a decade and decline in absolute terms thereafter' (RSA 2010).

Effectively, the strategic direction set by Cabinet based on consideration of the LTMS in mid-2008 has been internationalised. The LTMS analysed a series of mitigation options, and also considered a range of economic instruments to incentivise these mitigation options. One of the most effective mitigation options was putting a price on carbon, which could see reductions relative to baseline of 12 287 Mt CO_2-eq between 2003 and 2050. With South Africa pledging achieve a deviation below 'Business as usual' (BAU), the question had shifted from *whether* to reduce emissions growth to *how* to achieve the deviation below BAU.

In this paper, the particular focus is on how a particular group of industries could be part of such a solution. The focus is on energy-intensive (EI) industries, and particularly those that are also trade-intensive (EITI), and what policy options exist to achieve emission reductions in these sectors, in the context of an overall climate policy for South Africa.

South Africa should learn from international experience with carbon taxes and cap and trade mechanisms, which globally have been key instruments to mitigate climate change. In applying such lessons to the South African context, the specific context must be taking into account – particularly the context of poverty. The aim would be to achieve mitigation at the same time as achieving national goals of eradicating poverty and achieving more sustainable development. The question is how energy- and trade-intensive industries could be part of the solution, rather than part of the problem.

Given our historical development around a minerals-energy complex (Fine & Rustomjee 1996), much of our economy – and its politics – is structured around EI sectors (Winkler & Marquard 2009b). Three quarters of primary energy supply comes from coal and more than 90% of electricity from coal-fired power stations (Winkler 2009a). The use of electricity is comparatively inefficient. The combination of EI industry, low energy efficiency, carbon-intensive electricity and the large-scale direct use of coal implies that South African industry would be significantly more affected by a carbon tax than industries in comparable countries. Yet the policy of the ruling party envisages placing a price on carbon (ANC 2007). EI industries would be expected to shoulder a significant part of the burden.

Exposure to trade raises a different concern, namely that of competition in international markets with other firms which may face lesser constraints or costs. Those industries that are EITI would be expected to feel the impacts of a carbon price more than others. If not addressed in a structured way as part of climate policy, EITI sectors can be expected to lobby for complete exemption from mitigation. A structured approach would be preferable to *ad hoc* exemptions. The goals of a structured approach would fall into two broad categories: 1) to deal with the concerns of industries that will face higher risks than others following the implementation of a carbon price, in a way that does not undermine mitigation efforts; and 2) to provide support to more EITI sectors to be part of a solution. The second goal would be achieved both through greater energy efficiency and through diversification.

Proposed policy options should achieve the goal of preventing either the stranding of assets in these sectors, whereby investments made under a significantly different set of incentives become worthless as the result of the introduction of a diametrically-opposed set of incentives, or the associated social and economic impacts of stranding, particularly job losses. At the same time, policies should incentivise as much energy efficiency in these industries as possible. Special measures or lower tax rates should not provide perverse incentivise to extend the life of plants in these sectors.

Alternatively, strategies are needed to reduce emissions in these sectors, including, in extreme cases, the closure of plants accompanied by appropriate plans for a 'just transition' for those working in those industries to lower-carbon livelihoods. There are cases where the sectoral regulatory environment impedes the incentive impact of the tax on consumers. For instance, in the liquid fuels sector, synfuels producers would incur far higher carbon taxes (or costs for emissions permits) than crude refineries, but due to the current regulatory system, would be unable to pass this additional cost to consumers. It is doubtful whether this incentive, if it were passed on, would achieve anything except the shutdown of the only synfuels plant in the country. If this is a desirable policy outcome, it could be better achieved through a specific policy measure. The imposition of a tax might be effective in gaining concessions for lowering the carbon intensity of the plant. A related but different issue is posed by electricity tariff structures – due to the lack of transparency in electricity pricing in South Africa, additional measures would be required to pass through the marginal cost of the tax to individual consumers.

This paper proceeds is organised as follows: First, the context in which economic instruments are being considered is briefly recalled. In section 3, we identify sectors which are EI, those that are TI and those that are EITI. The following analysis focuses on EI and EITI sectors, not those that are only TI or simply large energy users. The next section considers international experience with carbon taxes, emissions trading and policy instruments for addressing the specific issues of EITI industries. Section 5 then draws on both the previous sections to suggest a range of possible approaches to EI and EITI sectors, in the context of the development of South African climate policy.

2. Context: an energy-intensive history

This paper considers the question: How could economic instruments be applied in South Africa to EI TI industries. This question is posed in the context of emerging national policy on climate change mitigation – and in the context of the specific challenges faced by South Africa. The context is that of a political economy which historically has been dominated by the minerals-energy complex (Fine & Rustomjee 1996).

The history of the minerals-energy complex has resulted in carbon-intensive electricity generation, comparatively inefficient use of energy and support for EI industries. Electricity generation has relied on coal for many decades, with over 90% generated from coal-based power plants. Using the methodology of Hohne et al to evaluate emissions intensity of electricity, developed countries average 0.4 kg per kWh, developing countries fare worse with 0.7 kg per kWh, and South Africa has an emissions intensity of 0.869 for its electricity (Höhne et al 2008).

Due to long-term low energy prices, partly because of ultra-cheap industrial coal prices and partly because of massive overcapacity in the electricity sector from the mid-1980s, South African EI sectors are also very inefficient by comparison to most other countries (Marquard 2006). The costs of using coal have not been internalised (Spalding-Fecher & Matibe 2003; Van Horen 1996). Incentives have not promoted more efficient use, and so industries are not efficient by international comparison. For instance, South Africa's iron and steel industry is amongst the top 20 such industries in the world by output, but is also the most inefficient. A comparison of five EI sectors across a representative sample of countries globally reveals that South Africa is least efficient or close to least efficient in over half of them, and its aggregate score is the third worst out of about 50 countries (Den Elzen et al 2007)

EI sectors have long been supported by policy. A recent policy initiative in this regard was the 'Developmental electricity pricing programme' (DEPP) of the Department of Trade and Industry (DTI), which sought 'to attract industrial investment projects to the Republic, which would in the absence of DEPP not invest in the Republic, through providing them with electricity tariffs that will … enable an IRR [internal rate of return] that will ensure that the applicant can invest in South Africa' (DTI 2005). While expressed as 'beneficiation of downstream industries', this policy essentially promoted key EITI sectors at direct odds with climate mitigation objectives. The programme was effectively suspended after the electricity crisis of 2008, but was just the last in a long series of state initiatives since the 1970s to develop EI industries in the economy, to take advantage of low coal and electricity prices, the country's minerals industry, and to boost foreign exchange earnings. After the overbuilding of generation plant by Eskom in the 1970s and 1980s, the policy was accelerated to use the available excess capacity (Marquard 2006).

Put together, the combination of policy support for EITI industry, carbon-intensive electricity and inefficient use of energy have resulted in high energy-intensity. This has been acknowledged in government planning, such as the first Integrated energy plan (DME 2003). This stated that by 'international standards, South Africa has a high energy intensity.' This is because low energy costs and an abundance of mineral deposits have led to an emphasis on primary extraction and processing, which is inherently energy intensive'. It is in this context that we look to identify EI, TI and EITI sectors.

3. Identifying energy-intensive and trade-intensive sectors

The first step in a structured approach to EI and EITI sectors under a carbon price must be to identify the industries concerned. This paper identifies EI sectors, then TI ones separately, before combining the findings to identify EITI industries. It is the latter two categories which are the focus for policy recommendations, particularly considering how economic instruments might be applied to EI and EITI sectors. The scope of this paper does not include sectors that are TI only; future work on border adjustment might include these. In the context is domestic climate policy and economic instruments, the relatively greater costs in EI sectors and competitiveness concerns of EITI are most relevant.

3.1 Energy-intensive sectors of the economy

In this paper, energy-intensity is measured as energy demand (in terajoules) per unit of GDP (in millions of 2000 constant rands), following the approach taken in establishing baselines for energy efficiency (Hughes et al 2002). The data needed to derive a measure of energy intensity are energy consumption per sector and GDP (total output) per sector. Energy intensity is then calculated as energy consumption per sector, divided by economic output per sector. Table A.1 in the Appendix and Figure 1 below show the trends in energy consumption per sector between 2001 and 2006.[1]

To determine the energy intensity of these industrial sub-sectors of the economy, the Department of Minerals and Energy (DME) energy balances data were employed along with Statistics South Africa (SSA) gross domestic product (GDP) figures. This task involved determining the overlap between industrial classifications in the Energy Balances and those in the SSA figures. The energy balances are generated according to the methodology employed by the International Energy Agency (IEA) and the International Industrial Classification as (partly) used by SSA (Weidema 2010). The SSA GDP figures are produced based on the Standard Industrial Classification of all Economic Activities (SIC) which is based upon the third revision of the International Standard Industrial Classification of all Economic Activities (ISIC) (UN Statistics Division 2002).

Two caveats should be noted before proceeding – energy intensity is used as a first approximation for emissions intensity, and the analysis focuses on energy users in the industrial sector only. On the first point, energy intensity is highly correlated with emissions intensity due to the emissions-intensive nature of the South African energy sector. However, there are industrial sectors such as iron and steel and cement which produce additional non-energy emissions (industrial process emissions which produce GHG as a result of non-combustion processes), which would increase the emissions intensity of these sectors. This initial analysis has not taken these impacts into account; thus, interventions in the energy system (fuel switching, or energy efficiency measures) will reduce the emissions intensity of some sectors more than others, and might be an area for future work.

The second point is simply that the analysis is on EI industrial sub-sectors, which are those that use a large amount of energy *per unit of output*. Industry in South Africa has shifted from being mining-intensive to EI manufacturing processes (Hughes et al 2002). In addition, South Africa derives substantial wealth from energy-related activities (Consult 101 et al 2001: xvi). This characteristic of the economy is described by Fine and Rustomjee (1996) as the minerals-energy complex. Given that in South Africa the industrial sector is the largest user of energy in final energy consumption (Winkler et al 2006) we continue reporting on industry in this section, which is a sub-

1 Figure A.1 in the Appendix highlights the trends of the other seven main industrial energy consuming sectors.

set of the entire economy. Table A2 in the Appendix shows the large energy-consuming industrial sub-sectors.

The question of interest is the impact of pricing carbon on those that use energy intensively. For ease of comparison of the highest energy consuming industrial sub-sectors, only a subset comprising the top-six energy consuming sector are reflected here in text. Figure 1 shows the trend in energy consumption for these six highest-consuming industrial sectors. The energy consumption trends for all other sectors are shown graphically in Figure A1 in the Appendix. Energy consumption data on all sectors is in Table A 2.

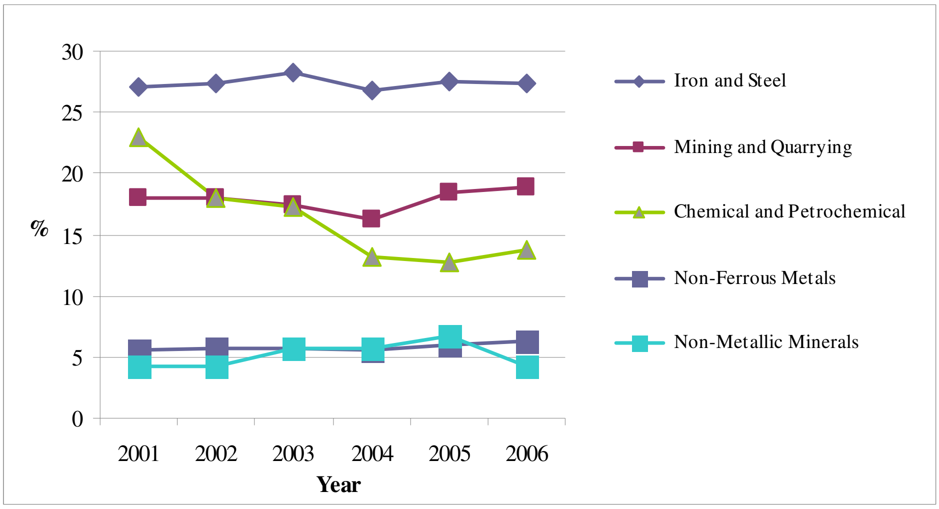

Figure 1: Industrial sectors with highest energy consumption, 2001 to 2006

Source: Own calculations based on DME (2001-2006)

It should be noted that the reported energy consumption in the chemicals and petro-chemicals sector may be due to several factors, not all of which are clear from the available data. Much of the decline from 2001 to 2006 may be explained by, firstly, the shutting down of a small electricity plant in the sector, so that efficiency losses would be accounted for elsewhere, secondly, the switch to natural gas in a smaller plant, and thirdly – and least transparently – a change in accounting for some of the energy use in the industry from final energy use to transformation. In terms of economic output in each of these industrial sectors in Figure 2 (and a fuller set in Table A.2 in the supplementary data in the Appendices) indicate that unsurprisingly the mining and quarrying sector as well as chemical and petrochemical products and iron and steel (inclusive of non-ferrous metals in SSA GDP figures) contribute significantly to GDP of the industrial sectors assessed. The construction and food and tobacco industries follow close behind. The construction industry showed a notable increase in GDP during the 2001 to 2006 time period where as the mining and quarrying sector appeared to decline in output between 2003 and 2006.

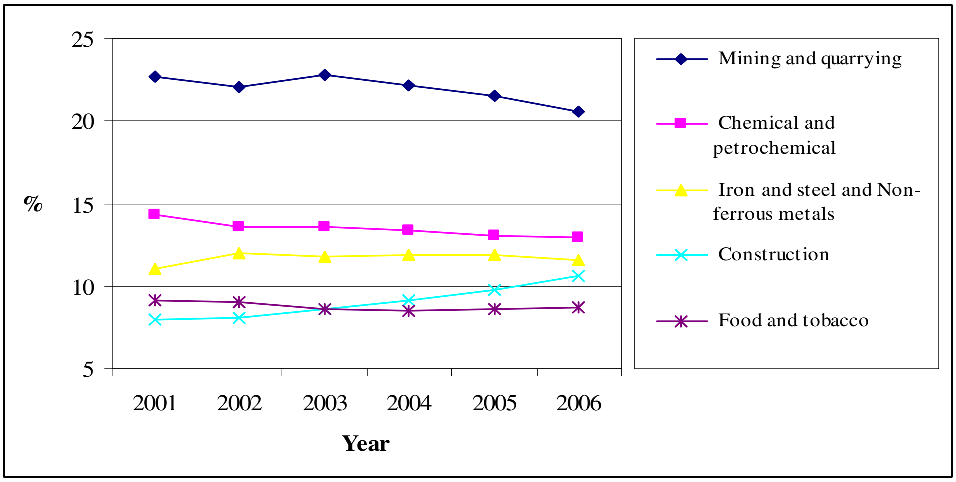

Figure 2: Trends in GDP across industrial sub-sectors, 2001 to 2006[2]

Source: Own calculations based on SSA (2001–2006)

Having shown energy consumption and GDP, energy intensity is simply calculated by division. Table 1 shows energy intensity by industry as energy use per unit of economic output. (the trends in GDP across the other main industrial sub-sectors are shown in Figure A.2 in the Appendix),

Table 1: Energy intensity (energy per economic unit of output) (Terajoules)/GDP (Millions of constant 2000 Rands)

Source: Own calculations based on on DME (2001-2006); SSA (2001–2006)

Industrial sub-sector	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Rank*
Iron and steel and non-ferrous metals	10.8	9.7	10.2	10.5	9.8	9.3	1
Non-metallic minerals	8.7	8.0	10.8	12.1	12.9	7.6	2
Chemical and petrochemical	5.9	4.7	4.5	3.8	3.4	3.4	3
Mining and quarrying	2.9	2.9	2.7	2.8	3.0	2.9	4
Construction	0.7	0.7	0.7	0.6	0.5	0.4	5
Paper pulp and print and wood	0.6	0.6	0.5	0.5	0.5	0.5	6
Machinery	0.2	0.2	0.5	0.4	0.4	0.4	7
Textile and leather	0.2	0.2	0.2	0.2	0.2	0.2	8
Food and tobacco	0.1	0.1	0.1	0.1	0.1	0.1	9
Transport equipment	0.0	0.0	0.0	0.0	0.0	0.0	10

It is immediately clear that the most EI sectors are iron and steel, non-ferrous metals, non-metallic minerals, chemical and petrochemical products,[3] and mining and quar-

[2] The trends in GDP across the other main industrial sub-sectors are shown in Figure A.2 in the Appendix.

[3] Energy use in the chemicals and petrochemicals sector seems, from interpretation of the DME's energy balances (DME (2001-2006), to include coal use for chemicals manufacture, as well as for private electricity generation, but excludes coal use as feedstock for synfuels manufacture, including

rying. Figure 3 shows the clear separation between these four sectors and other industrial sub-sectors. In the figure, iron and steel is combined with non-ferrous metals – the basic metals. Sectors are ranked by average energy-intensity (most to least) between 2001 and 2006. Note that within mining, the gold mining sector is a particularly EI sector, as the deeper gold is needed to be mined the more energy is required to make this possible.

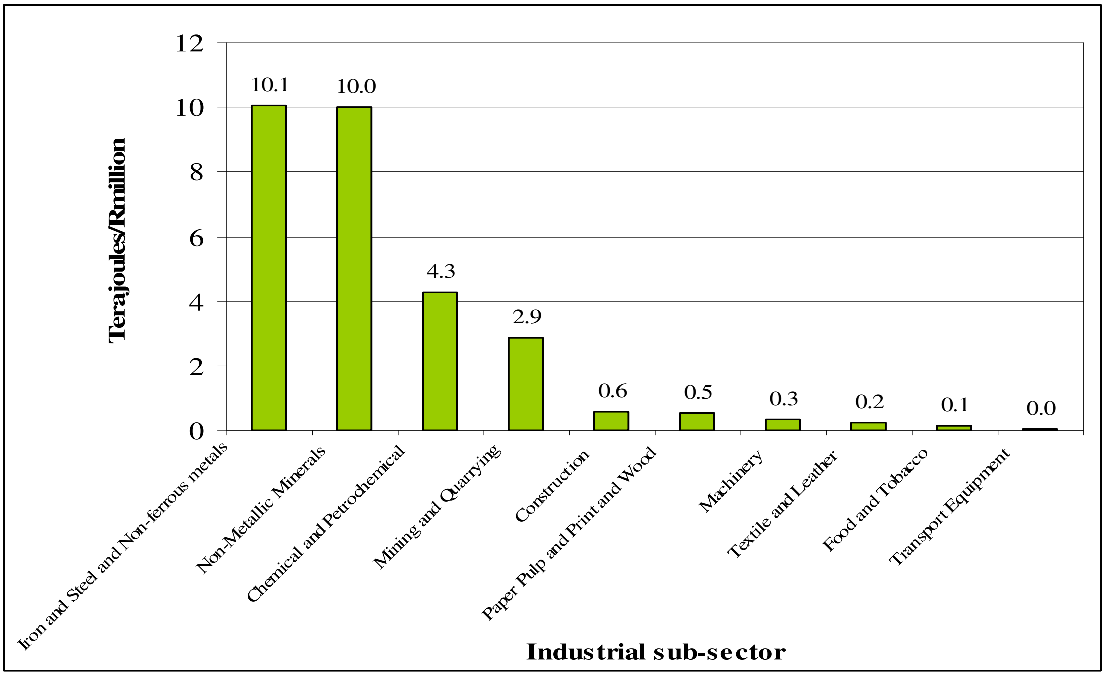

Figure 3: Average energy intensity between 2001 and 2006 of each industrial sector

Source: Own calculations based on DME (2001-2006); SSA (2001–2006)

Having identified EI sectors, the next step in the analysis was to assess which sectors are TI – and by what measure.

3.2 Identification of trade-intensive sectors of the South African economy

To identify TI sectors the proportion of total output composed of exports and imports were assessed. The approach followed here is as taken in previous work on which this section draws extensively (Jooste et al 2009), which employed the United Nations Commodity Trade Statistics database (UNComtrade – see http://comtrade.un.org/) at the two digit level of commodity disaggregation (according to the Harmonised System or HS classification) as well as the Quantec Standardised Industry Database (www.quantec.co.za/data/easydata-rsa-standardised-industry) which identifies 46 industries at varying levels of two to three digits South Africa Standardised Industry Classification (SSA 1993). Using these data sources and their sectoral definitions, export intensities were assessed. Trade intensity could conceptually also apply to imports (e.g. components), but the concern of competitiveness was taken to apply

the use of such coal for generation of process heat (completely integrated into the synfuels process), which is accounted for elsewhere in the energy balances.

primarily to exports.[4] The analysis therefore measured exports as a proportion of the total output of sectors of the South African economy, with output measured in monetary terms. The analysis showed that that there are six sectors which have export intensity above 44%, namely

- gold and uranium ore mining;
- other mining;
- coal mining;
- machinery and equipment;
- basic non-ferrous metals; and
- basic iron and steel.

The next sector had an export intensity of 28%, significantly lower than the top six (Jooste et al 2009).

3.3 Energy-intensive and trade-intensive sectors of the South African economy

The preceding sections have assessed EI sectors and trade-intensity respectively, laying the basis to determine those sectors which are EITI. The analysis of EI sectors is based on energy analysis, while that for TI sectors comes from a different tradition, both with their complexity. For this initial analysis, the combination is done in a simple but transparent manner. The methodology is a comparison of lists, as shown in Table 2.

Table 2: Energy intensive, trade-intensive and EITI sectors

Energy-intensive sectors	*Trade-intensive sectors*	*Energy-intensive and trade-intensive sectors*
Iron and steel	Basic iron and steel	Iron and steel
Non-ferrous metals	Basic non-ferrous metals	Non-ferrous metals
Non-metallic minerals		
Chemical and petrochemical products		
Mining and quarrying	Gold and uranium ore mining	Gold and uranium mining
	Coal mining	Coal mining
	Other mining	Other mining
	Machinery and equipment	

4 Taking into account both exports and imports, the top six TI sectors were similar, with four sectors in also in the top six: gold and uranium ore mining; other mining basic non-ferrous metals; basic iron and steel. The distinct two in each case were, for export-intensity: coal mining and machinery and equipment; for both export and import: leather and leather products, and basic chemicals.

Table 2 shows that the basic metals – iron and steel, as well as non-ferrous metals – are EITI. Mining is also EITI, although listed differently. Within mining, the trade analysis provides a more detailed break-down, considering gold and uranium mining, coal mining and other mining. Machinery and equipment is TI only, and would not be included given the focus of this paper. Chemical and petrochemical products may merit consideration in carbon pricing, but in terms of energy- rather than trade-intensity. Non-metallic minerals are similarly in the first column of Table 2, but not the second. Both chemicals and non-metallic minerals are therefore considered in the remainder of this paper as E) sectors, together with the EITI sectors as above. In consideration of further work, we make suggestions for refinement of the identification of EITI sectors.

Having identified EI and EITI sectors, our paper turns to consideration of lessons from international experience.

4. International experience on carbon pricing and possible approaches to EITIs

Two major approaches to pricing carbon are the imposition of a carbon tax and emissions trading. Other papers in this collection of conference papers compare these two economic instruments more generally (Goldblatt 2010; Robb et al 2010). The purpose of reviewing these two approaches here is to draw lessons for approaches to EI and EITI sectors. A brief review of the concepts underlying the instruments informs our discussion.

Carbon taxes use the price mechanism, imposing an additional cost that is aimed at reflecting the external costs of carbon emissions in the price paid. The price is set in the tax levels, which need to be determined. Emissions trading schemes (ETSs) start with quantity rather than price. The cap regulates the quantity that may be emitted, which creates scarcity. Emitters must acquire permits, but are allowed to trade with other entities which may have different mitigation costs. Firms compete to purchase permits they require, either by auctioning or on secondary markets. Permits will be tradable and a market price will be formed.

The distinction between instruments, for this purpose, is not a hard one. There are measures applicable both taxes and trading – such as recycling of revenue. Variants of emissions trading (also called cap-and-trade) and carbon taxes are examined.

4.1 The European Union Emissions Trading Scheme

The EU-ETS is currently the only fully-functioning GHG cap-and-trade scheme, although a number of others are in the design phase, whereas carbon taxes have been applied in a number of countries since the early 1990s. The EU-ETS includes large emitters in the power and heat generation sector as well as other EI industrial sectors – combustion plants, oil refineries, coke ovens, iron and steel plants and factories making cement, glass, lime, bricks, ceramics, pulp and paper are included in the scheme (EC 2005). An initial lesson is that EI sectors can be included.

One approach to EI and EITI sectors under emissions trading might have been to allocate free allowances. The initial allocation of permits is given to those emitting, which some consider a reward for bad behaviour. The experience of the EU-ETS, however, was to move from free allocation in the first phase to auctioning of initial allowances, increasing over time.

Analysis of the EU-ETS has found that TI sectors, specifically export-intensive sectors such as cement and aluminium, are risk of damage to their competitiveness as a result of the EU-ETS, should prices rise or their allocations decrease (Grubb & Neuhoff 2006). There is no explicit provision for for EITIs in the EU-ETS, with the EU having in 2009 identified a lengthy list of sectors deemed to be potentially 'at risk of carbon leakage' and is to decide on policy approaches in 2010 (Grubb & Counsell 2010). A relevant approach is that of limiting the pass-through of the carbon price to consumers. In the EU-ETS, this was constrained to a degree in countries with less liberalised electricity sectors through regulation or the threat of regulation. However, this is likely to undermine the potential of an ETS to internalise emissions pricing (Grubb & Neuhoff 2006).

4.2 Australian emissions trading schemes

Australia's policy on mitigation is being built around a medium-term target for national emissions and a domestic emission trading scheme, called the Carbon pollution reduction scheme (CPRS) (Australia 2008). The CPRS is a key means to achieving the emission goals – which sets the 'cap', covering about 75% of GHG emissions. In November 2009, the Australian Senate voted to reject the legislation, but indications were that it might be reconsidered after Copenhagen. In January 2010 and following the Copenhagen Accord, the Australian government made a submission to the UNFCCC, a range of -5% up to -15% or -25% (conditions being a deal with participation by major developing countries and, for the highest level, the global effort being consistent with stabilisation at 450 ppmv) (Australia 2010). Of particular interest is that EITI sectors would receive an administrative allocation of permits, as a transitional assistance measure. The Green Paper that informed discussions leading to the CPRS considered the impact on EITI industries, in particular the most emissions-intensive electricity generators. The proposed administrative allocations is linked to the EITI industry's output (Australia 2008).

Under an Electricity sector adjustment scheme, the Australian government will provide during the first five years of the CPRS about A$ 3.9 billion worth of such permits, based on an initial price of $ 25 per ton of carbon. Furthermore, responding to concerns of non-EITI sectors, the proposed scheme would include an Administrative Appeals Tribunal. Effectively, if there are concerns that EITIs earn windfall profits, these could be challenged. To enable this, details of administrative permits issued would be published by the regulator.

The CPRS also has specific provisions for emissions-intensity (not EI) in the electricity sector. Not all power plants would be eligible to trade, only those above the grid-average emissions intensity from 2004 to 2007 (0.86 t CO_2-eq / MWh in Australia; the comparable figure for Eskom is 0.96 t CO_2-eq/MWh).

New South Wales in Australia piloted a GHG reduction scheme (GGAS), prior to the development of the national Carbon pollution reduction scheme (CPRS). GGAS was a regional baseline and credit scheme that started in 2003, building on an existing emissions benchmarking programme linked to retailer licensing conditions (Tyler et al 2008a). One element considered in this state-level ETS was voluntary participation of some large electricity customers. In the context of a baseline and credit approach, the incentives drive participation, rather than a firm cap. Following the trend in the EU-ETS, the Australian scheme proposes to move to 100% auctioning over time.

4.3 Differential rates under a carbon tax

The Scandinavian countries pioneered carbon taxes. Various approaches were tried (Winkler & Marquard 2009a), and the details on levels set and experiences gained have been reviewed elsewhere (Tyler et al 2008b). What is of interest to the present discussion are examples of differential application of carbon taxes – either lower rates of taxation for specific sectors, or complete exemptions.

The Finnish tax was based on carbon content, later combined with energy content in a 60:40 ratio. However, international transport fuels (so-called bunker fuels resulting in marine and aviation emissions) were exempted. Sweden similarly set its tax levels in relation to the average carbon content of the fuel. In the Swedish case, biofuels and peat were exempted, but also fuels for electricity generation. Sweden and Finland provide examples of setting a different tax level for EI sectors, with some sub-sectors entirely exempted. The basis of such reducing tax levels could be energy or carbon content.

The German environmental tax reform was not considered effective in achieving mitigation initially, since it excluded coal (Anderson 2008). Germany has had energy taxes since the 1950s, including natural gas but not include coal until 2007. Coal was heavily subsidised through a so-called *Kohlepfennig*, with different rates for industry and households. Between 1999 and 2003, Germany undertook environmental tax reform, increasing taxes on transport fuels and phasing in an electricity tax. The revenues were earmarked for recycling into pension contributions. Energy products other than transport, by contrast, received tax relief – paying 40% of the standard energy tax rate, once the tax burden exceeded a threshold level. The manufacturing sector is eligible for a refund of 95%, if the energy tax burden is greater than tax relief (Speck 2008). By the end of this evolution, Germany provides an example of balancing the tax burden with tax relief.

The UK includes in its climate policy a Climate change levy (CCL) – a tax on electricity, gas, coal, liquefied petroleum gas used for energy. The CCL is levied on power generation, industrial iron, steel, mineral chemicals and transport. A reduced levy applied to EI users, provided a climate change agreement was signed

4.4 Adjusted tax rates under emissions trading

Up until this section, we have considered examples specific to a tax or trading. The EU experience considered differential tax rates, in a context where both instruments apply. The experience of the EU in integrating existing carbon taxes by member states in a broader emissions trading scheme may provide lessons. Anderson (2008) notes the complicated schemes have been designed to balance, cap, or reduce the tax, as countries with a tax fall under the EU cap. Member states apply to the European Commission for approval, essentially for lower tax rates. While the burden on EI industries 'remains negative … due to many exemptions, the actual burden is rather modest' (Anderson 2008: 79).

Under the EU-ETS, EI companies receive compensation for the additional energy costs, through a reduction in social security contributions. Even these exemptions are adjusted, given that EI sectors in countries with high shares of hydro- or nuclear power in their mix are less sensitive to carbon-based energy taxes. As the compensation is considered to be 'state aid', there are limits on the concessions that can be granted. The European Commission guidelines codify agreements relating to selective tax reductions. An energy taxation directive limits the duration of exemptions to five or ten years. The exemptions have reduced the burden on EI sectors, which range between one and four percent of gross operating surplus across different countries and industries (Anderson 2008).

4.5 Use of carbon tax revenues for energy efficiency incentives

Denmark has combined the levying of a carbon tax with subsidies for energy efficiency. A study comparing the effectiveness of this combined approach suggests that this led to the best results in terms of mitigation achieved, while noting that its energy sector is more carbon-intensive than others in Scandinavia (Anderson 2004). European experiences suggest a 'relatively broad consensus about the properties of revenue-neutral environmental tax reform' (Anderson 2008:64).

Revenue recycling can be applied not only with a tax, but also the revenues from auctioning of allowances, or other instruments. The UK climate change levy was offset by a reduction of 1% in the employer's rate in national insurance, and to fund energy efficiency incentives. The UK Department of Climate Change considers the levy to be revenue-neutral.

A fiscally neutral approach is both more attractive for tax policy, and the incentives packaged together with the carbon tax can address socio-economic priorities.

4.6 Domestic sectoral approaches

Among sectoral approaches, one should distinguish between international and domestic approaches. Setting sectoral targets internationally (IEA 2009; Japan 2008) was seen by many developing countries as equivalent to commitments. On the other hand, developed countries were expected to adopt economy-wide commitments. The relevance to this paper, however, is that sectoral approaches apply particularly to EITI sectors.

In a new context, with major developing countries having pledged deviation below BAU (as South Africa) or reduction in carbon intensity (China, India and others), domestic implementation will have to be considered sector by sector. EITI sectors may benefit from access to sectoral crediting mechanism. The competitiveness concerns of EITI sectors could be addressed by seeking to ensure that all participants in the sector are internationally subject to the same benchmark.

Benchmarks could be defined as specific emissions intensities; for example the cement sector could aim to reach x kg CO_2-eq per ton of cement. In practice, a range of different benchmark figures would be needed, given different processes and products. Technically, these could be resolved, but as a matter of negotiation, reaching consensus on benchmarking during negotiations is often difficult. Another approach would be to require the best available technology (or in the 10^{th} or 25^{th} percentile in terms of emissions per output) to be installed. Again, this would require long lists of technologies.

4.7 Summary

Before turning to policy options for South Africa, it is worth summarising the lessons learned from international experience. Generally, more provisions under carbon taxes and emissions trading have considered EI sectors, with fewer examples of policy for EITIs. In countries where carbon taxes have been implemented, differential tax rates have been applied, based in Scandinavian countries on energy or carbon content. The German system evolved to a complex balance of tax relief with tax burden, while the UK reduction in the climate levy was subject to firms signing an agreement with government. In the EU context, tax rates have been adjusted as countries fall under the cap of the ETS – including exemptions for EI companies.

For emissions trading, the trend in both the EU-ETS and the proposed Australian scheme is to shift from grandfathering (free allocation of initial allowances) to 100% auctioning. The most explicit provision for EITIs that this paper has found is the administrative allocations to EI, TI and emissions-intensive power plants. To counter concerns of windfall profits from non-EITI sectors, an appeals tribunal is an interesting option.

Revenue from taxes or auctioning allowances provides a means to encourage mitigation in EI and EITI sectors – or to achieve broader socio-economic goals. Fiscally neutral design seems to be an attractive element from climate and development perspectives.

Finally, this paper reflected on the possibilities for sectoral approaches, domestically and also allowing incentive-driven participation in baseline-crediting systems. The technical issues of agreeing benchmarks, particularly at the international level, would need to be addressed.

5. Range of possible approaches to carbon pricing for South Africa

Drawing on early work on economic instruments to put a price on carbon and lessons from international experience of dealing with TI and EI sectors, this section explores a range of policy options for SA. While focusing on economic instruments, EI and EITI sectors, the proposal should be considered as part of South Africa's development of climate policy more broadly. Some of these options apply irrespective of which instrument is chosen (emissions trading, carbon tax or indirect measures), while others are integral to a specific option. If successful, the measures should achieve the intended outcome of the carbon price – provide incentives to producers to reduce carbon intensity, provide incentives to consumers to decrease the carbon intensity of their consumption, and result in a shift to a low-carbon economy. The aims of these options would be to maintain other policy goals (international competitiveness, economic growth), while helping South Africa achieve its 34% deviation below BAU by 2020 and more beyond.

Another consideration would be the timing of measures elsewhere – either the imposition of equivalent carbon price mechanisms elsewhere, or the unilateral imposition of border adjustments in export destinations for goods produced by South African EI and EITI sectors. This will depend on the outcome of the current international negotiations, but implementation of any of the special measures proposed below would depend on the prevailing international environment. Implementation of equivalent carbon pricing policies among major trading partners should obviate the requirement for special measures.

5.1 Apply any lower carbon tax rates on objective basis

If a carbon tax were implemented, experience elsewhere indicates that industries will lobby for lower tax rates. This consideration returns to the initial problem, which is that – absent a structured approach – government will face special pleading. The outcome of such a process is not often in the interests of environmental integrity, as *ad hoc* arrangements cut against the initial intention of reducing emissions. Drawing on the experience gained from other countries, a structured approach for EI and EITI sectors could base the rates set for a carbon tax on energy or carbon content. The iron and steel sector, for example, would have a rate set in relation to kg CO_2 per ton of steel produced. To enable a common metric, a national benchmark would have to be defined. Alternative to specific emissions intensity would be assessing emissions intensity in kg CO_2 per rand of economic output, analogous to Table 1 for energy-intensity in industry. Either measure would provide an objective measure, rather than a complete exemption. Lower rates or tax relief should also, following the UK example, be subject to an agreement of the entity with government indicating how it will contribute to mitigation.

5.2 Allocate initial allowances by auctioning

Economic theory suggests that initial allocation of allowances is the most efficient, but most emissions trading schemes started by free allocations in relation to past emissions, called 'grand-fathering'. Grandfathering is inherently very administratively burdensome, requiring a high level of data on the part of the regulator (Tyler et al 2008a). It also lacks flexibility in allowing change in industry structure. Furthermore, the approach is at odds with the principle of equity, in rewarding historical polluters the most with new assets. Finally, it is doubtful that grandfathering would prevent EI and EITI industries lobbying for their special case. Increasingly, the trend in the EU, the proposed Australian CPRS and legislation for a US scheme, is towards auctioning of permits to emit GHG emissions. In our context, EITI sectors such as mining and the EI production processes by SASOL, for example, should be covered through full auctioning.

Maximum coverage in an ETS is desirable to achieve the most mitigation, and to maximise economic efficiency in mitigation. In South Africa, with an energy system dominated by Eskom, Sasol and a few large EI industrial sectors, and with the absence of an electricity market, there might not be sufficient liquidity in any domestic emissions-trading scheme without participation of EI and EITI sectors. A clear policy option thus would be to have 100% coverage and full auctioning of initial allowances.

5.3 Administratively allocate permits to EITIs for a transitional period

There are compelling reasons to move to auctioning as rapidly as possible. Some free allocations may be necessary as a transitional measure to make a scheme acceptable to EITI industries. If grandfathering were applied at all, it should be as a transitional measure to auctioning, rather than an option in its own right. This would follow the proposal of the Australian CPRS in its approach to EITI sectors.

5.4 Combine carbon tax or auctioning revenue with incentives for energy efficiency or other goods

Revenues from auctioning of allowances or from the levying of a carbon tax could be used to provide incentives for energy efficiency. These are important in South Africa at a time when the choice has become to face unpredictable black-outs and brown-outs, or to structure a power conservation programme. Legislation requiring mandatory energy efficiency standards to be met is now needed, which would provide the regulatory basis. The impacts of such a law for poor households and for EI and EITI industries could be softened through targeted incentives. As an example, non-ferrous metals would still pay a tax or buy permits, but receive support in improving the efficiency of their production – and thus reducing their energy-intensity. Energy efficiency more broadly has the benefit of contributing to employment.

Diversification away from EI sectors could be promoted via subsidies for investment in green industries by specific EITIs as a *quid pro quo* for the early retirement of inefficient plant. An example would be support for the synfuel industry to shift to electric vehicle – although this would pose the question which specific companies should be supported. Incentives should be part of a general industrial policy aimed at diversification away from EI sectors.

The revenues generated from a tax or auctioning are not motivated by revenue-generation and could be made revenue-neutral by combining the measure with an incentive package. It is likely that different views will be expressed on the use of carbon revenues. International experience suggests that one should expect government (and treasuries in particular) to motivate for the revenue to be retained in the general fiscus or to be used for additional mitigation. Business will want to see revenue spent on the worst affected sectors. Small customers and poor households – if they are effectively represented through civil society, consumer organisations and unions – will want to reduce the impact on households, particularly the poor. A balance between these different interests will need to be negotiated.

5.5 Sectoral approaches

As outlined in section 4.6, South Africa has expressed interest in sectoral approaches primarily at the domestic level. With the announcement of a 34% deviation below BAU by 2020, the question of how this would be achieved would require planning for implementation in each domestic sector. The development of national policy is being structured in this way. The particular issues of EI and EITI industries, as outlined above, should be taken into account.

A further consideration for EITI sectors, given their exposure to exports, emerges from trade modelling of impacts of response measures on South Africa (Jooste et al 2009). This analysis indicated that mechanisms such as sectoral baseline and crediting mechanism could be attractive for South Africa and EITI sectors in particular. At the national level, losses can be turned into gains, with lost exports outweigh advantages of increased EITI industry exports, reinforcing the findings of an earlier study (Consult 101; EC & IDC 2001). The recent study made a similar finding at sectoral level, in particular for iron and steel, as well as ‘other’ mining (not gold mining). In a situation without access to trading, these sectors showed losses when Annex I implemented mitigation measures. But with something approximating sectoral crediting (labelled ‘no-lose emissions trading’ in the study), these losses turned to gains (Jooste et al 2009). Sectoral crediting mechanisms can potentially provide gains for EITI sectors – rather than losses – through access to a carbon market on a ‘no-lose’ basis.

5.6 Set specific energy-intensity targets

The above options have drawn on international experience in various ways; the following two consider policy options specific to our own context. One option would be for government to set energy-intensity targets for industries, as has been suggested elsewhere (Tyler et al 2008a). South Africa has not expressed its national pledge as an intensity target (unlike China and India), but as a deviation below the BAU trajectory (RSA 2010). Part of the national goal could be translated into sector-specific intensity targets, which could be negotiated on the basis of international benchmarks. Specific emissions-intensity targets could build on companies goals already established. Sasol has adopted an emissions-intensity target, aiming to reduce its GHG intensity by 10% below 2004 levels by 2015. While actual trends in GHG intensity reduction suggest that the numerical value of the target could be doubled to 20%, the point for current purposes is that this policy option has the advantage of directly using approaches taken by companies, including by EITI industries. If leadership were shown by Sasol, it might be possible that one of our EI sectors, chemicals and petrochemicals, as a whole might take on ambitious intensity targets. The 2009 Carbon Disclosure Project found that of the JSE top 100 companies, '20 have GHG emissions targets, while 11 are in the process of defining such targets' (CDP 2009). The initial phase of 'peak, plateau and decline' needs to slow emissions growth and intensity targets could make a contribution. However, if there is continued growth in other sectors (e.g. energy supply), then more has to be done elsewhere.

5.7 Review policy promoting energy-intensive industry

If South Africa is to achieve a deviation below BAU, a shift of incentives will be needed from EI to climate friendly investments and technologies. Incentives such as the DEPP (see section 2) were designed to utilise the excess capacity in the South African electricity system in the 1990s and early 2000s, and benefited amongst others smelters in the iron and steel and non-ferrous metals sectors – identified in this paper as both EITI sectors. In 2010, facing an electricity supply crisis, continuing such policies would exacerbate the current crisis. If these incentives were phased out, the reduced burden on the fiscus would in principle free up resources that could be used for investment in climate-friendly sectors. The basis for such a shift has been laid by an in-principle decision by the Department of Trade and Industry (DTI) to integrate climate change into its industrial policy. Climate-aligned industrial policy might, for example, promote a solar industry development programme (Edkins et al 2009; Winkler 2009c).

6. Limitations of this study and further work

This paper focuses on how EI and EITI sectors might be included in carbon pricing, as part of broader climate policy. It does not seek to answer all questions, and its focus is derived from the identification of EI, TI and EITI sectors in section 3. An important area for further work is refinement of that identification. The approach in this paper was based on distinct methodologies for EI and TI sectors, and identifying the combined list EITI by comparing lists. Significant effort was made to check that sectoral definitions are consistent – that apples are being compared with apples. A dedicated study on sectoral definitions in energy balances and modeling, compared to those used in trade databases, would not only validate or amend our findings, but should also consider levels of disaggregation. A further study might investigate statistical methods (e.g. analysis of distribution, clustering methods) of comparing not only top five or six, but how full sets of groupings overlap. In particular, the large set of smaller industries under the category 'non-specified industry' add up, as a group, to the second largest energy user within industry in South Africa. A detailed analysis of sectoral definitions was not the purpose of our paper, which focused on policy options.

Having identified EI, TI and EITI sectors, we chose to focus on EI due to the comparatively greater cost they might face, and EITI due to competitiveness concerns. Further work is needed on TI sectors (even if they are not EI), in relation to border adjustments. The US and EU are considering such unilateral measures, in which a border tax or other measure is imposed on imports of emissions-intensive goods from countries that do not have a constraint on carbon. In the academic literature, the idea that South Africa could consider its own border adjustments has been proposed: 'In order to contain the competitiveness impact of an energy sector ETS for energy intensive export orientated industry, mechanisms such as tariffs on imports or tax rebates at the point of export could be considered' (Tyler et al 2008a). However, the notion of conducting climate policy by trade war seems a highly risky one (Winkler 2009b). If climate policy post-Copenhagen did degenerate into countries focusing on domestic law and dealing with others by border adjustments, then this option may need to be considered. It is not, however, a desirable scenario nor one currently pursued by South Africa, and thus a possible topic for future work.

Further work is needed on the impacts on the poor of putting a price on carbon. In this paper, the focus was on industry. However, the poor are even more vulnerable to impacts of higher energy prices. Revenue recycled from tax or auctioning allowances should be spent on ensuring that there is no such impact. Learning from the Scandinavian experience, one could combine climate objectives with other socio-economic objectives, in that context reducing income tax. In the South African context, particular preference should e given to the poor, and in avoiding any negative impacts on poor households through higher energy prices due to pricing carbon. Various options that have been considered in previous analysis (Pauw 2007; Winkler 2007, 2010) include a food subsidy, a general VAT subsidy, an income tax subsidy and a general increase in welfare transfers. This is an area in which we intend to do further work.

Having considered some of the areas in which the analysis presented here could be taken further, we conclude with the main findings of this paper.

7. Conclusion

This paper has explored how the sectors that have been central to the minerals-energy complex that has dominated our economy in the past, could be part of the solution to the problem of climate change. It has focused on the question how economic instruments might be applied to sectors that are EI and those that are EITI. Economic instruments – notably carbon tax or emissions trading – are key elements of emerging climate policy. What policy options exist to achieve emission reductions in EI and EITI sectors using economic instruments?

A first step in a structured approach must be to identify the sectors. We identified EI sectors based on methodologies and definitions used for energy balances and modelling, TI sectors based on trade analysis and SIC codes, and compared the results. Basic metals, including iron and steel and non-ferrous metals, are EITI sectors. Mining of gold, uranium, coal and other mining are also in this group. Sectors considered in the policy analysis for their energy-intensity only are chemical and petrochemical, and non-metallic minerals. In the context is domestic climate policy and economic instruments, the relatively greater costs in EI sectors and competitiveness concerns of EITI are most relevant.

The paper then considered key lessons from experience in other countries (already summarised section 4.7). We focus in this conclusion on the application of those lessons in the South African context.

The long-term mitigation scenarios found that a carbon tax was the 'wedge' yielding the most emission reductions among the options examined. Drawing on the Scandinavian experience, the rate of a carbon tax could be linked to energy or carbon content. If EITI sectors were given a lower rate, this should be subject to an agreement with government on how it will mitigate, drawing on the UK example. If the economic instrument chosen were emissions trading, international experience suggests moving to auctioning of initial allowance – rather than grandfathering – as rapidly as possible. That would cover both EI and EITI sectors. The proposed Australian scheme considered a transitional measure of administratively allocating permits. If this were done, the notion of an appeals process to prevent windfall profits from being achieved at the expense of mitigation would seem desirable.

The recycling of revenue from either a carbon tax or auctioning of allowances can serve several purposes. It could promote more mitigation through increased efficiency, which would be desirable in EI and EITI sectors. It could also support diversification, for example from synfuels to electric vehicles.

Three options considered relate to sectors. Existing policy that favours EI industry should be replaced with incentives for climate-friendly approaches, developing a solar industry programme rather than supporting smelters. A recent study suggests that access to sectoral crediting mechanisms can turn EITI sectors that stand to lose without 'no lose' emissions trading into winners. Domestically, some companies in EI and EITI sectors have set targets for energy- or emissions-intensity. This could be built on as a contribution to the national effort to achieve a deviation below BAU of 34% by 2020.

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Appendices: Supplementary material and data

Table A1: Energy demand (in TJ) per industrial sub-sector (%) between 2001 and 2006

Source: Own calculations based on DME (2001-2006)
Energy consumption (first row for each sub-sector) in TJ, and percentage of total industry energy consumption (second row) in %

Industrial sub-sector	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Average*
Iron and steel	277 078 (27.1)	280 727 (27.4)	292 005 (28.2)	313 771 (26.7)	305 487 (27.6)	293 426 (27.4)	293 749 (27.4)
Non-specified (industry)*	193 139 (18.9)	239 165 (23.4)	232 777 (22.5)	350 907 (29.9)	280 190 (25.3)	282 522 (26.3)	263 117 (24.4)
Mining and quarrying	183 744 (18.0)	183 795 (18.0)	180 699 (17.5)	190 274 (16.2)	204 592 (18.5)	201 982 (18.8)	190 848 (17.8)
Chemical and petrochemical	235 000 (23.0)	184 584 (18.0)	178 524 (17.2)	154 006 (13.1)	141 809 (12.8)	147 625 (13.8)	173 591 (16.3)
Non-ferrous metals	56 974 (5.6)	58 043 (5.7)	58 530 (5.7)	64 630 (5.5)	67 104 (6.1)	67 106 (6.3)	62 065 (5.8)
Non-metallic minerals	43 406 (4.2)	43 944 (4.3)	59 019 (5.7)	67 349 (5.7)	74 818 (6.7)	44 867 (4.2)	55 567 (5.2)
Construction	15 044 (1.5)	15 816 (1.5)	16 939 (1.6)	15 982 (1.4)	16 535 (1.5)	15 665 (1.5)	15 997 (1.5)
Paper pulp and print	8 835 (0.9)	8 837 (0.9)	7 777 (0.8)	7 697 (0.7)	8 635 (0.8)	9 441 (0.9)	8 537 (0.8)
Food and tobacco	3 724 (0.4)	3 785 (0.4)	3 688 (0.4)	3 516 (0.3)	3 783 (0.3)	4 135 (0.4)	3 772 (0.4)
Textile and leather	1 774 (0.2)	1 901 (0.2)	1 880 (0.2)	1 890 (0.2)	1 868 (0.2)	1 868 (0.2)	1 864 (0.2)
Machinery	1 010 (0.1)	1 019 (0.1)	2 337 (0.2)	2 071 (0.2)	2 278 (0.2)	2 479 (0.2)	1 865 (0.2)
Wood and wood products	1 011 (0.1)	1 115 (0.1)	974 (0.1)	1 044 (0.1)	1 068 (0.1)	1 069 (0.1)	1 047 (0.1)
Transport equipment	682 (0.1)	717 (0.1)	343 (0.0)	304 (0.0)	332 (0.0)	329 (0.0)	451 (0.0)
Total	1021419 (100)	1023448 (100)	1035492 (100)	1173440 (100)	1108500 (100)	1072513 (100)	100

Note: Individual sub-sub-sectors are not large energy users, but when put together smaller industries account for just under a quarter of industrial energy demand

Table A2: Annual GDP per industrial sub-sector
Source: SSA (2001–2006)

Industrial sub-sector GDP	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*Average*
Units: GDP in constant 2000 prices, R millions (first row for each sector); Shares of industrial GDP: % (2nd row)							
Non-metallic minerals	4 989 (1.8)	5 470 (1.9)	5 446 (1.9)	5 576 (1.8)	5 806 (1.8)	5 933 (1.8)	5 537 (1.8)
Iron and steel and non-ferrous metals	30 875 (11.0)	34 777 (12.0)	34 456 (11.8)	36 086 (11.9)	37 832 (11.8)	38 667 (11.6)	35 449 (11.7)
Chemical and petrochemical	40 140 (14.3)	39 550 (13.6)	39 478 (13.5)	40 675 (13.4)	41 553 (13.0)	43 362 (13.0)	40 793 (13.5)
Mining and quarrying	63 325 (22.6)	63 927 (22.0)	66 502 (22.8)	67 363 (22.1)	68 818 (21.5)	68 591 (20.5)	66 421 (21.9)
Construction	22 154 (7.9)	23 441 (8.1)	25 053 (8.6)	27 830 (9.1)	31 268 (9.8)	35 494 (10.6)	27 540 (9.0)
Wood and paper, publishing and printing	16 605 (5.9)	16 614 (5.7)	16 381 (5.6)	17 447 (5.7)	18 725 (5.9)	20 824 (6.2)	17 766 (5.8)
Machinery	5 133 (1.8)	5 079 (1.7)	5 084 (1.7)	5 104 (1.7)	5 636 (1.8)	6 246 (1.9)	5 380 (1.8)
Textile and leather	7 503 (2.7)	8 108 (2.8)	7 919 (2.7)	8 599 (2.8)	8 279 (2.6)	8 262 (2.5)	8 112 (2.7)
Food and tobacco	25 582 (9.1)	26 094 (9.0)	24 990 (8.6)	25 847 (8.5)	27 575 (8.6)	28 952 (8.7)	26 507 (8.7)
Transport equipment	16 134 (5.8)	15 925 (5.5)	15 271 (5.2)	16 337 (5.4)	17 469 (5.5)	18 406 (5.5)	16 590 (5.5)
Total of GDP across these industries	279 920	290 377	291 417	304 398	319 517	334 229	100

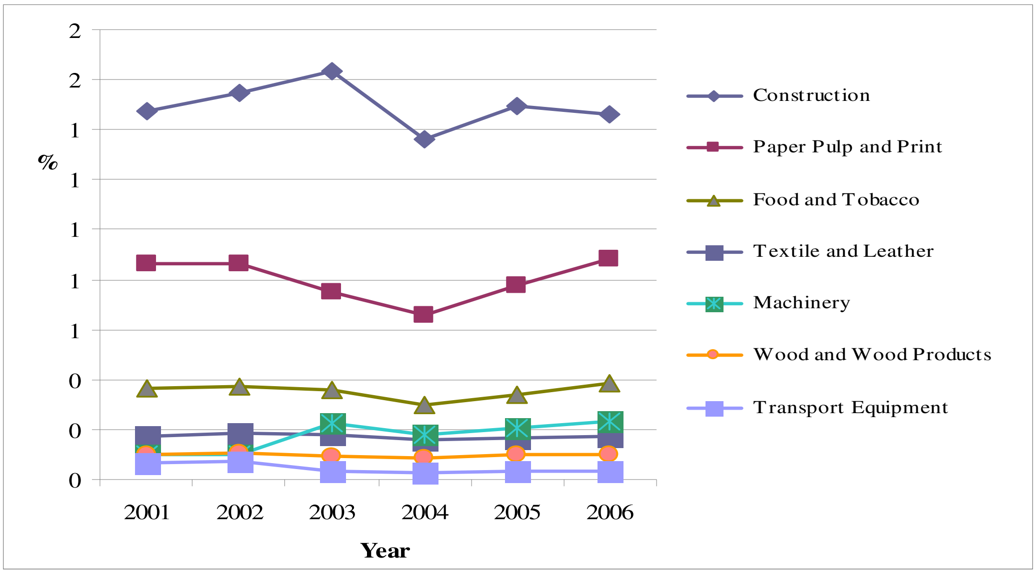

Figure A1: Trends in the other main energy consuming industrial sectors between 2001 and 2006
Source: Own calculations based on DME (2001-2006); SSA (2001–2006)

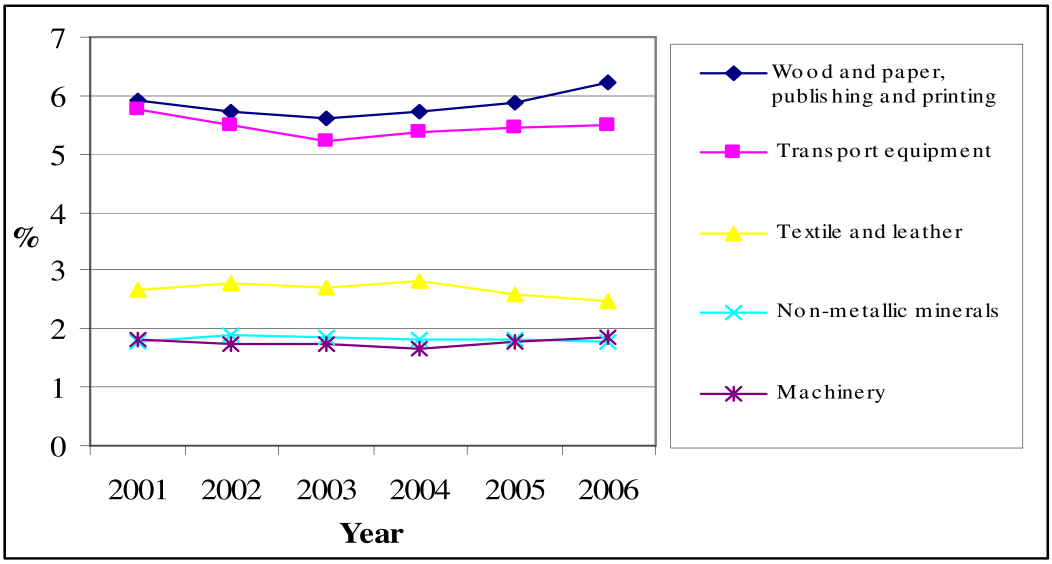

Figure A2: Trends in GDP across the other main industrial sectors between 2001 and 2006
Source: Own calculations based on SSA (2001–2006)

Mitigation in India: Emission trading as a possible policy option

Prabhat Upadhyaya

Abstract

It is important for countries to undertake actions at home in addition to engaging in the international negotiations. The Emission Trading Scheme can be one of the policy tools to promote mitigation actions, but has not yet been implemented in any developing country. The paper gives an overview of the climate change debate, carbon markets and proposed government action to tackle climate change in India. The paper studies the proposed Perform, Achieve and Trade (PAT) scheme in India, under one of its eight national missions to tackle climate change, besides identifying the key design aspects of emission trading based on international experience. The challenges that the PAT will face in the future, if it were to be a flagship programme to tackle carbon emissions as well, are highlighted. The key strengths that the country has to implement such a mechanism and factors that it needs to take into consideration while it is finalising the implementation plan for an in-country enhanced energy efficiency trading scheme are investigated. Based on the initial study, emission trading research topics that need to be analysed in greater detail have been specified.

Keywords: India; Perform, Achieve and Trade (PAT); emission trading design; emission trading experience; implementation challenges; mitigation.

1. Introduction

Climate change is today recognised as one of the biggest problems facing life on earth. There is enough scientific evidence to prove that the problem is anthropogenic in nature (IPCC 2007). The critical questions therefore are who will take the necessary measures (commitments by developed countries and actions by developing countries), how much emission reductions are to be undertake and by when. The 2009 Conference of Parties (COP) in Copenhagen tried to reach an agreement on these questions but the complexity of arriving at solutions can be gauged from the fact that no consensus was reached on a plan of action. The outcome of the negotiations, if it can be so-called, is what is known as the Copenhagen Accord. As many as five countries opposed it, so it could only be taken notice of by the COP, with Cuba opposing it formally (ToI 2010). The Accord, as such, is not a legally binding agreement for it is not a COP decision. However, being a part of the process that resulted in the Copenhagen Accord, India is politically bound to the text. Ultimately, the Accord certainly is not enough to ensure a strong response to the problem of climate change.

1.1 Recent developments

Taking cognisance of an atmosphere marred by lack of trust (Shrivastava & Upadhyaya 2009; Dubhash 2009) and the little time available at hand to reach an agreement to tackle climate change, it becomes important for countries, in their own limited capacities, to prepare domestically so that the implementation of a global agreement in future does not meet unpreparedness. This calls for study of the policy tools that are currently available to facilitate undertaking actions at home in addition to engaging in international negotiations. With its entry into force, the Kyoto Protocol created the foundation for what we now know as carbon markets[1] (Ellis & Tirpak 2006). Emission Trading Schemes (ETSs) and Joint Implementation (JI) in Annex I countries and the Clean Development Mechanism (CDM) in non-Annex I countries have been the prime mechanisms laying the foundation of the carbon markets. It has also been suggested that new mechanisms will play a greater role in the post-2012 carbon market (IETA 2009).

It is in this light that emission trading (ET) as a policy tool to mitigate climate change should be closely examined. The benefits of the successful implementation of such a scheme include that it can enable the generation of fair economic returns which can then be used in a positive fashion towards income redistribution to tackle problems of importance to the country (Tänzler & Steuwer 2009). The design aspects are unique to each ETS. International experience exists in putting the principle of ET to use in developed countries such as those of the European Union (EU). However, no such scheme has been implemented in developing countries as at 2009. In the recent past there have been announcements from some developing countries that signal the potential establishment of domestic trading schemes including in Mexico, China and India. Mexico is in talks with its major emitting companies to set up a cap and trade scheme to take action domestically (Carbonpositive 2009). China plans to include a pilot ET system in its five year plan from 2011 to 2015 (Businessgreen 2009; Reuters 2009). India has indicated undertaking a trading scheme in terms of energy saving certificates based on enhanced energy efficiency for intensive energy users (*The Hindu* 2009; Pew Centre 2008a), but this is different from ET as the commodity being traded will be energy-saving certificates, or white certificates. Against this background the paper examines the specific question of the relevance of ETS as a possible climate change mitigation policy option for India.

The paper is structured as follows. Section 2 gives an overview of India in the context of climate change, its emission profile, negotiating position, mitigation policies and the carbon market. It then outlines the planned enhanced energy efficiency scheme in India along with a briefing on the proposed Perform Achieve and Trade (PAT) scheme (which aims to promote energy efficiency and not tackle emissions as an objective but in the process will reduce emissions). Section 3 considers experience gained from existing ETSs in developed countries. The key building blocks and their design elements discussed. Section 4 analyses the feasibility of implementing ET in India. It highlights key challenges to be addressed if the PAT is to also be the flagship scheme to undertake emission reductions, besides identifying specific areas of study if a new ETS is to be created.

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1 Carbon markets refer to the market scheme where units issued against reduction of GHG emissions are traded for a price. The market here includes both mandatory as well as voluntary schemes.

2. India: Background and factors relevant to implementing ET

In terms of historical emissions (1850-2006) India, the world's fourth largest economy (Pew Center, 2008b), is the ninth-largest greenhouse gas (GHG) emitter, accounting for 2.38% of CO_2 emissions from energy sector (WRI CAIT 2009; Pew Center 2008b). India's total CO_2 emissions in 2006 excluding land use, land use change and forestry (LULUCF) account for less than 5% of global emissions, making it fifth in terms of emissions worldwide (WRI CAIT 2009). Moreover, as economic development is undertaken, India's emissions are also growing, although per capita emissions of 1.7 tCO_2 (WRI CAIT 2009) are low, even relative to other major developing economies (the world average is around 5.8 tCO_2 per capita).

India is home to largest number of poor people in the world, with nearly 35% living on less than a dollar a day. Up to 400 million people (and well over 50% of the rural population) lack access to electricity (FIIA 2009). While climate change is likely to exacerbate India's development challenges, especially for rural and small scale livelihoods, economic development remains the government's overwhelming priority. The economy is growing rapidly, with GDP rising about 8% a year over the past five years. As the economy has grown, emissions intensity (GHGs per unit of GDP) has declined significantly. India's GHG intensity is currently 20% lower than the world average (and 15% and 40% lower than that of the United States and China respectively).

2.1 Emission profile and future estimates

The largest part of India's emissions arises from the energy sector. In 1994 energy accounted for about 61% of total CO_2e emissions – of which almost half came from electricity supply, 20% from industrial fuel combustion and around 11% from transport. Road transport accounted for nearly 90% of transport emissions, the remainder coming from rail, aviation and shipping (MoEF 2004). The World Resources Institute (WRI) estimates suggest that the overall contribution of the energy sector is rising (around 66% by 2005). Of the other sectors, agriculture accounted for 28% of total emissions in 1994 (MoEF 2004) (around 22% in 2005 as per WRI CAIT data sets), industrial process emissions contributed around 6-8%, waste disposal accounted for 2% (rising to nearly 7% in 2005), and land use and land use change accounted for 1% (net carbon storage in 2000).

The emission intensity of India's economy in 2006, estimated at 0.34 $kgCO_2$ per US\$ GDP (at 'purchasing power parity', 2000 prices), was roughly equal to the emission intensity for EU-27 (0.33 $kgCO_2$) and below the world average (0.49 $kgCO_2$) (IEA 2008).

According to a study based on five modelling exercises, per capita emissions projections in 2031 range from 2.77 to 5 tCO_2 (MOEF 2009a), while that of total emissions range from 4 billion to 7 billion tCO_2.

2.2 India and climate change negotiations

India is actively engaged in climate negotiations through the United Nations Framework Convention on Climate Change (UNFCCC). To date, India steadfastly refuses to countenance taking on mandatory emission reductions, arguing that developed countries bear full responsibility to pay for mitigation and adaptation in developing countries, as the dominant historical polluters (MoEF 2009b). At the same time, however, India is highly supportive of collaboration with developed countries to advance and deploy technologies which can both enhance energy access opportunities for India as well as achieve mitigation outcomes. India has maintained its opposition to sectoral-based approaches as it feels them to be a means to place commitments on developing countries and not in accord with the principles of the Convention (MoEF 2009b). A formal stand on ET has not yet been articulated and there are different opinions on using it as possible mitigation tool for the country.

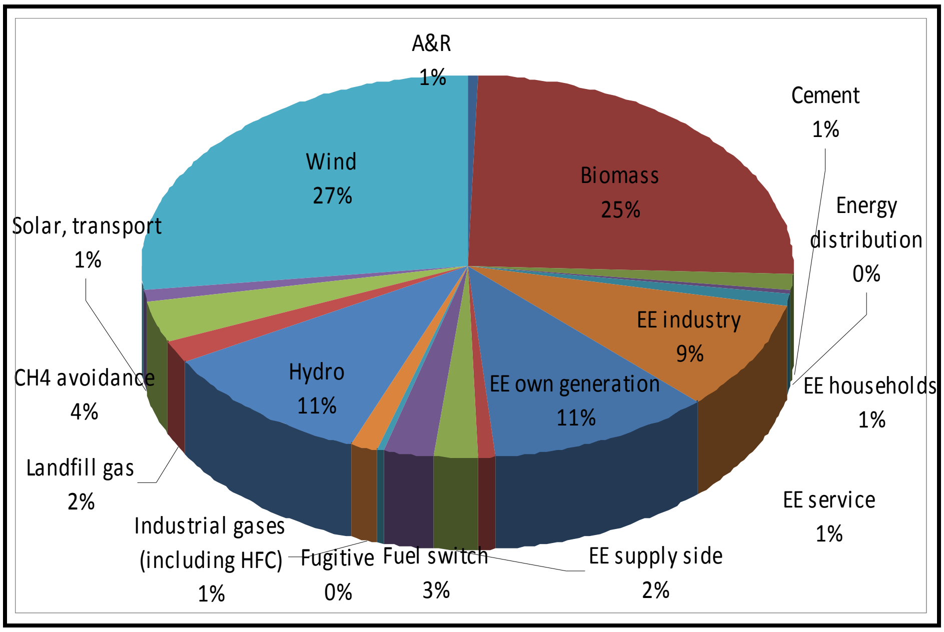
2.3 Policies addressing climate change mitigation in India

India has a number of policies that, while not driven by climate concerns, contribute to climate mitigation by reducing or avoiding GHG emissions. It has also been estimated that in the absence of a number of energy policies that are currently being implemented, CO_2 emissions from the country would be nearly 20% higher compared to business as usual scenarios in both 2021 and 2031 (TERI 2008). In July 2007, Prime Minister Dr. Manmohan Singh publicly committed to ensuring that 'India's per capita emissions never exceed the per capita emissions of the industrialized countries' (GOI 2008). India's strategy for tackling climate change while pursuing development has been set out in its National Action Plan on Climate Change (NAPCC), released in 2008. The NAPCC comprises eight national missions. Some of these are already being finalised. The solar mission, the Jawaharlal Nehru National Solar Mission Towards Building SOLAR INDIA, has already been released (MNES 2009). The mission is ambitious in its approach and aims to have 2000MW of off-grid solar applications by 2022 and 20 000MW of utility grid power by 2022. The National Mission on Enhanced Energy Efficiency gives an indication of using trading schemes as a tool to reach its goals (EMT-India 2009) – this is discussed in section 3.5.

2.4 The carbon market in India

It is also important to take stock of how the carbon market has fared in India till date. Taking note of key lessons will help in preparing the ground for ET in India. Under the Kyoto Protocol India can participate in the international carbon market as a supplier of carbon credits originated from CDM projects. The carbon market in India primarily comprises CDM projects registered with CDM-EB, besides a few scattered voluntary carbon reduction projects.

India was one of the early movers into the CDM market. CDM has been fairly successful in promoting investment in sustainable projects here, and at present India is the second largest supplier of Certified Emission Reductions (CERs) in the world after China, with 20.22% of the 380 million CERs issued till date (UNFCCC 2010a). India also has the second largest number of projects (488) registered with CDM-EB, out of a total 2 057 projects registered worldwide (UNFCCC 2010b). Distribution of these projects by type is given in Figure 1. Programmatic CDM has also started to pick up now. At present, six projects from India feature at the validation stage in the programmatic CDM pipeline (CD4CDM 2010) indicating that the country can move beyond a purely project-based approach. Some of the key factors that ensured success of CDM in India were preparedness of the government to implement CDM; an increase in awareness related to climate change; financial benefit to the industries; and interest generated in academia.



Note: EE: Energy Efficiency, A&R: Afforestation and Reforestation

Figure 1: Distribution of projects in India

Source: UNFCCC (2009)

The carbon market in India still continues to face problems. It is important to take note of key factors that the carbon markets continue to grapple with:

- an inability to generate large-scale projects especially in renewable and energy efficiency;
- low instances of technology transfer from Annex I countries (Seres & Haites 2008);
- the inability of CDM to tackle the problems faced by small and medium enterprises, which are important in India;
- the highly bureaucratic CDM process leading to delays in getting final approval; and
- a lack of clarity on price expectations.

It will be interesting to see whether the carbon markets will continue to have a role in promoting energy efficiency and, if they do, how will it interact with the PAT scheme.

2.5 Enhanced energy efficiency and role of PAT

The National Mission on Enhanced Energy Efficiency is the key focus for future government action on energy efficiency. The mission is in its final stage of preparation and has come up with innovative proposals to promote energy efficiency by making use of the markets.[2] It is intended that the mission will be implemented from 1 April 2010 (Energymanagertraining 2010). The plan outlines four key initiatives:

2 Government officials clearly specify, however, that this scheme is not about emissions but about energy saving certificates and their trading; it will be therefore important in the near future to see how and if such a scheme would link with existing ETS

- Introducing an energy saving certificate trading scheme to maximise the economic efficiency by which large energy-intensive energy users will meet future mandatory efficiency requirements; also referred to as PAT (see Box 1).
- Providing partial risk guarantees to financial institutions for commercial lending to energy service companies (ESCOs).
- Fostering market transformation in appliances, using the carbon market (programmatic CDM) as a financing vehicle. An initial target area is compact fluorescent light bulbs.
- Introducing fiscal signals, namely peak electricity price for industrial and commercial users, as a way of stimulating demand management initiatives.

The PAT scheme (Box 1) makes reference to market-based mechanisms and promotes energy efficiency by making use of energy saving certificates. The nine designated consumer industries will be given goals and consumers will try to reduce their energy intensity. On achieving efficiency beyond the target, consumers will be given tradable energy permits.

An important point is that the PAT scheme is based on emission intensity and will trade energy saving certificates, which implies that technically it will not be an ETS. Rather it will be based on energy saving and will be in line with what are termed white certificates. Its implementation will, however, provide valuable lessons that can prove helpful in designing an ETS in future, notably a chance to get perspective on 'rebound effect' or the extent of increase in consumption of energy services due to reduction in its price on account of undertaking energy efficiency measures (Greening et al 2000; Oikonomou & Patel). It will also help gauge the preparedness of the

Box 1: Perform Achieve and Trade (EMT-India, 2009)

The PAT scheme is a market-based mechanism to enhance energy efficiency in 'designated consumers' (large energy-intensive industries and facilities). The scheme includes the following project steps:

- ***Goal setting:*** *Set a specific energy consumption (SEC) target for each plant, depending on the level of energy intensity (specific energy consumed = energy use / output) of that plant. The target will specify by which percentage a plant has to improve its energy intensity from the base line value in a period of three years.*
- ***Reduction phase:*** *Within a three-year period (2009-2012) the designated consumers try to reduce their energy intensity according to their target.*
- ***Trading phase:*** *Those consumers who exceed their target SEC will be credited tradable energy permits. These permits can be sold to designated consumers who failed to meet their target. Designated consumers who fail to achieve their target have to compensate for this failure by buying permits. If they fail to do either of these, they may have to pay penalties.*

The energy consumption reported by designated consumers is based on an audit by any of the BEE accredited agencies. The BEE may verify correctness of reported values.

administrative structure in the country if downstream approach is to be undertaken.

3. Creating an ETS

ET was first used in North America in the early 1990s for reducing emissions of SOx and NOx. EU-ETS is now the largest mandatory ETS currently in operation. Even though experience with respect to ETS is fairly limited, a lot has been learned and improved upon in the recent past. Some lessons are discussed in detail below. For the convenience of compartmentalising various points related to ETS, Harrison et al (2008) identify three broad categories in which public policy issues related to ETS can be categorised. Based on Harrison et al (2009) these are:

- creating the scheme (defining the design);
- addressing competitive and leakage concerns (protecting the interests of participating entities); and
- linking different schemes (ensuring uniformity across the board).

Perhaps the most important (and basic) finding learnt from trading is that it can be both cost-effective and environmentally effective, particularly if it is of the cap-and-trade variety (Harrison et al 2008). However, the single most important factor that can decide the fate of an ETS is how its design and constituent elements are defined (Tyler et al 2009). Whether ET will be included as a globally acceptable flexible instrument or not is dependent on outcome of these negotiations. This paper will therefore limit the discussion to the realm of national political dynamics and will focus on design elements alone.

In designing an ETS, policy-makers must take into consideration not only the quantitative but also the political, economic and regulatory aspects of its implementation into consideration. It is important to remember that the biggest ETS at the moment, EU-ETS, grew out of failure that was more political in nature. The two failures that paved ground for the EU-ETS were firstly, the failure of the EC to have an EU-wide carbon energy tax in the nineties, secondly, the EC was not successful in blocking the inclusion of trading as a flexible instrument in the Kyoto Protocol in 1997 (Convery 2009; Christiansen & Wettestad 2003). After opposing ET, several unexpected developments made the EC embrace it within six month as a cornerstone of its climate change strategy. Such factors can also influence how a particular ETS interacts with other such schemes in future (Flachsland et al 2009). The USA has seen bills being tabled for approval by the House of Representatives and the Senate. These various bills are discussed briefly. At the moment all eyes are set on US domestic climate legislation that includes a Cap-and-Trade system. The future of the same is hugely dependent on political and economic developments in the USA.

3.1 Point of regulation

Systems can be 'upstream', wherein the trading of emissions takes place at the level of fuel providers such as mining industries, or 'downstream', where regulation occurs at the point of direct emissions such as manufacturing industries. The upstream approach will target fewer point sources thus bringing simplicity and ease of administration and monitoring, whereas a downstream approach can cover a higher number of emission sources, thus bringing liquidity and flexibility. It is advisable that the decision of coverage be based on local conditions and the capacity of the implementing entity.

Currently the EU-ETS follows the downstream approach covering close to half of EU CO_2 emissions by encompassing nearly 12 000 installations. It does not currently cover households, agriculture, or transport. Aviation has, however, been included in the second phase of EU-ETS (Euractiv 2009). The Regional Greenhouse Gas Initiative (RGGI) only covers power plants at the moment (Litz 2009a) and is spread across 10 states in the US. The United Kingdom Emission Trading Scheme (UK-ETS) comprises direct and indirect emission sources. The American Clean Energy and Security Act (ACESA; also known as the Waxman-Markey Bill) in the US has proposed to cover entities having emission above 25 Kt CO_2e. US trading proposals have proposed to follow a hybrid approach including both downstream and upstream emitters. The New South Wales GHG Reduction Scheme and the Australian Carbon Pollution Reduction Scheme include both direct and indirect scope 2 emissions.

The downstream approach has been dealt with quite satisfactorily in EU-ETS. Having bigger and fewer industries made it easier to monitor and administer the scheme. India will need to be cautious in deciding the approach to be followed and industries to be included, as the country has a huge number of SMEs.

3.2 GHG emission and sources

The implementation of an ETS is not possible without GHG emissions data which is robust and consistent across years. Emissions data is necessary for a number of reasons, such as defining the starting point (baseline), deciding upon the number of allowances to be introduced into the system, defining the liability of defaulters, and deciding on the scope, target type as well as the sectors to be covered at different stages (Litz 2009b). Data of a single year may not be representative and so it is always preferred to have data available consistently from different years. The availability of data alone, however, cannot ensure the implementation of a system as dynamic as an ETS.

All six GHGs currently covered by the Kyoto Protocol can be targeted by an ETS. In the first phase of the EU-ETS the scheme covered CO_2 and provided opt-in for additional gases to its member states, whereas it has been proposed to include gases other than CO_2 in the second phase. The RGGI covers direct CO_2 emissions from power plants which run on fossil fuels. The Chicago Climate Exchange (CCX) and UK-ETS both covered all six Kyoto GHG. Both of these schemes are voluntary in nature. The ACESA proposes to cover all six gases.

The availability of data decides whether all the six gases can be covered or not. India has covered CO_2, CH_4 and N_2O emissions in its National Communications and so the data availability will be better for these gases. Effort though will be needed to measure remaining three gases as well so that in due course of time emissions of all the six gases can be accounted.

3.3 Allocation or auction

Whether the allowances are to be auctioned or are to be given for free is a contentious issue. In the past, especially during the first phase, the allocation has typically been done by using a grandfathering approach or giving allowances for free on the basis of historical emissions. Arguments for free allocation of allowances can include past output per unit of emissions or compensation against adverse impact of ET on companies. Of late, auctioning is gaining support as it addresses the concern of 'windfall profits' to some entities (Harrison et al 2008). Most member states though, have an interest to support their national industry through allowance over allocation. This can be detrimental to the environmental effectiveness of the system (Clo 2009). An entity can also decide on when to undertake auction. As the market, especially in its formative years, is far from being perfect, it is preferable to have frequent auctions initially leading towards a single auction (Mandell 2005), thus reducing transaction costs and tackling the possibility of collusive behaviour amongst the bidders.

Auctioning was limited to a maximum of 5% for Phase I and 10% for Phase II in EU-ETS, but the actual level of auctioning for both phases has remained far below these levels (Harrison et al 2008). It has been proposed to have 100% auction by 2020. In RGGI, allowance allocations are left to each state, but all states agree to set aside 5% of their emissions budget to fund environmental benefits (Mace et al 2008). The EU-ETS is continuously improving distribution of allowances in the system. Environmental effectiveness and economic feasibility are to be considered while deciding how the allowances are dealt with.

In United States of America (USA), ACESA, being one of the main pieces of climate legislation currently under consideration by Congress and which passed in the House of Representatives in June 2009, has specific allowances to aid both industry and consumers who could be affected by the introduction of the Bill. Significantly, between 2012 and 2025, 76% of the allowances are to be allocated towards consumer assistance schemes. This value then increases to 83% from 2025 to 2050 (Larsen & Heilmayr 2009).

A mix of grandfathering and auctioning approach is preferable in initial stages. The managing entity can also hold back certain amount of allowances so as to control the price volatility particularly close to end of a phase.

3.4 Timeframes

A long-term market signal increases certainty, which is of importance to business. A long lead time can help the business to take important investment decisions that are synchronised with compliance needs. Also it reduces transaction costs and increases confidence. Timeframes decided after taking a stakeholder's viewpoint into consideration will enjoy the benefit of participant approval. Having lead time will provide space for rectifying any problem faced in the systems and increasing their efficacy. The same was seen in the phase I of EU-ETS wherein almost all the member states over allocated the allowances resulting in a steep price dip in the ETS. As a result they were more conservative when allocating the allowances for Phase 2.

The first phase of EU-ETS from 2005-07 was a learning phase. Phase 2 (2008-12) coincides with the Kyoto Protocol's commitment period. The EU is committed for Phase 3 from 2013-20 and has maintained a target of minimum 20% emission reduction below 1990 level by 2020 that can be increased to 30% if other developed countries take up ambitious targets after COP15 as well (UNFCCC 2010c). RGGI aims to stabilise emissions by 2014 and to reduce 13% below 1990 level by 2019 (Litz 2009a). The America's Climate Security Act (ACSA; Also known as the Lieberman-Warner Bill) in USA gives a signal to have 72% reduction below 2005 level by 2050 using only caps (WRI 2009).

There is still a lot of uncertainty around RGGI and the time-frame involved. EU-ETS, on the other hand, with experience behind it, generates much more confidence regarding its future. Long-term planning and market signals ensure that the entities participating in the scheme can manage their investment behaviour. On the flip-side, the entities can delay the investment to make a rush to buy credits at the last minute and thus increasing the volatility in the overall market (Tyler et al 2009).

3.5 Offsets

Offsets and their usage is a policy issue which is of direct interest for developing countries as well. It is the prerogative of the governing entity to decide the extent of offsets to be allowed in the system, at what time and at what prices. As of now, CDM and JI brings in international offsets for usage in various ETS. The CDM is one of the first kinds of mechanisms to be implemented in developing countries and has an inbuilt mechanism wherein the CDM Executive Board (CDM-EB) meets and decides to take steps to improve CDM on a regular basis. A trading scheme can decide whether to include uptake of such credits or not. The points to be considered while deciding upon the role that offsets (Mace et al 2008) can play are relative stringency, differences in project eligibility, and the difference in any quantitative limit on usage of credits while linking the ETS.

The offsets are not to be confused with allowances that are set aside. Offset are created outside the system under discussion and can be used for meeting the targets, whereas allowances are a permit for an entity to emit. The credits from sink projects are not eligible in EU-ETS whereas in USA they were acceptable under the Boxer-Lieberman-Warner Bill. Offsets from domestic Afforestation and Reforestation (A&R) projects that meet the definitions for these activities established under the CDM are recognized by the New South Wales Greenhouse Gas Reduction Scheme. The proposals in USA vary in the type of offsets allowed and restriction on their usage (Sterk & Kruger 2009). Boxer-Lieberman-Warner allows 15% of compliance credits to be routed from domestic offsets schemes and 15% from international offsets. The ACESA makes way for two billion tons of offsets annually. It starts discounting international offsets after the first five years of the programme. All the major proposals in USA allow for potential usage of international offsets. Waxman-Markey allows for one billion tonnes of international offsets that can be increased to 1.5 billion tonnes under certain circumstances. Kerry Boxer has the provision to increase international offsets from 0.5 billion tonnes to up to 1.25 billion tonnes under certain circumstance (WRI 2009).

A number of other issues need to be taken into consideration while designing an ETS. However, the points discussed above are the basic building blocks of any ET and so warrant a thorough analysis while applying them to local conditions.

3.6 Key learnings

Any ETS rests on mutually agreed reduction targets (Ott & Sachs 2000). Based on the above discussion, some of the key points to be considered while designing any new ETS are as follows:

- The point of regulation needs be decided, based on the spread of industry and sectors that are major emitters of GHGs. If there are a large number of small energy consumers then it is not advisable to follow downstream approach. Similarly if the sector comprises a couple of very large fossil fuel providers then the ETS can get monopolised.
- Based on availability of data, the gases to be covered need to be identified. It is preferable that the data for a number of years is available.

- In the initial stage of ET, a grandfathering approach is advisable. It can give free permits to large polluters, therefore it should give way to auction-based allocation so as to promote fair distribution, environmental integrity and circumvent windfall profits. The process of auction can be further streamlined to avoid collusion.
- It is preferable to have a long time-frame so that the market participants can take long-term decisions regarding their investments and take a longer planning horizon as reference.
- Demand of offsets can stimulate markets in developing countries. However, care must be taken, as the small markets can become price takers and they might lose control of pricing by linking to a big ETS. It will be interesting to see whether registries can help to nullify this threat by playing role of an intermediary system between a number of buyers and sellers.
- It is desirable that a scheme has different phases so that the learning can be incorporated into the system at different points.

When dealing with the design aspects, factors that make implementation of ET smooth should be focused upon.

4. Implementing ET in India – Analysis

Based on the discussion in section 2 on the NAPCC, it can be inferred that there is a strong political will in the country to tackle climate change. A successful carbon market developed by implementation of CDM projects also indicates that industry is willing to rise to the challenge of reducing GHG emissions. The pressure exerted by civil society and media coverage given to the issue of climate change in COP 15 indicates a rising awareness on climate change issues in the country. The local environment is supportive of actions being taken by government to tackle climate change and scrutiny will ensure that they are ambitious enough, as has been witnessed in the case of the National Solar Mission. It can therefore be said that the country is well placed to look at the possibility of implementing an ETS.

There is a considerable interest both nationally and internationally in the proposed energy saving certificate scheme based on plant specific energy intensity. The BEE has given it priority by including it in the mission document, reflecting that the policy environment is in favour of such a scheme. India is also home to some of the most efficient plants in the world, especially in the cement sector. These sectors can lead the efforts to promote energy efficiency in the country, as well as globally. However given that Indian industry also comprises a large portion of small and medium enterprises, it will not be possible to incorporate these players at the moment. The administrative and regulatory structure needed to tap these players will need some implementation experience. Taking these factors into consideration the currently proposed PAT scheme focuses on a small number of target-specific industries. A combination of downstream and upstream regulation may be followed to include a varied scale of industry present in the country.

With reference to implementing an ET in the country, the proposed PAT scheme by BEE will serve to give good learning experience to the nation. Alhough essentially based on the concept of white certificates, it will bring out key lessons for ET as a possible policy tool. The policy-makers may decide to make this scheme itself the flagship emission reduction scheme with appropriate modifications or undertake a parallel new scheme in the future that will specifically aim at reducing emissions.

However, the answers to this policy question will be influenced by developments made at the international negotiations as well as by the experience gained from PAT. If, however, we assume that PAT will be the flagship scheme and a vehicle to promote both energy efficiency and emission reduction at the same time, then the following challenges need to be taken care of:

- It is imperative that the inventory of emissions in the country is comprehensive. As of now India communicates its emissions via National Communication. The Second National Communication is in the process of formulation. Data collection and its reporting will be needed at a much more frequent rate.
- Legal frameworks on means to collect data, specifying enforceable entities and the penalties for not meeting the targets, should be clearly laid out. Incorporating a voluntary phase can help to streamline the operation in future.
- A long-term signal is imperative so that the investment decisions get a favourable policy environment.
- There needs to be clarity on the targets given to the players.
- Sectors such as agriculture, forestry, building and transport that involve a huge number of point sources should not be included in the initial phase of any such scheme. Even in later stages these may to be included only after assessing the preparedness of the administrative machinery to handle these sectors that include a large number of emission sources.
- A common registry is to be formulated that is accessible by all the parties concerned. This will help in avoiding information asymmetry.
- The approach towards allocating emission allowances is to be defined; however, an effort to move towards auctioning in the long run is advisable.
- Trading rules should be legally embedded and the defaulters be made to pay penalties that can be used to further work upon the guiding objective of the scheme. For the same reason a robust regulatory mechanism needs to be put into place.

Based on an initial study it can be inferred that the ETS could be one of the policy instruments that the government could implement in the future. The proposed PAT will give the necessary experience; however, if ETS is to be created in the near future in the country for undertaking emission reductions then further study is needed on following specific issues:

- A detailed analysis of existing ETS and their design elements is needed to internalise the salient features.
- The point of regulation, whether upstream or downstream, to factor in varying industry types in country, particularly the SME sector.
- It is too early to comment on the possibility of linking PAT with existing schemes. In the near future this will demand closer scrutiny so as to increase the market demand.
- Price concerns will need to be taken care of, in addition to meeting the stringent standards needed in some of the schemes. The possibilities of including a safety valve to stop the sale of credits if a certain minimum price is reached, and to auction more credits to bring down the price, also need exploration.

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Regulating energy demand and consumption in South Africa: Is carbon pricing sufficient?

Tebogo Makube

Abstract

Globally, attention is being given to fossil fuels and their impact on climate change, environment, health and related issues. The economic policy issue is that carbon emissions represent a negative environmental externality, and in many cases the value of emissions is not easily monetised. Achieving sustained levels of economic growth, whilst protecting the environment and fostering sustainable development involves a complex trade-off. South Africa is not spared from this trepidation, because of high environmental emission levels brought about by its heavy reliance on fossil fuels for economic growth and development.

Economic instruments are touted as cost-effective in dealing with climate change challenges. However, this study contends that economic instruments are important but not sufficient in comprehensively dealing with the impacts of climate change. In order to reduce emissions and transit towards low carbon economy, South Africa needs a myriad policy interventions to alter the economic structure which in the first place gives rise to environmental emissions. There is a need to reduce overall energy intensity whilst extracting more productivity and consumer welfare per unit of energy consumed. This will involve policy choices and complex trade-offs to balance the interconnection between economic growth, climate change and sustainable development.

Keywords: cap and trade, carbon tax, monopoly, Pigouvian tax, competition, regulation

1. Introduction

Climate change and carbon pricing have been dominating energy and environmental policy debates in recent years. Globally, countries are aware of the risks and opportunities associated with greenhouse gas emissions and mitigation. Many have taken steps to reduce heavy reliance on fossil fuels, and adopt climate change policies. The debate on these policies is centred on strategies needed to migrate to a low carbon economy. This relates to the pricing of carbon emissions to the development of clean energy technologies.

In analysing the efficacy of climate change policies and carbon emission strategies it is important to understand historical energy supply and demand patterns. It should be noted that energy supply and demand are influenced by government policies on matters such as the economic structure and growth patterns, socio-economic and, infrastructure priorities, transport policies and spatial development patterns, amongst other things. Government regulation of the energy supply industry and the environment also affects the overall performance of the industry from a supply and demand perspective.

This study examines the implications of implementing climate change policies and carbon emission strategies in South Africa. An attempt is made to answer complex political economy questions relating to climate change and mitigation instruments. In the carbon pricing policy debates, questions of political economy are embedded and involve tradeoffs. In dealing with climate change policy issues, public choice decisions will have to be taken on: (i) strategies to reduce energy intensity whilst growing the economy; (ii) carbon pricing instruments (taxes, caps and incentives); and (iii) the policy mix required to migrate to a low carbon economy. Any policy choice on these matters will have economic, technological and behavioural implications. Nonetheless, countries are incorporating the risks and opportunities associated with the physical effects of climate change in their economic policy scenarios. A contention is made that in South Africa, for carbon pricing to have an intended effect, other policy aspects of the South African economy such as spatial development plans, industrial, housing and transport policies will have to be reviewed as well. These latter policies are an externality to energy demand.

2. Methodology and purpose of the study

This study investigates how carbon emission mitigation policies will economically affect energy demand and consumption in South Africa. It draws on economic theory and on empirical studies with implementation of climate change policies and strategies. The study uses economic literature and data to illustrate the impact of abovementioned policies and to argue that, if not properly designed, carbon regulation may be regressive. An assertion is made here that energy is a key input which turns factors of production into goods and services; it is also a key input into the standard of living for households (Nordhaus, 1980). The structure of the energy industry as well as the performance is analysed in order to understand the dynamics of regulatory procedures to must accompany the evolution of climate policies in South Africa.

These factors are reviewed and inform the analysis of this study, which thoroughly reviews carbon tax as an economic instrument. It drills deeper on tax design issues, especially the revenue source, the tax base and rate, including distributional issues regarding the tax incidence. It also reviews in detail international trade concerns regarding the efficacy of carbon tax and its limitations, and uses the analysis generated from literature and data to recommend an exposition of novel paths for South Africa's transition to a low carbon economy.

3. Energy supply and demand in South Africa

South Africa has an abundance of coal which is the main source of energy and accounts for 73% of total primary energy supply (TPES) (DME 2006). As Figure 1 shows, oil accounts for 17% of the supply, and about 63 per cent (319 000 barrels per day) of the crude oil used in South Africa in 2006 was imported, the remainder generated from coal through a petrochemical programme (EIA 2007).

Energy supply is critical for transport, agriculture, mining and industry. South Africa's rising energy demand in recent years has been influenced, amongst other things, by firm economic growth rates spanning five years until 2009, the emergence of a black middle class, increasing motor vehicle usage, infrastructure and property booms (National Treasury 2008). In essence, South Africa's economic structure and land-use patterns largely determine energy needs. It is, therefore, important to consider is the overall role of energy in the economy. In order to get an understanding of the importance of this role, a comparison of the relationship between TPES and gross domestic product (GDP) is made here. South Africa's energy usage to produce one unit of GDP is compared with other selected developed and developing countries, as energy use relative to GDP is an important indicator for understanding the relationship of energy consumption to economic growth in any country (Suehiro 2007).

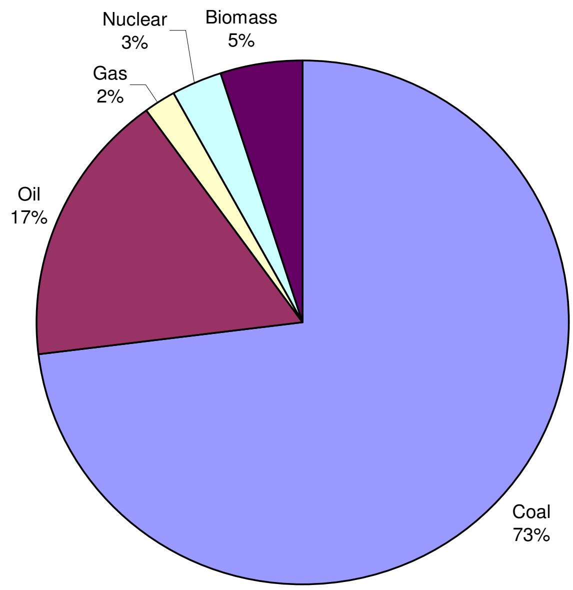

Figure 1: Total primary energy supply in South Africa
Source: DME (2006)

Analysis of the relationship between TPES and GDP per capita from 1971 to 2007 in (China, Germany, India, Malaysia, Spain, South Korea and South Africa) is presented in Figure 2. TPES is expressed in tonnes of oil equivalent per capita and GDP per capita. There are striking differences in energy supply and economic growth in these countries. In South Korea, TPES per capita in 2007 was nine times higher than in 1971, and it more than doubled in Spain over the same period (OECD 2009). In the 1970s, South Korea had low TPES/per capita levels relative to South Africa but it has bypassed the latter by making its economy competitive and export-oriented, thus increasing its economic growth levels. In the 1970s, Malaysia also had low TPES per capita levels relative to South Africa but is quickly catching up. Germany has used its comparative advantage in technological development to increase its energy efficiency whilst at the same time increasing its economic growth. China and India have rapidly increased their GDP per capita levels over the years but TPES per capita remains relatively low (OECD 2009). In South Africa, the annual per capita energy consumption is 2.51 tons of oil equivalents (toe) compared to a world average of 1.67 (Cooper 2007; OECD 2009). The next section measures energy intensity in South Africa in relation to other countries.

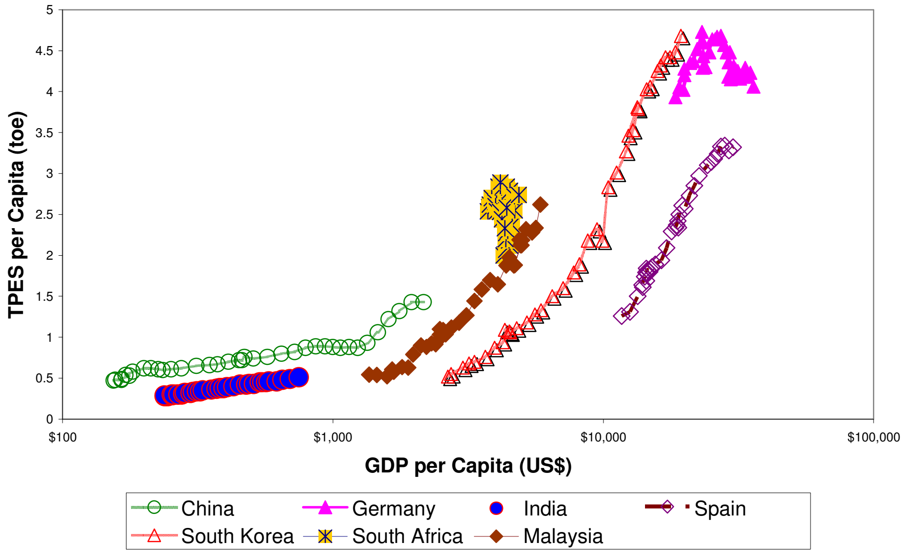

Figure 2: TPES per capita in tons of oil equivalent versus GDP per capita (1971-2007)

Source: Cooper (2007); OECD (2009); own calculations

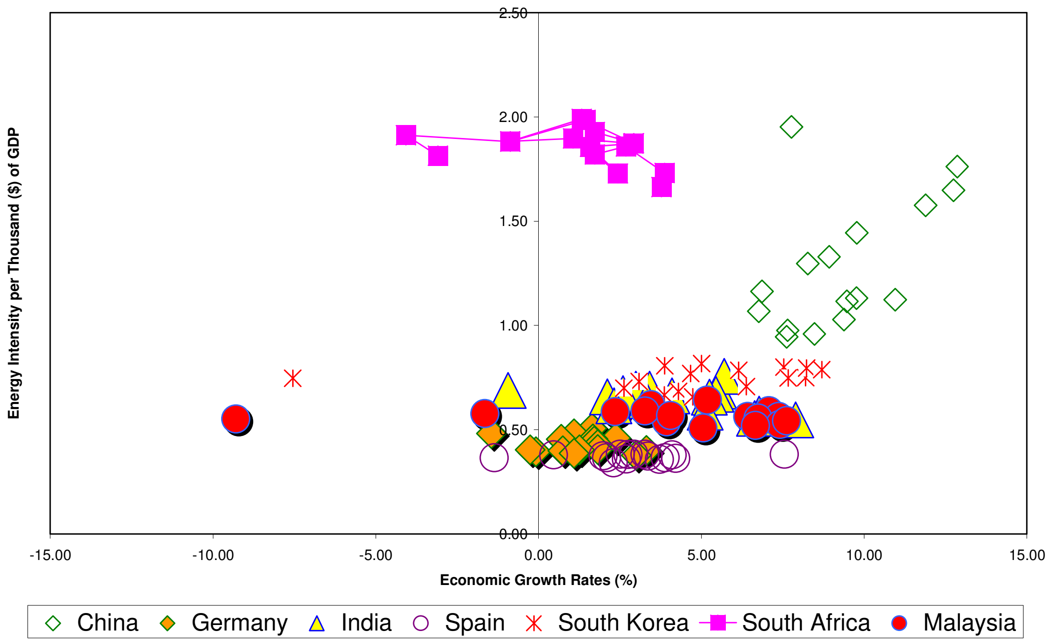

Figure 3: Energy intensity versus economic growth rates (1991-2006)

Source: Cooper (2007); OECD (2009); own calculations

A comparison of energy intensity per thousand of dollars of GDP and economic growth rates in China, Germany, India, Malaysia, Spain, South Korea and South Africa from 1991 to 2006 is reflected in Figure 3. This is an assessment of the changes in the ratio of energy use to GDP. The comparison shows that the South African economy is highly energy-intensive relative to the others. What is striking is that over the years these other countries have been able to grow their economies using less energy. China is rapidly growing its economy but also intensifying its energy use. High energy-intensity levels in South Africa are a result of mining, primary minerals beneficiation companies, a synthetic fuels industry and electricity generation which is dominated by coal-fired power stations (DME 2006). Cheap energy policies may once have been sensible to stimulate industrial development in South Africa but now there is a legacy of energy inefficiency which imposes economic, social and environmental harm. The situation in a way confirms the assertion made by Fine and Rustomjee (2006) that South Africa's economy is trapped in the minerals-energy complex (MEC). According to them the MEC conundrum has been used as a form of economic accumulation in South Africa.

There is no doubt that economic growth is inextricably linked to energy. Economists argue that GDP and other economic indictors are important measures of the performance economy over time. However, these indicators are not sufficient measures of societal wellbeing or welfare, because environmental emissions impose transaction costs to society which often are not monetised (Tietenberg 2001). Besides high energy intensity, South Africa has high carbon emissions which are not fully costed. Unwanted by-products or negative externalities such as environmental pollution are in many countries not measured. Firms fail to take into account full economic and social costs of their environmental emissions which tend to be greater than socially efficient levels (Perman et al 2003).

The Organisation for Economic Cooperation and Development (OECD 2009) estimates that in 2005 South Africa's carbon emissions per capita were 2.35 mtoe and energy intensity was 2.8 mtoe. South Africa's carbon emissions per capita of GDP are considerably higher than in most developed countries (e.g. Germany, Spain and South Korea) and other developing countries (e.g. India and Malaysia) (see Figure 4). Part of the reason for this is that 'the petrochemical programmes is at least sixty per cent more greenhouse gas intensive than conventional oil refining' (Copans 2008: 1).

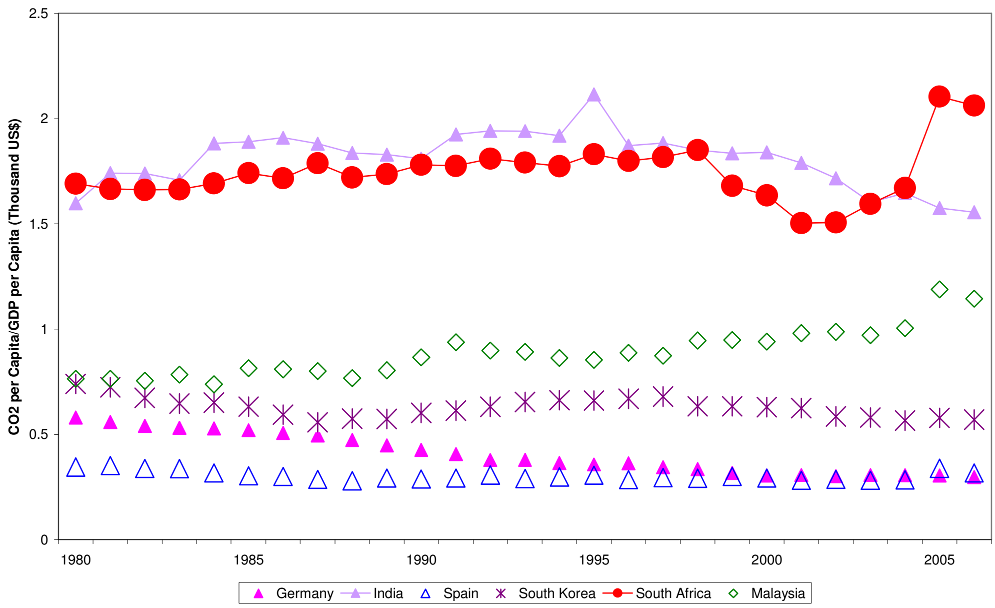

Figure 4: Carbon emissions and economic growth (1980-2006)
Source: Nakata and Matsumoto (2008); OECD (2009); own calculations

Although South Africa is still classified as a developing, or 'non-Annex I', country in terms of the United Nations Framework Convention on Climate Change (Kyoto

Protocol), its carbon emissions per capita of GDP are considerably higher than other countries. This puts the country increasingly under pressure to take proactive action to mitigate environmental emissions. Another issue to consider is that South Africa's heavy dependence on fossil fuels has both internal and external economic costs because part of the energy supply is imported. This necessitates serious political, economic and regulatory considerations. In responding to conundrum and broadly dealing with climate change challenges, the South African government approved the Long-Term Mitigation Scenarios (LTMS) process in 2007. The purpose of LTMS was to 'outline different scenarios of mitigation action, to inform long-term national policy and to provide a solid basis for South Africa's position in multi-lateral climate negotiations on a post-2012 climate regime' (DEAT: 2007:1). Realising the objectives of LTMS require critical thinking on a variety of policies and instruments. The next section discusses policy instruments which South Africa must consider in dealing with climate change and environmental regulation challenges.

4. Economic instruments for mitigating against carbon emissions

Arthur Cecil Pigou (1877-1953) argued that environmental degradation and resource depletion generate a social cost that should be dealt with by the government through taxes and not by markets. Pigou saw taxes and regulations as the best way to promote economic efficiency in the presence of spillover costs (Pigou 1960). Environmental taxes also classified as Pigouvian taxes became an orthodox approach to internalise negative externalities into the price system (Herber & Raga 1995). The fervour for environmental taxes also gained momentum with the double dividend hypothesis, meaning that revenues from carbon taxes can be used to cut other taxes. The first dividend will be realised when an improvement in environmental quality is secured and the second dividend will be realised when there are gains in economic efficiency which can lead to employment opportunities, all other things being equal. In essence, double dividend asserts that a carbon tax reform does not only contribute to sustainable environment but also increases non-environmental welfare (Morden 2009).

The rationality for environmental taxes or Pigouvian taxes was challenged by Ronald Coase (Lee & Sanger, 2008). The Coase theorem postulates that there is no need for government intervention because if parties in the transaction, that is, the polluter and the victim, are properly organised they can agree on the settlement cost for environmental damage (Lee & Sanger 2008). Coase argued that for as long as property rights are defined and allocated, there is no need for a command-and-control system of regulation. His point is that the market fails to fix the environmental problems because no one or both parties has the property rights.

The Coase theorem assumes that Pigovian taxes are inefficient. He postulates that 'in the absence of taxes and regulations, (suppliers and bystanders) will find the most efficient of all possible solutions and agree to a system of reimbursements or bribes that will make them both better off. The most efficient outcome could be either a cutback in production or some scheme for eliminating or reducing (the harmful effects)' (Landsburg 2002: 456). However, the Coase theorem is limited in dealing with people without property rights but are affected by environmental externalities. In such a situation, government has a role to correct the market failure. It should be noted that pricing carbon either through taxes, tradable permits or regulation means that society will bear the social costs of resource utilisation. A consideration should be made that any form of regulatory model maximises social benefits. The next section discusses policy issues and instruments to be considered in applying carbon prices.

4.1 Pricing carbon: choice of policy instruments

According to Lee and Sanger (2008) energy sources upon which carbon prices are imposed are both inputs into the production of goods and services and a final product purchased by consumers. This presupposes that there must be a distinction between the direct and indirect effects of carbon taxes. This distinction is important for analysing the economic effects of a carbon tax and its effectiveness as a vehicle of environmental policy.

This consideration is part of several policy issues that are at the core of climate change mitigation strategies. One key policy issue is whether a country prefers to have a system with direct control over price (a tax) or with indirect control over price (cap and trade). A carbon tax as an economic instrument puts a price tag on emissions; cap-and-trade sets a quantity target. A policy issue is to consider the effect of carbon prices on coal-reliant countries such as South Africa and this relates to industries' competitiveness, and distributional consequences. Grainger and Kolstad (2009) assert that the distributional effect on consumers arises because a carbon tax can be applied to consumers as well as industry, but a cap and trade system can only be applied to industry. They also argue that cap and trade has typically been applied at the point of emissions, targeting large emitters due to administrative complexities whilst a pure carbon tax offers certainty of price. Cap and trade is a form of rationing; economic literature teaches that in a rationed market, predictable behaviours, such as rent-seeking, generally emerge. Any choice of an economic instrument has to pass a test of credibility and reliability, objectivity, transparency and simplicity. Carbon tax has an advantage over other economic instruments because it is designed on the basis of a existing tax collection system and administrative simplicity.

4.2 Carbon tax: design and targeting issues

Herber and Raga (1995) contend that since fossil fuels do not emit carbon in their natural state, a carbon tax on the stocks of such fuels would be meaningless. They propose that a tax should take the form of an excise tax levied upon carbon emissions which result from the use of such fuels to produce energy for production and consumption purposes. However, they acknowledge that it is administratively difficult to levy an excise duty at the actual time of environmental emissions. Part of good tax design is to ensure that the tax system is transparent, meaning that the underlying purpose and principles behind the design of a carbon tax should be clearly identified: it should be clear what is being taxed, who is liable, and how their liability is calculated. Alternative methods of imposing a carbon tax as recommended by Herber and Raga include: 'a) a primary carbon tax on fossil fuels when they are mined or imported into a nation, or (b) a final carbon tax when fossil fuels are sold to industry and households for production and consumption purposes.' Public finance literature teaches that when a tax is imposed on a final product, its incidence is the same whether the tax is levied on the consumer or on the seller. The same literature teaches that in designing any tax system, the source of revenue, base and rate should be specified and transparent. Herber and Raga further propose that for environmental tax, 'the base should be defined in specific rather than ad valorem terms since it is the physical amount of fuel used to produce energy that is linked to carbon emissions, not the pre-tax price of the fuel'.

In determining carbon tax rates, Lee and Sanger (2008) propose that differential marginal tax rates should be imposed upon the various fossil fuels based on the various amounts of carbon per unit of energy production they emi. They are of the view that carbon taxes should be imposed solely upon fossil fuels and not upon alternative sources of energy which do not emit carbon. In designing a carbon tax, it should be noted that coal emits 25.1, oil 20.3, and natural gas 14.5 grams of carbon per 1000 British Thermal Units (BTUs) of energy production (EIA 2007). This shows that coal has the largest carbon emissions per unit of heat energy of any of the fossil fuels; as such the carbon tax rate should be highest on coal, next-highest on oil, and lowest on natural gas in accordance with the above mentioned carbon intensity ratios (Herber & Raga 1995). Where similar substitute or alternative energy sources are taxed differently, substantial behavioural changes can be expected when the tax rate is significant, on coal for instance. Similarly, a pure carbon tax, which taxes coal more heavily than any other source of energy, will be disproportionately burdensome on South Africa.

The implementation of a carbon tax is expected to generate macroeconomic effects (employment, output and changes in the price level), distributional effects (changes in the distribution of income and of the tax burden), and environmental effects (the primary goal being a reduction in carbon emissions, and the secondary objective, and a reduction in overall energy consumption reduction in greenhouse gas emissions) (Lee & Sanger, 2008). In the case of energy-intensive companies, fossil-based energy sources are important production factors and the carbon tax will alter the relative price of these inputs. Depending on the economic and technological viability of non-fossil fuels, there is the potential for input substitution in the production process as well as shifting of the tax through the price mechanism (Farzin & Kort 2000).

To illustrate the economic transmission mechanism of carbon prices, Figure 5 shows that the equilibrium point is set at point *E,* where demand and supply functions intersect. The challenge is that at point *E,* the industry also imposes a huge negative environmental externality on society as shown by the marginal social cost (*MSC*) function lying above the industry supply or marginal private cost (*MPC1*) function. In this regard, the size of the negative environmental externality is the distance *EF* in unit terms, or the triangle *EFG*. This indicates the level of environmental emissions.

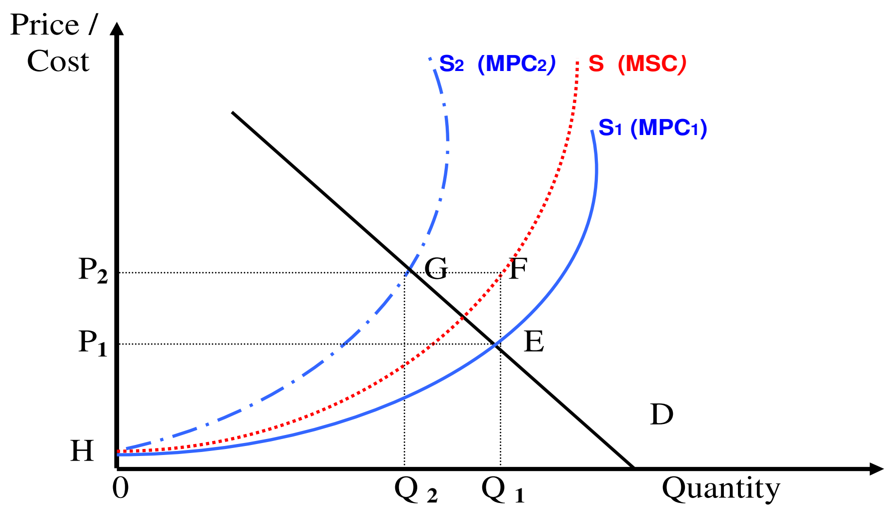

Figure 5: Economic impact of environmental regulation
Source: Adapted from Sloman (2000)

By introducing new environmental regulations to curb emissions, Figure 5 shows that the private cost of production will rise by *EG,* shifting the industry supply function from S_1 to S_2. Whilst this will eliminate the economic cost of emissions, at the initial equilibrium point *E* there will be excess demand for services equal to Q_2–Q_1. This will raise prices and lower quantity, until the new equilibrium at point *G* is reached. The net effect of a cut back in output to Q_2 will be job losses as production declines, coupled to a rise in the price to P_2. The economic impact will also depend on the price elasticity of demand and marginal rate of substitution between factors of production. This scenario becomes worse if the market is dominated by monopolies. The next section discusses market structure and the efficacy of carbon taxes.

4.3 Market structure, economic regulation and carbon taxes

The shifting of tax burdens through prices is more prevalent in a market structure that is non-competitive and in such a case the market structure will have to be regulated. The energy industry, however, is more closely regulated than many other industries because of the unique characteristics surrounding energy supply and delivery. Electricity, natural gas distribution and transmission are considered to be natural monopolies. Natural monopolies include infrastructure industries that are capital-intensive and offer vital services. It is not economically worthwhile to create competition in such a market structure; this is due, in part to the inefficiency of having duplicate facilities (Herber & Raga 1995). Since there is a significant economic barrier to entry because of sunk costs incurred whilst constructing the infrastructure, a firm in a natural monopoly position could price its products and services significantly above costs.

For reasons mentioned above, carbon regulation may be regressive for poor households if not properly designed and regulated. The degree of 'regressivity' will vary depending upon the budgetary proportions of energy consumption among households. However, the impact of taxation on different households will require an in-depth analysis of the economic incidence of taxes and the distributional aspect of government spending. According to Herber and Raga (1995), for an optimal reduction in environmental emissions, carbon taxes should reflect the price elasticity of demand for each fossil fuel, the cross-price elasticity of demand between different fossil fuels, and the cross-price elasticity of demand between fossil fuels and non-fossil fuels. Herber and Raga's postulation is that a pure carbon tax levied only upon fossil fuels would encourage the substitution of non-carbon-emitting energy sources by making them relatively cheaper than fossil fuels.

Firms that exercise market power determine their own prices. Market power dominance is prevalent in the energy sector which is dominated by monopolies and oligopolies. In such a market structure, independent economic regulators are needed to limit market dominance, cap prices and protect consumer welfare. Economics literature teaches that in a competitive environment profits will generally be maximised where marginal revenue equals marginal cost: $MR = MC$. However, monopolies are price-setters with downward sloping demand curves. Figure 6 shows that monopolies use their market power to set prices above the marginal costs: $P>MC$. This leads to a dead weight loss to the consumer (the shaded area formed by the *MC* curve and the lines from P_m and Q_m). This is a loss from the total economic surplus (Sloman 2000).

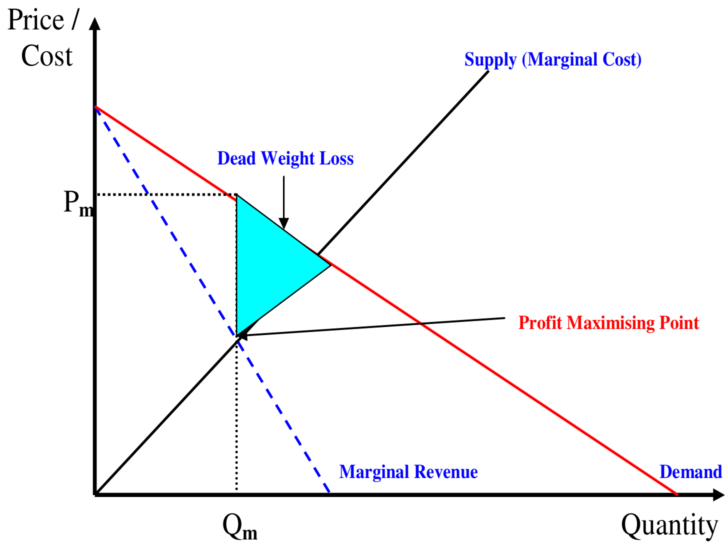

Figure 6: Monopolistic price determination structure

Competitiveness concerns are the main barrier to adopting more ambitious domestic carbon policies. Economic theory teaches that in a market structure dominated by monopolies and oligopolies, economic agents liable for paying a tax do not always end up bearing the burden of that tax because of the possibility of shifting the tax to others. To avoid this tax incidence from occurring, there must be proper regulatory frameworks and institutions to make sure that the cost of environmental emissions does not end up being paid by a final consumer. The industrial structure, conduct and behaviour must be robustly monitored as well.

All other things being equal, a carbon tax will yield an optimal outcome in a competitive market where the social marginal benefit of the tax is equal to the social marginal damage (Esoula 2007). However, under imperfect competition, like monopoly and oligopoly, there is no guarantee carbon taxes will yield optimal returns, for reasons mentioned above. In the absence of competition, economic regulation is often applied as a substitute for competition. It will be important to consider the range of possible regulatory options available. In recent years, price cap regulation has become established as the preferred approach to economic regulation in many countries (including other regulated industries in South Africa). Like the main alternative approach – rate of return regulation – price cap regulation is intended to prevent monopolists from exploiting market power. In addition, it also aims to provide regulated firms with incentives to improve cost efficiency, to make efficient investment decisions and, where appropriate, to generate increased demand.

Under price cap regulation, the maximum price that the firm can charge each year is typically expressed by a formula such as:

$$P_t = (1 + CPI - X)\, P_{t-1}$$

where Pt is the maximum price that the firm can charge in year t, CPI is the change in the consumer price index, and X is a factor (sometimes, rather misleadingly, called an 'efficiency factor') that leads to a real increase or decrease in prices over time. The X factor may be the same for each year in a price control period, or different values of X can be set for specific years. Price cap regulation can be used as an instrument to create incentives for firms to invest in alternative or clean energy technologies.

The next section discusses the application of carbon taxes at an international level and implications for South Africa.

4.4 Carbon tax and international trade

Carbon emissions vary considerably across nations in both absolute and per capita terms, but overall the industrial nations and some developing nations (China, India and South Africa, amongst others) are the primary polluters (OECD 2009). Through the United Nations Framework Convention on Climate Change (UNFCCC) or Kyoto Protocol adopted in 1997, participating nations agreed to set binding greenhouse gas emission targets for 37 industrialised nations and the European community. On average, countries party to the Kyoto Protocol committed to reduce GHG emissions by five percent below 1990 levels over the first commitment period, which lasts from 2008 to 2012 (OECD 2009). The Kyoto agreement includes several mechanisms designed to give the industrialised nations flexibility in meeting their targets.

The Clean Development Mechanism (CDM) and Joint Implementation (JI) allow nations to fund and receive emission reductions credit for actions taken in countries with less expensive mitigation options. Figure 7 shows that countries with high carbon emissions (country D in 2000 and countries B, C and D in 2010) can buy permits to emit carbon dioxide from countries with surpluses thereby creating a carbon trading market. Countries with surpluses can either sell them or bank such carbon credits (Perman et al 2003).

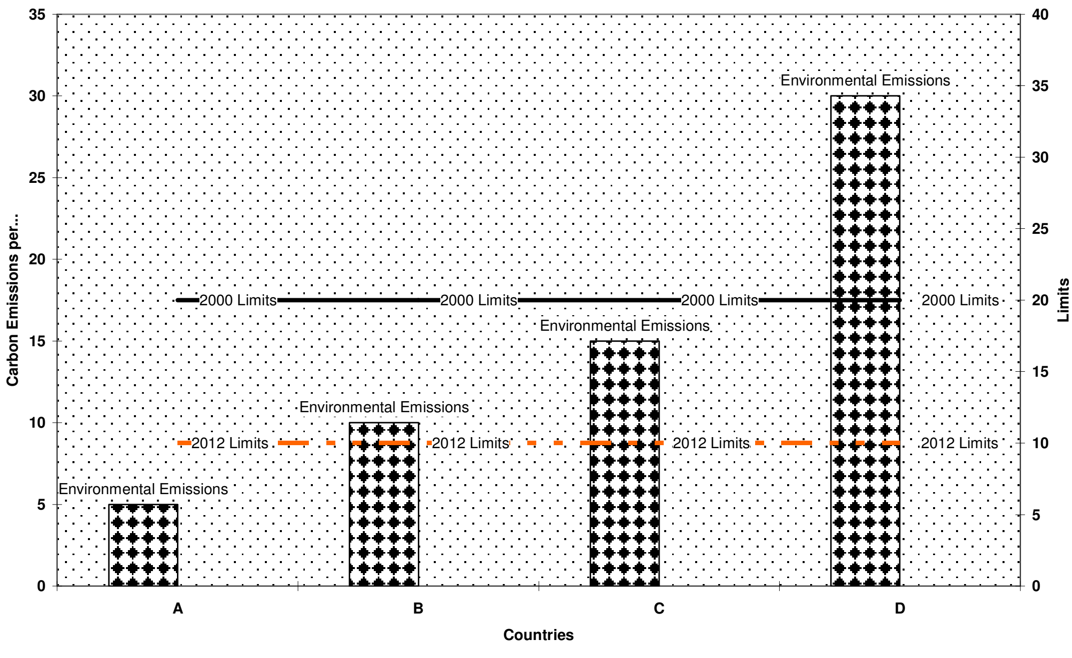

Figure 7: Example of carbon trading
Source: Adopted from Perman et al *(2003)*

One of the criticisms of the Kyoto Protocol is that it did not set mandatory global carbon abatement targets; it also failed to adopt specific policy instruments such as a carbon tax to reduce global warming. Further, the refusal by the United States to commit itself to a mandatory carbon abatement target and to enact comparable taxes diminished prospects of a global carbon tax (Farzin & Kort, 2000). The carbon tax is a market-based, economic-incentive of helping to attain the goals of Kyoto protocol but without global harmonisation no country will be motivated to impose a carbon tax alone. This means that even if South Africa can take unilateral action on carbon tax, this is largely going to be irrelevant in global terms. For export markets this option will create trade distortions and induce free-rider behaviour by trading partners who do not pay such a tax. For carbon tax to be effective at an international level, it will require ratification and the degree of interstate harmonisation of tax bases and rates. The next section discusses policy options that South Africa needs to consider for it to migrate to a low carbon economy.

5. Options to migrate to a low carbon economy: is carbon tax sufficient?

Challenges faced by South Africa in addressing challenges posed by carbon emissions include uncertainty about the form and cost of regulation, and economic effects. The LTSM which was adopted and published by government in 2007 sets out ambitious environmental objectives and makes combating climate change one of the main priorities for the government. This study has argued that carbon emissions represent a negative environmental externality. In many cases the value of carbon emissions is not easily monetised, since there is no market value currently for carbon emissions across all sectors of the economy.

There are currently several proposals being considered in South Africa for a national climate change policy. There are proposals for a national tax on carbon, while other proposed policies rely on a cap and trade strategies for limiting and reducing carbon emissions. Like a carbon tax (pricing), a cap and trade strategy (quotas) has the effect of inducing a price on carbon.

This study has analysed the efficacy of these policy instruments and has argued that on their own these instruments are important but not sufficient for a country like South Africa. An assertion was made that in a monopolistic market structure, the propensity to pass through the costs of compliance with environmental regulations is very high. The burden is ultimately borne by consumers, or the firm. Another critical consideration this study advocates is that environmental regulations should make sure that the burden of the limiting environmental emissions does not fall disproportionately on one income or consumer group.

In South Africa, policy instruments for mitigation against environmental emissions should be complemented by other energy conservation and economic policy strategies. South Africa must consider a myriad of policies to redirect the overall economic trajectory and limit its dependence on fossil fuels. This must be linked to the issues of energy equality and sustainability (Büscher 2009). This an important policy challenge, especially in the context of shrinking energy resources coupled with rising prices.

The adoption of energy policies and economic choices to migrate to a low carbon economy is a complex and sensitive matter which involves trade-offs. Carbon taxes are important but insufficient in achieving this policy objective. It is important to consider the overall role of energy in the economy. Because energy demand is a derived demand, it should be treated as a premier resource or primary feeder for economic growth, spatial development plans, human settlements, public transport, and sustainable communities (see Figure 8). Investments in the abovementioned sectors must be informed by energy considerations which should be priced accordingly as well.

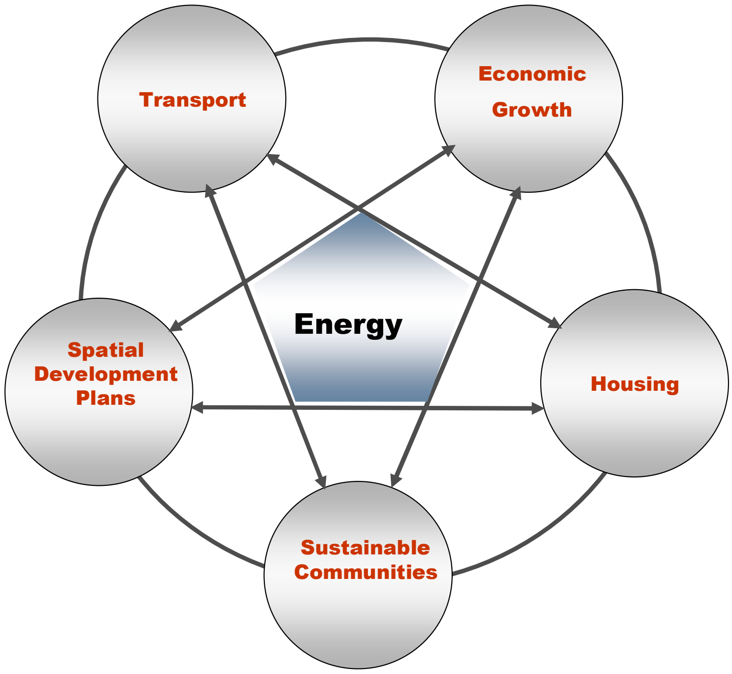

Figure 8: The economic role of energy

There is no doubt that carbon taxes have an important role to play in abating environmental emissions, but it should be noted that the optimal tax that maximises welfare depends on the market structure of the polluting output (Esoula 2007). Accompanying taxes is a need to thoroughly examine the nature, determinants and typical values of pollutants. As a result, it is best to implement carbon taxes together with other appropriate policies and programmes which promote energy efficiency and emission reductions.

6. Conclusion

To deal effectively with climate change in South Africa, this study argues, a tax instrument is the most efficient way to allocate a price to carbon, but that is not sufficient. Given the scale and weight of the effort required, economic efficiency must be given significant weighting in designing and choosing economic instruments. South Africa needs innovative solutions that increase overall energy and economic efficiency by reducing energy intensity and extracting more productivity and consumer welfare per joule of energy consumed. This means that integrated resource plans for housing, agriculture, transport, industries and energy should not be isolated from land-use patterns. Land-use policies should also consider the close juxtaposition of workplace and residence, and should promote sustainable development patterns. It is in this regard that this study recommends that energy should be at the centre stage of spatial developments, failing which South Africa will be hardest hit by new global environmental regulations debated and adopted in Copenhagen in 2009. Intergovernmental coordination and business partnerships are critical in ensuring that there are synergies between energy policies, economic policies and spatial development plans. New methods for dealing with the critical challenges of economic growth and spatial development plans are needed. This will require innovative thinking for changing the economic structure and improving efficiencies of the South African economy

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THEME 5: CARBON TAX VERSUS EMISSIONS TRADING SCHEMES

A comparison of emissions trading and carbon taxation as carbon mitigation options for South Africa

Michael Goldblatt

Abstract

There is consensus that carbon pricing is required to support a lower carbon pathway for South Africa. However, there remains debate on the most appropriate mechanism to introduce such a price. Although theoretically similar under restrictive assumptions, carbon taxes and emissions trading have very different environmental and economic implications in practice. The well understood differences between price and quantity instruments remain fundamental but there are other important criteria when comparing instruments. On the basis of a broad set of public policy criteria, carbon taxation appears to have many merits for a middle income developing country. Fundamental considerations are the relative political credibility, welfare impacts and long term stability of either instrument. The concentrated market structure of the South African energy sector raises further concerns about the ability to construct a competitive and efficient emissions trading market and supports taxation as the more appropriate instrument. A comparison of the instruments should not, however, be treated as a simplistic polarity and there are mechanisms that can be used to modify either instrument. The evaluation of the instruments in South African circumstances suggests potential criteria for evaluation and instrument modifications which may also be useful for other developing countries.

Keyw ords: carbon tax; emissions trading; regulatory options; climate mitigation

1. Introduction

While South Africa has not committed to any binding emissions target, the Cabinet (RSA 2008) has outlined an intended future emission trajectory for the country. Under this trajectory greenhouse gas (GHG) emissions would grow till 2020, plateau from 2020-2025 and begin to decline in absolute terms from 2030-2035 (DEAT

2009a). The trajectory has, as yet, not been incorporated into formal government policy or legislation. Given historic trends in emissions this emissions pathway requires significant changes to both demand behaviour and energy supply over the next two decades.

There is a sound argument that energy and carbon pricing measures will be required to effect the needed change in South Africa's emissions pathway. The wide-ranging adjustments required in consumption, production technologies and energy supply are likely to be best promoted through economy-wide price signals rather than specific sector by sector regulatory control (Fullerton et al 2008). At the same time, it is unlikely that pricing policies alone will be sufficient and a range of other measures will need to be utilised.

The National Treasury in South Africa is leading the development of economic instruments to manage GHG emissions, with the primary medium-term focus being the introduction of a carbon tax of some kind. There is no full carbon tax policy yet, and in the interim the National Treasury has been developing a set of environmentally-related taxes and tax incentives which largely effect the energy sector. A number of these have many of the elements of a carbon tax though none are true carbon taxes (National Treasury 2008).

Scope and structure of the paper

This paper outlines the key carbon pricing instruments available to national government in South Africa and compares them on a number of public policy criteria. In particular, the paper compares carbon taxes and emissions trading on theoretical and practical grounds based on a review of international literature and experience. There is not a similar depth of experience or policy analysis with GHG regulation in developing countries as with developed countries. There may well be important differences between countries at different development stages in the appropriate type of instrument and in the application of policy choices, and this paper also helps to outline some of these distinctions. It should be noted here that the paper generally refers to 'carbon' as a shorthand for GHGs. For the most part, the measures under consideration relate to carbon dioxide emission reductions with a lesser focus on the other GHGs of concern.

2. Description of policy options

There are a wide range of policy measures which can be used for GHG emission reductions. These measures include quantified limits on emissions, carbon taxes, energy efficiency standards on vehicles and building stock, renewable energy subsidies, and research and development support for clean technology sectors. There is, however, increasing acceptance that a major plank in the mitigation regulatory structure, will be economic instruments which create a price of GHG emissions within the economy. There appears to be broad consensus that without internalising the external social costs of emissions there is unlikely to be the required short, medium and long term responses required by consumers and producers to significantly alter the emissions profile of the economy (see for example, IMF 2008; Nordhaus 2007; CBO 2008, Stern 2007).

Economic instruments are typically divided into the two distinct options of taxes or emissions trading:

- Carbon taxes are a 'price instrument' which directly establishes a price on GHG emissions. Emitters therefore face the full price of their emissions and take this into account in investment and output decisions.
- Emissions trading is a 'quantity instrument' which directly establishes an emissions quantity through a cap on emissions imposed on emitters. Emissions trading allows for emitters to trade their emission allowances and hence indirectly establishes a price on GHG emissions.

These two mechanisms can be shown to be economically equivalent under a relatively restrictive set of assumptions – both leading to emissions taking place at least cost to the economy. Conceptually, emitters facing a carbon tax will reduce emissions up to the point where marginal GHG abatement is less costly than the tax. Therefore marginal costs of emissions will be equivalent through the economy and equal to the emissions tax rate. Emitters under an emissions trading scheme will reduce their own emissions as long as these are lower than the prevailing market price for emissions. Under competitive conditions, this will lead to the situation where the marginal costs of emissions will be equivalent throughout the economy and hence economically efficient.

The two approaches would lead to an equivalent outcome if the tax rate was set at such a point that it led to the same abatement level as would be set under the emissions trading scheme. If the restrictive assumptions are not met, the equivalence between the approaches no longer remains and this gives rise to some of the considerable policy debate over the instruments.

Prices versus quantities

Regulation of GHG emissions is a special case of the more general problem of pollution control. There has been substantial consideration of the application of economic instruments to pollution and in particular to the relative merits of price (tax) versus quantity (tradable permits) schemes (see Baumol & Oates 1988; Norregard & Reppelin-Hill, 2000). A key area finding in economic analysis is that uncertainty about the abatement costs and benefits introduces important asymmetries between the two instruments. These were first formalised by Weitzman (1974) and his analysis forms the basis for much of the evaluation of these options subsequently. His results are summarised in the Stern Report (2007) which explains that:

- Price instruments are preferable where the benefits of making further reductions in pollution (i.e. the marginal benefits of abatement) change less with the level of pollution than the costs of delivering these reductions (i.e. the marginal costs of abatement). In economic terms, prices are preferred when the marginal damage curve is flat relative to the marginal abatement cost curve, as emissions increase.
- Quantity controls are preferable, conversely, where the benefits of further reductions increase more steeply with the level of pollution than do the costs of emission reductions.

Although this analysis greatly advances the understanding of when and how to apply different instruments it is not complete and still relies on a number of assumptions. One particular issue is whether this result changes from the short term, where capital stock and technology is fixed, to the long term, where adjustments in capital stock can be made. This difference is important in the case of climate change.

Unfortunately, not all policy analysts agree on the policy implications flowing from the economic literature – one grouping arguing that the theory suggests that quantity approaches are to be preferred since the potential impacts and costs of climate change are likely to be rapidly increasing and may have unforeseen catastrophic consequences. Others, such as Nordhaus, take a different policy message from the uncertainty inherent in climate change policy development. Nordhaus (2007)notes that

> the structure of the costs and damages in global warming gives a strong presumption to price-type approaches. The reason is that the benefits are related to the stock of GHGs, while the costs are related to the flow of emissions. This implies that the marginal costs of emissions reductions are highly sensitive to the level of reductions, while the marginal benefits of emissions reductions are close to independent of the current level of emissions reductions (Pizer 1999; Hoel & Karp 2001). This combination means that emissions fees or taxes are likely to be much more efficient than quantitative standards or tradable quotas when there is considerable uncertainty.'

The divergence between policy analysts is demonstrated by a recent study undertaken by the Government Accountability Office (GAO 2008) in the US. The GAO was asked by the US Congress to elicit the opinions of experts in the field of climate change economics on actions the Congress might consider to address climate change and what is known about the potential benefits, costs, and related uncertainties of these actions. The GAO reported that

> all of the economists on the panel agreed that the Congress should consider establishing a price on GHG emissions using a market-based mechanism but expressed differing views on the type of mechanism and its stringency. In addition, a majority of panelists recommended implementing a portfolio of actions, including at least one complementary policy action in areas such as research and development, adaptation, or international negotiations and assistance. In terms of the mechanism for establishing a price, 8 panelists preferred a cap-and-trade system with the government having the ability to use a cost control mechanism (called a safety valve) if the price of permits exceeds certain levels, 7 preferred a tax on emissions, and 3 preferred a cap-and-trade system without the safety valve.

Thus one can see that the policy debate, at least amongst the US economic policy community, is relatively evenly divided – with some small tendency to quantity-based instruments.

Combinations of instruments

The polar distinction between price and quantity mechanisms excludes some proposed approaches which combine elements of both instruments. The options are also not mutually exclusive and can co-exist in an economy, addressing different sectors, or even overlapping. Although these mixed approaches are noted, for the purposes of helping to clarify the policy approaches most appropriate to South Africa there remains value in first considering tax and trading as opposing instruments, to highlight their distinguishing positive and negative features. The comparative evaluation of the two instruments also exposes the respective limitations of the options and implicitly therefore provides some insights into modifications that could improve the application of either.

3. Comparison of policy options

In addition to the distinction created by imperfect information there are additional distinguishing factors between the instruments. This section of the paper compares the two instruments using a set of public policy criteria that includes, but is broader than, the basic price-versus-quantities distinction.

3.1 Criteria for comparison of policy options

A wide range of criteria have been used by various analysts to compare carbon taxes with emissions trading. Common amongst these include the following public policy considerations (see, for example, Aldy et al 2008; GAO 2008; IMF 2008):

- *Economic efficiency*: the extent to which net social benefits are maximised.
- *Administrative complexity and cost*: the administrative capacity, cost and regulatory effort required to implement the policy .
- *Relationship to international GHG reduction policies*: the potential ability of the policy to interact with GHG reduction regimes in other countries or regions.
- *Certainty of result*: the predictability of the impacts of the policy by the regulator, such as the likely impact on economic activity and on the behavioural responses by firms and consumers.
- *Environmental effectiveness*: the extent to which the policy achieves its environmental (emission reduction) objectives.
- *Price volatility*: the certainty and stability of the market signals that are provided to firms and households.
- *Coverage and exemptions*: the degree to which the instrument affects all emissions in the economy.
- *Public finance considerations*: the extent of revenue raised by the instrument, the ease of revenue raising, stability of revenue raised and other issues related to the impact of the policy on the public fiscus.
- *Welfare impacts*: how the benefits and costs of the policy are distributed across different income groups as well as their distribution across economic sectors and areas of the country.

Other considerations that have been raised include the political feasibility of the policy; the impact on technology development and deployment, the degree to which rent-seeking and corruption are minimised, how independent the policy is from political influence, the distribution of costs and benefits across generations, the level of emissions leakage from the national economy, the transparency of costs and benefits, and the flexibility afforded policy-makers to respond to changing circumstances and information (GAO 2008).

It is difficult to determine which of these policy criteria are the most important, although the consideration of economic efficiency, cost effectiveness and environmental certainty appear to be those most consistently raised. The criteria are also not completely distinct from each other and there is significant interaction and correlation between some of the criteria. The table below therefore attempts to categorise the main criteria used to compare carbon taxes and emissions trading into a manageable set.

Table 1: Public policy criteria for the comparison of policy instruments

Public policy criteria	*Sub-criteria*
Economic efficiency	• Price volatility • Impact on investment
Environmental effectiveness	• Certainty of results • Coverage and exemptions • Ability to monitor and enforce
Public finance considerations	• Ability to raise revenue • Cross country revenue flows • Tax incidence and interactions
Welfare impacts	• Distribution of costs and benefits across income groups, economic sectors and generations • Transparency of costs and benefits
Administrative complexity	• Institutional capacity • Costs of administration • Minimisation of corruption
Relationship to global GHG reduction	• Level of emissions leakage • Ability to harmonise global carbon pricing efforts

3.2 Comparison of options

The policy options are compared against these criteria below. It should be noted that the comparison is not a formal multi-criteria decision-making analysis with scaling and weighting of the 'scores' of policy options against criteria. It is rather a qualitative attempt to show how a rounded comparative consideration of these economic instruments can provide policy insights for national government.

3.2.1 Economic efficiency

Although the basic economic result is that either instrument would arrive at an equivalent marginal cost of reductions across the economy there are some arguments that the greater flexibility allowed to firms by a carbon tax of selecting the *timing* of emissions reductions under changing economic conditions makes taxation a more efficient instrument. This analysis suggests that is more efficient to allow emissions to vary annually because short-term changes in economic conditions can affect the costs of emissions abatement. On the other hand, since the benefit of emitting one less ton of carbon in a given year is roughly constant, the precise timing of emission reductions does not affect damage costs significantly.

Under a carbon tax, firms can choose to abate less and pay more when abatement costs are high, and abate more and pay lower taxes when the costs of emission reduction are low (Parry & Pizer nd). Firms will typically be better able to smooth and manage their abatement costs than will regulators. A standard emissions trading system does not provide the same flexibility because the emissions cap has to be met within the particular regulatory period, whatever the prevailing abatement cost. The US Congressional Budget Office suggests that in the US the net-benefits of a tax could be five times greater than those of an inflexible cap (CBO 2008).

It is important to note that the analysis above relates to an inflexible cap. An emissions trading programme that includes some form of price ceiling and price floor to contain prices within a known band, or the banking and borrowing of credits, is likely to be significantly more efficient than an inflexible cap. These hybrid policies could be superior to single policy instruments. For example, raising the level of the safety valve over time could allow for the targeting of emission prices over the short run while targeting the quantity over the long term (IMF 2008; Pizer 2002). However, this flexibility comes at the price of relaxing the controls over the quantity of emission reductions.

Price volatility

A corollary of the inflexibility of the timing of emissions reductions under an emissions trading system is that supply and demand for credits will tend to fluctuate considerably. Emissions trading, in theory and in practice, will give rise to volatile pricing in the face of either changing demand conditions or in the face of regulatory changes. This has been seen in practice in the EU Emissions Trading Scheme (ETS) where prices have moved sharply in response to information on the national allocation plans and on progress towards these.

Price stability is important to provide the right signals to firms making long-term investment decisions as well as decisions about research and development and innovation in emissions reduction. This stability is also important for national economic development – as carbon prices become more important within the economy, price fluctuations will become increasingly disruptive.

Emissions taxes, by their nature, provide a much more stable price for emissions. Taxes are themselves subject to change and political influence. However, they tend to be changed less frequently and to be set for at least an annual period. As has been discussed by Winkler and Marquard (2009), there are options of structuring a carbon tax that responds to revealed emissions reductions, for example on an annual or two year basis – rising in the case of emission reductions below a target and falling in the case of over-achievements. This would introduce a degree of volatility to emissions prices, with the advantage of more closely targeting a level of reductions, but this volatility would be significantly smoother than the within-period volatility of an emissions trading scheme and would also be more predictable – with the tax being indexed to a specific emissions path.

3.2.2 Environmental effectiveness

All else being equal, an emissions trading system with an inflexible cap is most likely to achieve defined emissions targets. The degree of reductions under a tax is less certain – in the short term because emissions will vary from year to year with economic conditions, and in the long term because of the uncertainty about whether the tax rate has been set at the appropriate level. The emissions certainty of a emissions cap is clearly a strong argument in support of the instrument but it must be recognised that this is not an economic argument. The increased certainty of outcomes comes at an economic price, which may well be considerable.

Coverage and exemptions

The certainty of emissions trading with respect to the environmental outcome is dependent on the coverage of the emissions cap. The cap is clearly only of relevance to those sectors falling within it and hence the proportion of emissions covered within the cap will determine its ultimate impact on national emissions. This consideration is significant, as current emissions trading schemes are far from comprehensive – for example, the EU ETS accounts for approximately 50% of the EU's total CO_2 and about 40% of its overall GHG emissions (EC 2009). There are some reasons to suggest that a carbon tax is likely to be more broadly-spread than a carbon trading scheme, largely due to the administrative differences between the two instruments. However, this is not an absolute difference between the instruments as a tax can be circumscribed, and an emissions cap can be structured in such a way that its coverage is broad.

3.2.3 Public finance considerations

Both carbon taxes and emissions trading schemes can raise revenue for government. The main consideration differentiating the instruments is the scale of the revenue raised and related factors – such as stability of the revenue for government. In principle, an emissions trading scheme can include the full auctioning of allowances and hence can match the revenue raising ability of a carbon tax. In practice, however, this seldom occurs and there is often considerable limitations on the revenue raised from the process of allowance allocation. For example, in the EU ETS, more than 90% of allowances were freely allocated in the second phase from 2008 to 2012 (EC 2009). In comparison, the revenue raised by carbon taxes is likely to be considerable, and carbon and energy taxes already account for almost 5% of tax revenues in the EU (EC 2008). Experience, if not theory, therefore, suggests that the scale of the revenue raised is likely to be higher under a carbon tax system than from a cap-and-trade system.

A number of analysts suggest that the efficiency losses from carbon pricing can be mitigated by the appropriate recycling of carbon revenues to decrease these losses (Nordhaus 2007; Parry & Pizer nd; CBO 2008). These authors raise the concern that if the government does not fully raise this revenue, then there is no mechanism to mitigate these efficiency losses.

The price volatility under an emissions trading scheme also suggests that public revenue based on allowance auctions may similarly be subject to volatility. The revenue raised from a carbon tax is likely to be more predictable and stable and hence can allow for better planning of revenue recycling or tax-shifting programme. Of course, a carbon tax will tend to undermine its own tax base and it can be expected that tax revenues will decline as the tax has an increasing incentives impact. This effect may itself be offset by a rising tax rate.

3.2.4 Welfare impacts

Carbon pricing through any mechanism will affect the level and distribution of the real income of households. The size and distribution of these effects depends on the patterns of production and consumption in the economy and on how much of the price burden is felt by final consumers. The conventional economic assumption is that in the short-run there is a full pass-through of costs in a competitive economy and in general, it appears that in developing countries increased fossil fuel prices are likely to be regressive (IMF 2008b).

The degree and manner in which revenue raised by governments from carbon pricing is used to offset other distortionary taxes or to reduce the regressive impacts of the instrument will affect the distributional consequences of carbon pricing. Since there is not likely to be any difference in government revenue-use decisions based on whether the funds were raised from tax sources or from allowance sales, the more important difference between the instruments is likely to be the scale of the revenue. As discussed above, the scale and predictability of carbon tax revenue is likely to be greater than that from emissions trading. On the other hand, the probability of greater coverage of a carbon tax, for example the easier coverage of private transport fuel use, suggests that a carbon tax may be more regressive than a trading scheme. An economy-wide tax is less likely to exclude the household sector, as is typically excluded in an emissions trading schemes, and evidence suggests that increases in household energy costs are likely to be regressive in both developed and developing countries.

3.2.5 Administrative complexity

A commonly advanced reason for the preference of carbon taxes over emissions trading is that taxes offer some administrative advantages over trading systems. There are a number of reasons for this. The first is that a carbon tax can be based on existing tax instruments and mechanisms of tax collection. For example, the view of the US CBO (2008) is that an upstream tax is likely to be easier to implement than an equivalent cap-and-trade programme because many of the entities that would be covered by either policy are already subject to excise taxes and a carbon tax could build on the existing tax structure. The CBO argues that implementing an ETS, however, would probably require a new administrative infrastructure. The CBO does acknowledge, though, that experience with the US sulphur dioxide emissions trading programme indicates that the cost of administering such a program could be relatively modest.

On the side of the regulated community it is arguable that compliance for utilities and firms may be less burdensome under a carbon tax system if existing tax schemes are built on rather than new trading mechanisms created. However, this is possibly a weaker argument and the administrative burden depends more on the point of regulation rather than the nature of the policy.

Point of regulation

A second argument for the greater administrative ease of a carbon tax programme is that carbon taxes are more easily applied at an upstream level in the fossil fuel use chain and therefore do not require the monitoring of emissions needed in an emissions trading scheme. This argument is valid only if an emissions trading scheme is not similarly established on fossil fuel providers high in the value chain. Analysis of emissions trading suggests that an upstream point of application is rare. Most emissions trading schemes in operation or under investigation are based on emissions somewhere lower in the chain than the primary supply of fossil fuels.

A counter-argument against the cost effectiveness of a carbon tax is raised by the International Emissions Trading Association (IETA nd). They argue that under a carbon tax 'a crediting system would have to be devised for downstream projects that eliminate emissions (e.g. a carbon capture and storage project). Crediting would then require project oversight, measurement and verification, adding to complexity.' While this is correct, similar administrative complexities would be needed to bring such projects into an emissions trading scheme and there do not appear to be an major conceptual or administrative problems with including some form of tax crediting under a carbon tax system.

Corruption

A not insignificant consideration differentiating tax and trade systems is their susceptibility to corruption. Nordhaus (2007) argues that, in principle,

> quantity-type systems are much more susceptible to corruption than price-type regimes. An emissions-trading system creates valuable assets in the form of

> tradable emissions permits and allocates these to countries. Limiting emissions creates a scarcity where none previously existed. It is a rent-creating program. The dangers of quantity as compared to price approaches have been demonstrated frequently when quotas are compared with tariffs in international trade interventions.

Although these arguments are applied to countries rather than companies, they do carry weight at the firm level as well.

3.2.6 Relationship to global action

It is beyond the scope of this paper to consider the full picture of the relative merits of tax and trading schemes with regards to global climate policy. Theoretically it is possible to develop global systems of carbon pricing based on either carbon taxes or emissions trading. For example, countries can establish agreed-on carbon taxes that are harmonised internationally and which would produce a consistent global incentive for cutting emissions or countries can link trading schemes through fungible credits. There are, however, asymmetries between taxes and emissions trading with regards to international linkages. For example, the IMF (2009b) notes that currency rate adjustments would be more complex to manage under a tax than a linked trading system. Counter-examples favour harmonised taxes and there are theoretical benefits and risks to both instruments that certainly need to be considered in policy development.

3.2.7 The real-politik of carbon pricing

The review of the theoretical literature, consideration of carbon pricing in practice and a criterion-by-criterion comparison suggests that there is no clear *a priori* preferred carbon pricing approach in all circumstances. The objectives and priorities of the policy-maker will play a large role in scoring options and weighting the criteria (more often implicitly than explicitly) and therefore in determining final policy choices.

The practice of carbon pricing in developed countries appears to be trending relatively strongly towards emissions trading mechanisms. The reasons cannot be explored here in detail but may include such factors as:

- greater political acceptability of emissions trading than new taxation;
- preference for the greater emissions reduction certainty provided by cap and trade systems;
- political influence and lobbying by emissions trading advocates; and
- better fit with global agreements focused on time-bound quantifiable emissions reduction commitments

South African authorities should take into account the reality of pre-existing emissions trading schemes in many developed countries. This may well affect the choice of policy instrument but, in itself, should not be a determining factor in the choice of regulatory instrument.

4. Considerations specific to South Africa

The section above has provided a generic comparison of carbon taxes and emissions trading, with reference to South Africa where appropriate. However, the eventual choice of carbon pricing approach in the country should also take into account some specific local considerations.

4.1.1 Emissions uncertainty

An overriding consideration is the degree to which South Africa (and most developing countries in general) is able to predict a 'business-as-usual' emissions trajectory. Even with the best efforts of planners this is fraught with difficulty as there are currently significant uncertainty about the future energy supply mix and domestic demand growth. This uncertainty suggests that it would be extremely difficult to establish a credible emissions cap that could serve as the basis for allowance allocations under an emissions trading scheme.

A number of concerns arise about the consequences of an incorrectly calibrated emissions cap. If it were set significantly too high, it would be meaningless and result in an ineffective market with no impact on the real economy. If it were set too low, it would be constraining on the domestic economy, i.e. having significantly higher economic costs than predicted. In such a case there would be enormous credibility concerns in the face of inevitable political resistance to the continued existence of the constraint. Under conditions of expansion of the real economy, and with a growing population with unmet basic needs and socio-economic aspirations, more flexible carbon pricing instruments than a simple emissions cap are likely to be needed to create credible, long-term price signals for emissions reduction.

4.1.2 Market structure

An emissions trading scheme relies on a competitive and liquid market for the economic efficiency benefits to be realised. If there is market power on either side of the market this will introduce distortions that reduce the efficiency gains of the system. An initial allocation of allowances that concentrates ownership in a small number of firms will give those firms monopoly power in any subsequent trading (Smith 2008). Insufficient market liquidity will also reduce any gains available from trade even in the absence of the abuse of market power.

Market structure is particularly pertinent in South Africa where there is high concentration in the energy and fossil fuels sector. The design of an upstream emissions trading system would face challenges in addressing market power and in ensuring sufficient trading liquidity. Primary fuel supply in the country is dominated by coal and imported crude oil and there are remarkably few individual points through which the vast majority of the country's primary energy resources flow. There are about 71 collieries, six refineries (including coal-to-liquids plants) and two gas plants (including gas-to-liquids) refining (SAPIA 2008). This primary energy supply is even more concentrated if looked at on a company basis, rather than on the basis of individual plants.

The table below shows that of the total coal mined in South Africa in 2006, 61% was used for electricity production (and therefore purchased almost entirely by Eskom) and 30% was used by industry (of which a significant proportion is purchased by Sasol for coals-to-liquid processing). Two firms, Sasol and PetroSA, provide or purchase almost all the natural gas in the country. There is therefore also significant demand-side energy market concentration. This demand- and supply-side concentration has important implications for the regulatory options selected and suggests that it may be difficult to establish an emissions trading scheme with the characteristics required to deliver economic efficiency.

Table 2: Coal demand in South Africa, 2006
Source: DME (2006); Chamber of Mines (2007)

Transport	Electricity	Mining	Industry	Metallurgical	Merchants / Domestic	Total
0%	61%	0%	30%	5%	3%	100%

Regulated prices and incentives structures

A further important consideration for the application of any carbon pricing instrument in South Africa is the interaction between these instruments and current energy sector regulation. There is significant economic regulation and administered price-setting which affects the incentives structures in the energy sector. All final liquid fuels prices are government regulated, as are most consumer prices of electricity through the National Energy Regulator of South Africa (NERSA). NERSA is the economic regulator of Eskom and determines which costs can be passed through by the utility to the consumer and to what degree.

The eventual incidence of carbon price interventions, and hence also their incentives impacts, will depend on how these interventions are incorporated into price regulation. The nature of economic regulation of the energy sector in South Africa does not, *a priori*, suggest any particular preference for either emissions trading or quantity approaches or price based approaches. Detailed consideration of the current regulatory framework may favour one approach over the other. However, the introduction of any large-scale carbon pricing intervention would need to be done in collaboration with the economic regulators in the energy sector and are likely to require a review and alignment of economic regulatory approaches with the carbon pricing approach adopted.

A closely related matter is the existence of some significant subsidies within the electricity pricing system. An important example is the long-term, special pricing arrangements that a number of highly energy-intensive energy users have entered into with Eskom. Although the details of these agreements are confidential, it is highly likely that they represent significant price discounts to the marginal costs of electricity in the country and are implicit subsidies to energy use by these industrial users. This is an issue that also needs to be considered in the process of establishing the correct price incentives in the South African energy sector.

New entrants and independent power producers

An emissions trading scheme will face different challenges from a carbon tax with regards to new entrants into the power sector. The distribution of a fixed number of allowances may impose barriers to entry for new entrants into the energy sector. There is a policy intention that 30% of power generation is provided by new entrants in the medium term. If new entrants are required to purchase allowances from a fixed pool it would provide a means for incumbents, such as Eskom, to erect barriers to entry through market power over the allowance price. A carbon tax would not provide a similar constraint because it will apply equally to new entrants and to incumbents.

5. Conclusion

There is reasonable consensus that some form of carbon pricing will be required to support a transition to a lower carbon pathway for South Africa. This paper has started to explore the relative merits of the alternative mechanisms of introducing such a price. Although theoretically similar, under conditions of perfect markets and perfect information, it is readily apparent that there are significant practical differences between emissions trading and carbon taxes. The primary difference, when the 'pure' forms of both instruments are compared is that emissions taxes will provide a fixed price for carbon, have wide coverage through the economy, are relatively easy to administer and will generate significant and relatively stable revenue – but will not provide certainty on the levels of emissions to be achieved. On the other hand, emissions trading will provide greater certainty of the level of emissions but at the expense of more uncertain economic costs, the probability of volatile prices, difficult administrative requirements, and complexities related to coverage across the economy. There are also concerns, based on experience, that emissions trading is likely to result in lower revenue generated for government.

The issue of revenue generation is important, not to fill government coffers but because it gives government the ability to use this revenue to address the distributional impacts of the carbon pricing – particularly mitigating these impacts where they fall on poor or vulnerable households. An emissions trading system that provides free allowances and therefore has limited revenue raising ability will not provide government with this flexibility. International experience with carbon and energy taxes has shown that tax systems are themselves not immune from interest group pressure and that exemptions of one kind or another are rife in these instruments. Such exemptions will tend to reduce revenue raised, will increase distributional concerns and will reduce coverage of carbon taxes.

Importantly, adjustments to emissions trading systems can address a number of the concerns raised about such systems in their pure form. These adjustments can lead to many of the features of a carbon tax being included in an emissions trading scheme and start creating a continuum between pure price and pure quantity instruments. Safety valves in emissions trading schemes will ensure that such schemes can be limited in their overall cost to the economy. However, it must be recognised that the use of a safety-valve comes at the expense of discarding the certainty of the level of emissions and makes the trading scheme look much more like a carbon tax.

Some of the other key design issues of carbon pricing, such as the most suitable point of regulation, apply in theory in an equivalent way to emissions taxes and trading systems. However, this theoretical similarity is altered in practice. In particular, when the particular market structure of the South African energy sector is examined, it is apparent that the existence of concentrated energy supply markets, monopoly power in power generation, and a small number of liquid fuels refineries impose serious concerns about the ability to construct a competitive, liquid and efficient emissions trading market.

The existence of administered prices and economic regulation in South Africa, as well as state ownership of Eskom, introduce other important incentives issues which would need to be considered in detail in the design of either an emissions trading or carbon tax system if such a system were to achieve its aims. Importantly, this suggests that the design of a future carbon pricing regime will require close coordination between the economic regulatory framework for the electricity, liquid fuels and gas sectors and the carbon pricing instrument.

Whatever instrument is selected, a key feature determining its effectiveness in changing investment behaviour and innovation is the long-term credibility the instrument has. An emissions trading scheme faces the problem of uncertain economic costs and the real potential that a cap would be adjusted or abandoned in the face of significantly higher costs to the economy than anticipated. An emissions cap that was visibly constraining economic growth would face huge political pressure. A carbon tax is therefore likely to be a more credible long-term instrument, one which will have continued state support because of the revenue generated and one which provides a consistent, albeit possibly inadequate, pricing signal to power generators, producers and consumers.

On balance, there appear to be strong reasons to favour a carbon tax as the appropriate instrument for South Africa at this point. However, as noted, there is also merit in understanding that carbon pricing approaches do provide the ability for regulators to select programme features that allow somewhat of a continuum between taxes and emissions trading – acknowledging that trade-offs will be made in this process between certainty of costs and certainty of emission levels. If an emissions trading regime was preferred in South Africa, the introduction of such a system without strong recourse to some of the price flexibility mechanisms would seem to be inappropriate to the country's economic development path and industry structure.

It would be naïve and overly economically purist to imagine that a carbon pricing instrument alone is sufficient to address climate change objectives. Energy and climate policy in all countries operates within the context of a range of development imperatives. Alternative regulatory measures and climate change strategic choices should not be seen as running independently parallel to carbon pricing approaches as there are strong interactions between the two which should be understood and used to enhance the effect of both. For example, the size of price elasticities in the liquid fuels sector, i.e. how much consumers reduce fuel use in the face of increased costs, will depend to a large degree on the availability of alternatives. If substitutes are available in the form of affordable and efficient public transport, safe cycle lanes and compact and safe urban areas for pedestrians then these elasticities are likely to be much higher. These alternatives are public goods that can only be effectively provided through efficient government with a clear strategy towards developing a lower carbon, more socially equitable economy. For any carbon pricing policy to be effective it will need to supported by other government led interventions.

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Carbon trading or carbon tax? Weighing up South Africa's mitigation options

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Abstract
Economic instruments are proving to be the mainstay of carbon mitigation policy globally. South Africa's position is consistent with this, and government has indicated its intention to move away from regulation as an emissions reduction tool. However, it is not yet clear what form this economic instrument, or instruments, should take. Two approaches arise from theory and early international carbon pricing designs: taxation or emissions trading, and they differ in a number of ways. Whilst under strong assumptions, economic theory shows a tax and an auctioned cap and trade scheme to be equivalent, in the real world, under conditions of uncertainty and imperfect information, their different designs lend themselves to different contexts. This paper compares the use of a carbon tax and emissions trading scheme as the central instrument for South African GHG mitigation policy. The analysis is based on economic theory and the limited international experience of the two instruments, combined with detailed consideration of the South African context. The paper concludes that a tax is likely to be more appropriate in the immediate future, but that the choice could be different in the medium to long term; particularly if an international emissions trading framework is agreed upon. The paper also identifies number of areas for future research to inform policymaking.

Keywords: carbon tax, emissions trading scheme, theory, South Africa, developing economy

1. Introduction

The rationale for using economic instruments to mitigate climate change is to achieve a transition to a low-carbon economy at the least overall cost to society. Economic instruments effectively 'put a price on carbon' so that firms and households take the environmental cost of their actions into account when they are making decisions. This is generally accepted to be less costly than imposing rigid emissions controls on firms. Since the costs are eventually passed on to consumers, demand shifts away from carbon-intensive goods and services and towards those with a lower carbon footprint. Over the medium-to-long term, this will lead to a structural change within economies (Australian Government 2008). The South African government is in the process of developing domestic carbon mitigation policy. In line with environmental policy developments internationally, it has signalled its intention to move away from command and control regulatory mechanisms and to focus on economic instruments going forward (National Treasury 2006).

Two economic instruments have emerged from theory and international practice as being the most appropriate for consideration as greenhouse gas (GHG) mitigation policy choices: a carbon tax, or an emissions trading scheme. These will similarly be the focus of this paper. A carbon tax achieves reduced emissions through imposing a price on producers proportional to the volume of their emissions in order to provide them with the necessary incentive to abate. A carbon or emissions trading scheme (ETS), on the other hand, is based on allocating a certain number of permits to emit GHG s to producers, who need to demonstrate sufficient permits to cover their emissions at the specified compliance date, and then allowing these producers to trade permits amongst themselves in accordance with their compliance needs. Scarcity is created in the scheme through the allocation of fewer permits than emissions, resulting in emitters having to choose between reducing their emissions in line with their allowance allocations or purchasing additional permits to cover their excess emissions levels.

The paper will consider whether a carbon tax or ETS is more suitable for South Africa from a macro-economic perspective. It will focus on the short-to-medium term, and will touch on how this analysis may change as the country moves towards 2050 (the period considered by the Cabinet's vision of a peak, plateau and decline emissions trajectory for the country.

The primary aim of this paper is to advance the dialogue around appropriate economic instruments for carbon mitigation in South Africa by establishing a framework for discussion of the strengths and weaknesses of carbon tax and trading, and application of these instruments to the South African context. Whilst it is conceivable that the eventual policy choice may comprise a hybrid instrument or even the use of both instruments (as in a number of European countries), this paper assumes that the choice is between the two and uses the instruments' pure form as its point of departure. This abstraction is considered necessary to understand and highlight their relative advantages and disadvantages when applied to the South African context. Possible hybrid forms are touched on in the discussion where they can alleviate some of the key problems associated with the pure form instruments, but a detailed evaluation of all possible forms of each instrument is beyond the scope of this paper. The discussion arrives at some early conclusions, and identifies areas for further research and debate.

The paper begins by defining and describing carbon tax and carbon trading as economic instruments to reduce GHG emissions. Next, an analysis of international experience in the instruments is conducted, in order to extract lessons for their implementation in South Africa. Features of South Africa's specific carbon policy context are then described in order to help build a framework for the comparison of the instruments and their applicability in South Africa. This analysis is then conducted, considering both the main strengths and weaknesses of each instrument in the context of South Africa. The paper concludes with initial findings, and identifies areas for future research.

2. Carbon tax and carbon trading: theoretical and design considerations

As economic instruments, both taxes and trading schemes put a price on GHG emissions. In both cases, according to economic theory, this GHG mitigation will be achieved at a smaller overall cost to the economy than if command and control instruments are used. However, each instrument does this through slightly different means. A tax is a conventional price instrument, the regulator sets the price per tonne emitted, and emitters pay or reduce their emissions accordingly. A trading scheme can be understood as a combination of a price and regulatory instrument. The acceptable quantity of GHG emissions in the system is determined by the regulator, and permits issued for this amount. These permits are then traded between emitters, with a price being established by the market.

Whilst the price / regulatory difference is the defining one, there are other differences between the instruments, stemming from their respective designs. Under the strong assumptions of general equilibrium, full information and perfect functioning of markets, economic theory states that the design differences between carbon tax and cap and trade schemes do not impact their relative economic efficiencies, and that, in equilibrium, both achieve the optimal degree of abatement at the lowest possible cost to society (Weitzman 1974; Fischer 1996; Perman et al 1999; Sin et al 2005). However, these strong assumptions bear little relation to reality where, particularly in the area of carbon mitigation, there is uncertainty, incomplete information and imperfect market functioning.

Under more realistic assumptions, theorists find that the relative efficiency of the two instruments depends on the nature of the marginal costs and marginal benefits of mitigation. Both internationally and, particularly, in South Africa there is insufficient information available around the costs and benefits of mitigation at this time to usefully pursue this line of enquiry further, since the outcome of the analysis depends on the exact slopes and correlation between the slopes, of the two curves.[1]

In practice, however, there are a number of design features which distinguish the two instruments and which embed different advantages and disadvantages in each, and which inform the tax versus emissions trading debate. These design features are very

1 The presence of uncertainty around the marginal costs and (or) benefits of reducing emissions changes the trade-off between the two instruments (Weitzman, 1964; Newell & Pizer 1999; Pizer 1999; Pizer 2002; Hoel & Karp 2001), with the outcome being dependent on the slope and correlation of the marginal cost (MC) and benefit (MB) curves. Weitzman initially found that if the MB is relatively flat and the MC steep, and there is only uncertainty around the MC, resulting in a choice of the wrong quantity of emission reductions being more costly for the economy, and pointing to a tax as a more suitable instrument. Later studies extended this analysis to look at when there is uncertainty about both MC and MB, at which point the literature has concluded that the outcome becomes dependent on the slopes and correlation between the two curves. It is beyond the scope of this paper to explore in depth the level of uncertainty or slope of the South African MC and MB. However, from the authors' experience, and from the findings of the FRIDGE project which considers abatement cost curves in various sectors of the South African economy (forthcoming, 2010), it is assumed that there is a significant degree of uncertainty around the MC and its slope. For the purposes of domestic policy, Sin et al (2005) argue that the shape of the MB curve is mostly dependent on the benefit of adhering to internationally agreed action on climate mitigation, rather than the environmental benefit of reducing emissions (which is the marginal benefit typically considered in the literature). This is since the mitigation actions of one country will not have a significant impact on worldwide emissions and so is cannot directly lead to benefits for the country in terms of avoided environmental damage. Adhering to international regimes governing mitigation can, however, have direct benefits to a country (e.g. the avoidance of punitive measures or border taxation on exports, improved relationship with the international community). This suggests that for South Africa (and other countries) there is therefore also a significant degree of uncertainty around the MB and its slope currently as the international situation is very unclear.

briefly summarised below, whilst section 5 discusses them in more detail within a 'real' context, that of South Africa.

Overview of carbon pricing instrument design features

A carbon tax provides a stable carbon price upon which firms can base production and investment decisions. It generates fiscal revenue, and is more transparent than a trading scheme, and therefore less susceptible to corruption. A tax is a known and simple policy instrument, and government does not need access to firm level emissions data upfront to implement a tax. On the negative side, a tax does not deliver a certain volume of emissions reduction, and therefore cannot guarantee domestic compliance with an international target. Taxes are also inherently disliked by industry, which makes building consensus around a tax regime difficult.

An ETS provides mitigation volume certainty. It also allows for price discovery, providing important information to policymakers. A trading scheme is a complex instrument, offering sophisticated risk management mechanisms to firms to smooth their integration of carbon pricing over time. If emissions allowances are grandfathered (allocated free based on past emissions levels), an ETS is less punitive to firms in the short term. If emissions trading is adopted internationally, it provides a mechanism for global least cost compliance. ETS weaknesses include the presence of carbon price volatility and uncertainty, which is problematic for encouraging long term mitigation investment. An ETS is complex and sophisticated, and can be distrusted by the public, particularly if allowances are grandfathered. Grandfathering requires a high level of information on historical emissions at a firm level, which is often unavailable or unreliable. After the financial crisis, there has been reduced support internationally for the use of markets, and the development of new, complex and unfamiliar markets.

3. Lessons from international experience

Experience with economic instruments for emissions mitigation is still in early stages, having begun in the 1990s with the sulphur dioxide and nitrous oxide schemes in North America, and carbon taxes in Scandinavia. ETS for GHGs has only been in operation from the beginning of the current century. Given this, it is too early for conclusive retrospective analysis of these schemes. However, there are a few early examples and lessons which can be drawn, although these are largely context specific.

Prospective carbon taxes have tended to be politically less popular than trading schemes to date, primarily because it is easier for emissions- and energy-intensive industry to achieve protection through favourable permit allocation methods in trading schemes than through more transparent tax rebates. This is specifically true in the USA where there is strong opposition to any mechanism likely to increase the cost of energy, but particularly a carbon tax. Most industrialised countries or regions seriously pursuing mandatory emissions mitigation policy have opted for emissions trading above taxes (EU, Australia, US, Japan, Canada, New Zealand, South Korea, Switzerland). However, recent indications suggest that there may be a shift underway towards the reconsideration of taxes post the financial crisis (this will be discussed in more detail below), and a number of EU countries have recently decided to implement carbon taxes concurrently with their participation in the EU ETS.

Despite the relatively limited experience with taxes, there are examples of where they have been highly successful; in particular, a number of European countries, including

Denmark and Sweden have had broad-based carbon and energy taxes in place for some years (Speck 2008). Since Sweden's carbon tax was put in place in 1990, emissions in the country have reduced by 8% while the economy has grown by 48% (Shapiro 2009). An analysis reported by Andersen (2008) suggests that in all six European countries considered, environmental tax reforms contributed to lower fuel demand and lower GHG emissions between 1994 and 2004 compared to their projected levels without carbon taxation. In Finland the reduction in GHG emissions totalled 5.9% over the period.

The largest cap-and-trade system in the world currently is the European Emissions Trading Scheme (EU ETS), covering all 27 EU member states, which has been in operation for just under five years. The scheme is set to be extended to cover three non-EU European countries from 2013. The mandatory scheme began in 2005 and is now in its second phase (Phase 1 concluded at the end of 2007).

The EU ETS has run into a number of problems during the first phase of implementation. The over-allocation of permits in Phase 1 led to a price crash at the beginning of 2006 (Runge-Metzger 2008), which undermined confidence in the mechanism. This experience was similar to that of the US SO_2 trading scheme where price volatility was also a problem. Nordhaus (2007) shows that the price of permits from 1995 to 2006 was more than twice as volatile as the S&P500 index and almost as volatile as the oil price.

The second major issue for the EU ETS was that of windfall profits. Power producers are perceived to have benefited unfairly under the scheme as they received free permits (the majority of permits were grandfathered in Phase 1 and Phase 2) and power prices have increased significantly since the scheme's inception, prompting concerns that firms had passed on more than the increase in costs (Wettestad 2007). A study by Sjim et al (2006) found that under the EU ETS firms who were allocated emissions permits had passed on between 60% and 100% of the opportunity cost of permits to their customers, resulting in significant windfall profits for polluting firms.

The remaining main examples of implemented emissions trading schemes to-date and available analysis of their impact are summarised in Table 1. As the discussion of the EU ETS and the table show, the lessons that can be deduced from international experience to date are limited given the infancy of these policy instruments, and the number of teething problems that have been encountered. Emissions inventories are in early stages of development, and substantial inaccuracies still exist. This reduces the ability to accurately measure the success of any instrument to date. However, the following points can be taken from international experience in economic instruments to mitigate GHG emissions to date: ETSs are highly complex to establish; full auctioning is a political impossibility, reducing revenue generating potential; the problem of price volatility and lack of price certainty for planning is significant in the first years of a scheme. Norwegian tax examples are all we have, but seem to have been very successful at a low level. The problem of political resistance towards a tax seems to have been significant in the past, but may now be lessening as the performance of ETS in practice has proven ambiguous and confidence in markets have been undermined due to the financial crisis.

Table 1: International emissions trading schemes: Description and analysis

Trading scheme	*Type*	*Coverage*	*Effectiveness*	*Lessons*
US SO_x and NO_x	Mandatory, SOx and NOx (not GHG), but longest running.	Electricity generating facilities and large industrial boilers.	Phase 1 low prices, little investment due to over-allocation (EPA, 2002). Significant price volatility (Parry and Pizer, 2007; Nordhaus, 2007).	Stakeholders believe it lowered compliance costs (Tyler et al, 2009).
UK ETS	Voluntary	31 participants from wide range of sectors.	Achieved aims of capacitating firms and government around trading plus substantial over-compliance in terms of. emissions reduction	50% of sales came from 3 large sellers – concentration issues important to consider (Smith et al, 2007).
New South Wales GHG Reduction Scheme.	Mandatory and voluntary participants, permits allocated.	Electricity suppliers, customers and generators.	Thought to be overly complex and disrupted by plans for national ETS.	External developments can have big impact on carbon market – price volatile.
Regional GHG Initiative (USA).	Mandatory, majority auctioned.	Power plants burning fossil fuels.	Too soon to say – began September 2008.	

4. The South African context

The foregoing discussion has illustrated that the choice of instrument is not clear-cut in the abstract, and therefore context becomes all-important when considering the relative advantages and disadvantages of a tax or trading approach to economic policy instruments. This section describes aspects of the South African economy of relevance to carbon pricing.

4.1 Developing country context

South Africa is different from many of the countries which have so far implemented economic instruments to mitigate GHG emissions in that it is still a developing country with serious problems of poverty and unemployment to tackle. It has, however, committed in the Copenhagen Accord to a reduction of 32% below projected emissions by 2020, and 42% by 2025, subject to international financial and technical assistance. The country is committed to the long term decoupling of emissions from economic growth within a development context.

Climate change mitigation policy could have serious negative consequences for the economy which is based on access to cheap coal for power. Despite government's commitment to GHG mitigation, it faces other political imperatives, most importantly the need for economic growth and a range of development spending priorities which impose a constant strain on fiscal resources. Therefore, mitigation policy needs to be designed with South Africa's key development challenges at the forefront of thinking. In this context, an important point to note is that it will prove politically very difficult to implement any instrument which has regressive distributional implications.

South Africa is experiencing a serious skills shortage, particularly in the public sector, and has no experience in emissions mitigation. This may limit the sophistication of mitigation instruments that the country can work with. Furthermore, an instrument which utilises existing institutions rather than requiring the creation of new and potentially expensive institutions would be at an advantage.

4.2 Availability of data

The lack of available data on everything related to GHG emissions in South Africa is a major constraint to the development of policy. Recent studies go some way towards addressing the deficit: the LTMS (Winkler 2008) considered a number of sectors, mitigation options and transition paths. The recently released draft National GHG Inventory for 2000 (DEAT 2009) provides the most accurate assessment of South Africa's emissions, broken down into broad sectors. Information can be drawn at a high level (broad economic categorisations) from both of these sources, and indeed some data is available at a sectoral level for selected sectors. A third source, Blignaut et al (2005), computes sectoral emissions for the economy at a more disaggregated level based on the National Energy Balance for 1998 published by the Department for Minerals and Energy (DME). However, to understand fully the impact that an economic instrument will have on the economy, much more detailed information is required on emissions, as well as the availability, potential and cost of abatement options at a sectoral and even sub-sectoral level for every sector in the economy. A project initiated by the Fund for Research into Industrial Development Growth and Equity (FRIDGE) which is currently being undertaken highlights this through the study of seven sectors. The study (expected to be released early in 2010) derives 'indicative abatement cost curves' for each sector, and considers some early policy options, but is severely constrained in its reach due to the lack of data. This lack of information would present a barrier to the efficient distribution of permits under an ETS, which requires some knowledge of abatement opportunities available at a sectoral level.

4.3 Emissions profile

In 2000, 79% of the country's emissions profile was made up of emissions associated with energy, with the remainder being industry process emissions, and methane from waste management and agriculture (DEAT 2009). The high contribution of energy is largely due to the country's reliance on coal as a primary energy carrier. Coal burned for electricity generation makes up 39% of all emissions (DEAT 2009). From an institutional perspective, two organisations dominate South Africa's GHG emissions landscape, accounting for 56% of total emissions. 12% of emissions are attributable to the liquid fuels manufacturer Sasol (part energy and part process emissions), and 44% to Eskom, the state-owned electricity utility (ERC 2008; NBI 2008). This poses particular challenges for any climate change mitigation regime since it suggests that strategic decisions made by these two firms will have the potential to influence South Africa's GHG emissions more than any other factor.

4.4 Energy context

The South African economy is extremely energy-intensive as a result of energy, and particularly electricity, prices remaining amongst the lowest in the world for an extended period. This has attracted energy-intensive firms and projects to South Africa, and large capital investments then caused the economy to become 'locked-in' to a pattern of high energy consumption (Marquard & Winkler 2009). Commercial and residential users of electricity have had little incentive to pursue energy efficiency measures.

The state-owned utility Eskom operates as a long standing monopoly in the electricity sector, and has not seriously deviated from its focus on cheap, coal-fired electricity as a mode of energy service delivery over its lifetime. The 2007 electricity supply crisis highlighted a broader crisis of governance, leadership and co-ordination in the electricity and energy sector. The liberalisation of the sector has been a stated objective of government for some time, and it has mandated that in future 30% of new capacity must be generated by private suppliers or independent power producers (IPPs) (Eskom 2009). In practice, however, the institutional arrangements to facilitate such a transition are not yet in place, and there is considerable uncertainty about the future of the sector. Response attempts by government, business, Eskom and other energy sector players have only served to entrench this confusion. Most recently, President Zuma announced an Inter-Ministerial Committee on Energy in his 2010 State of the Nation address, which may go some way to addressing this issue. The Committee will be considering a twenty year integrated resource plan as one of its first tasks. Eskom has in the meantime embarked upon an investment programme which involves de-mothballing of coal generation and the new build of two additional coal power stations within the next decade.

The intention and mechanism to enable some renewable power onto the grid is in place with the Renewable Energy Feed In Tarriff (REFIT), although renewable energy targets are way below those required to address government's international climate mitigation commitments. Energy efficiency, a central component of all stalled electricity crisis responses, is a driving factor in short term emission reductions for the country.

4.5 Mitigation policy targets and prospects for international cooperation

Climate mitigation is a global challenge, and one which all countries will need to respond to in some form in order to avoid the escalating damage from climate change. South Africa has indicated its commitment through its conditional Copenhagen Accord targets, and Cabinet's endorsement of a target of 30–40% reduction of GHG emissions from 2003 levels by 2050 (van Schalkwyk 2008), in accordance with science and the country's 'common but differentiated responsibility' (UNFCCC 1998).

Global co-operation on climate mitigation is optimal, with a negotiated commitment to mitigation activities, and a synchronised policy response. However, this is far from a given outcome at this point in time. Should co-operation fail, bilateral actions through the trade regime could be an alternative, and sub-optimal, approach for small open economies like South Africa. No mitigation is the worst outcome, as South Africa will be badly affected by unmitigated climate change.

5. Comparison of tax and trade in the South African context

The following section explores the potential performance of tax and carbon trading in South Africa, predominantly from the theoretical perspective of the instruments' design, but incorporating relevant findings from international experience. The discussion is organised according to criteria considered to be of particular relevance to the country when considering climate policy design.

This paper began by acknowledging that the country's eventual policy choice may comprise a hybrid of tax and trading, or even the use of both instruments simultaneously. Since the paper's objective is to understand and highlight the instruments' relative advantages and disadvantages when applied to the South African context, it focuses on the instruments in their pure form as a point of departure. However, in this section particularly it becomes important to note how an instrument can be customised to combat its inherent disadvantages when applied to the South African context, or to enhance its advantages. Therefore this section necessarily expands to encompass hybridisation at a low level. Also, where one instrument would be best suited to one part of the economy, and the other to a different portion, this is identified.

A point to note in relation to hybrid instruments is the importance of proportionality. Whilst in some cases it has been suggested that a hybrid system can actually be preferable to either of the pure tax or trading instrument options (Robert & Spence as cited in Fischer (1996)), design 'tweaks' to instruments are only appropriate insofar as they do not create greater distortions or inefficiencies than the problem which they are trying to solve. In general, the further the instrument is from its theoretically 'pure' form, the less efficiently it will function, as each additional element which is incorporated has both a distorting and administrative implication.

5.1 Emissions certainty

In a situation of scarce information, emissions trading provides far greater certainty of emissions reduction volume compared to a tax (assuming that enforcement of the two is equal). Thus, if coverage is broad, it can give a reasonable degree of certainty of the amount of abatement that will occur in the economy as a whole. The more urgent the need to reduce emissions, the greater the benefit of a mechanism which can guarantee to hit a given emissions target. This, however, may not be the South African government's immediate top priority when it comes to mitigation. As a developing country, it has time on its side in any international negotiation around fixed emission reduction targets.

Government cannot tell accurately in advance what degree of abatement will be achieved by implementing a given tax rate, as this depends on the cost of abatement. However, by slightly altering the design of a tax, the predictability of emissions reduction can be increased. Marquard and Winkler (2009) suggest a mechanism by which a target path for emissions levels is set and then the tax level adjusted so that if emissions in a given year lie outside a pre-determined band around the target, this triggers an adjustment of the tax level to bring emissions back within the target range. This would also provide transparency and certainty about future tax levels, which is important in ensuring firms make the correct investment decisions and in incentivising the development of abatement technologies.

5.2 Incentives for innovation and investment

Price stability

The major benefit of a tax is that it provides a stable carbon price up front, which is critical from the perspective of encouraging investment in abatement and innovation. This point is of particular importance to developing countries where high levels of uncertainty tend to already impact negatively on the investment climate. Without price certainty firms may delay investment in emissions reducing technology as future payoffs are unclear (Parry & Pizer 2007). A tax provides consistent incentives to firms to change their behaviour, allowing them to plan accurately for the future and adapt at a pace appropriate to their business. Once a tax is established as a policy instrument, it is relatively easy to increase slowly over time. On the other hand, the flexibility to adjust the tax rate only once a year, compared to the constant self-adjustment of an ETS in response to new information, may be a weakness of a tax.

The main weakness associated with an ETS, however, is price volatility. The price of permits can vary substantially based on a broad range of factors such as break-throughs in mitigation technology, the demand for and supply of energy, general economic conditions, availability of information, compliance dates and specific demand and supply conditions in underlying product markets. This was borne out in practice when the EU ETS allowance price fell from a high nearing 30 euros to almost zero, based on an untimely announcement of emissions data by the scheme regulatory body. This price volatility not only undermines the effectiveness and credibility of an ETS but also disincentivises long-term investment by firms in mitigation technologies (Parry & Pizer 2007). Furthermore, it can have implications for the wider economy. A changing carbon price will contribute an added element of variability to already volatile energy prices (Shapiro 2009). In South Africa, which faces uncertain future prices of electricity in particular, a volatile carbon price could be especially damaging.

The introduction of a 'safety valve' can counteract the price volatility associated with an ETS. This involves a trigger price at which firms can buy unlimited permits from government, effectively providing a ceiling for the permit price. Economic analysis (CBO 2008; Pizer 1999; 2002) suggests that this type of hybrid scheme could lead to substantial efficiency gains. However, Mason (2009), notes that price caps have the potential to undermine the benefit of certainty of emission reduction, which is one of the main advantages to emissions trading, and that this may make the relative simplicity of a tax more attractive.

Transparency

A price-based instrument is much less susceptible to corruption than a quantity-based instrument (Nordhaus 2007). This is because a tax level is known to all stakeholders and the amount of tax paid by individual firms is known, at least by government. Firms cannot manipulate the carbon price and consumers can understand the increased costs firms are facing, making it more difficult for firms to increase prices excessively. Permit allocation on the other hand encourages rent-seeking as the permits to be distributed are valuable assets. According to the US Climate Taskforce (Mason 2009), indications are that the design of the EU ETS was to a significant extent influenced by dominant interest groups.

5.3 Cost to society

Potential for international co-operation

The economic instrument most heavily in use internationally currently is the ETS. Should the opportunity arise in the future, there are benefits to linking a domestic scheme with these international schemes, as it gives participants access to a greater pool of abatement opportunities, and therefore a potentially lower cost of compliance.

Sin et al (2005) find that the existence of an international permit market changes the theoretical comparison of the two instruments and it may become optimal for the country to also introduce an ETS. The reason for this is that the quantity target imposed by the cap is effectively relaxed, since firms can choose to comply by purchasing permits from other countries and no abatement need happen in South Africa at all. This is obviously dependent on the relative cost of emission reduction in South Africa versus elsewhere. It is anticipated that South Africa will have surplus emissions to sell due to the high level of energy inefficiency in the economy. Sin et al (2005) argue that in the case that an international trading regime exists, a tax and an ETS would have the same environmental outcome but the trading scheme would be more efficient since the price of permits would adjust quickly to any market developments whereas a tax stays fixed over a given time-period. A counter- argument against the ETS, however, is that South Africa would be at the mercy of international price volatility, with little power to control the underlying causes.

Revenue generation

By definition a tax is a revenue-raising instrument. In the context of a carbon tax this means that a significant amount of money could be collected, boosting the fiscal budget position. An auctioned or partially auctioned trading scheme could create equivalent revenue for government, but, as noted in section 3, in practice trading schemes have been predominantly grandfathered to begin with, as this allows the impact on firms to be offset, and perhaps explains a large part of the attractiveness of this mechanism to industry. The EU ETS is, however, auctioning a greater proportion of permits in each Phase, showing that, albeit slowly, a scheme can eventually reach a position where a substantial proportion of permits are auctioned. As noted above, as a developing country, South Africa has many competing demands on the public purse, and from this perspective the ability to generate additional funds may be important.

Flexibility

Climate change results from the slow build-up of GHG emissions over time which means that emissions in a given year make up only a small proportion of the total problem. This means that in order to limit climate change emissions must be reduced significantly over a long period of time but that precisely hitting the target in any given year is less important. By contrast the cost of abatement may vary quite substantially from year to year for a range of reasons, such as the level of economic activity, energy market disruptions, and the availability of new low carbon technologies (US Congressional Budget Office 2008). In this context, a tax is efficient, since it gives firms the flexibility to choose when they abate; they can emit more or less in one year and pay more or less tax. The optimal level of emissions will still be targeted in the long term but firms can respond appropriately to business cycle fluctuations and periods of high and low demand for their product.

A pure ETS does not have this advantage. However, an ETS is easily adapted to allow firms more flexibility through the inter-temporal banking and borrowing of permits. Banking allows firms to hold onto unused permits from one year to be used to meet compliance targets in the following year, whilst borrowing allows firms to use part of the following year's permit allocation in the current year. Generally banking is seen as more desirable, since borrowing may encourage firms to delay abatement which could destabilise the market later on, undermining the credibility of the scheme (UK Department for Environmental, Food and Rural Affairs 2008). All schemes in operation internationally make some form of allowance for banking or borrowing.

Distribution

A tax can be made more acceptable to various stakeholders through a degree of revenue recycling. For example, carbon tax revenues could compensate households bearing the greatest burden of carbon policies, or insulate the poor from the pass-through of carbon costs onto items such as food or energy. Alternatively it could fund incentives for the development of 'green' technologies or be used to lower other taxes. This final example has been termed the 'double dividend' effect, since it improves the efficiency of the economy twice; first from reducing the negative impact of the pollution externality, and second by reducing the distortion caused by other taxes in the economy. Computable general equilibrium (CGE) analysis conducted by Van Heerden et al (2005) suggests that such revenue recycling could have significant benefits in South Africa.[2] The South African Treasury however is not in principle in favour of this 'earmarking' approach. An auctioned ETS could have similar benefits.

Economic growth

Economic growth is largely seen as important for development. Given the initial finding that taxes and trading are equivalent (see Section 2), neither instrument is therefore a priori better or worse in its effect on economic growth, assuming each is appropriately designed. For example, if price volatility is not contained within a cap and trade scheme this will have negative consequences for investment, and therefore growth. The greater impacts on growth are more likely to be determined by the level of tax or emissions targets and the extent and effectiveness of redistributive policies employed to offset the effects of the instrument on households and business.

Risk mitigation

An advantage of an ETS over a tax is that it establishes a market, with all the trappings of a market including the ability to sell or buy forward, use derivative instruments, and involve additional players in the form of speculators. All this market infrastructure assists emitters to smooth their abatement investment over time, and better manage the risk that abatement technologies and emission reduction commitments introduce. A tax has none of these opportunities, although risk is capped at the level of the tax in any one year.

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2 Such models abstract from the realities of transaction costs and it may be that the cost of implementing a carbon tax would outweigh some of the benefits. Importantly, however, a tax would not channel government funds away from spending priorities but would rather provide funds which could be used to solve other problems.

Competitiveness
An ETS allows the government to protect certain strategic sectors by the imposition of weaker or stronger targets through the permit allocation mechanism. A tax does not have this flexibility, but it can be created by including a system of tax rebates, for example for export exposed industries.

5.4 Implementability

The implications of market power
Market concentrations can be a problem in an ETS, both while the scheme is being designed and set up, and during its operation (Muller & Mestelman 1997; Stavins 1997). If either the permit market or the underlying product market is dominated by a small number of firms, then these firms could exert too much influence, leading to inefficiencies in scheme design. Once in operation, excessive market power can allow firms to manipulate the permit price for their own gain and at the cost of smaller players. For example, firms may prevent entrants from joining by over-buying permits to push up the price and they could buy up permits in advance to give themselves the option of not abating or just to control the market (Sin et al 2005). In this way, permits can be used to further monopolise underlying product markets. In South Africa, therefore, unless Eskom and Sasol are excluded from the scheme, market concentration is likely to be a problem. However, their exclusion would have serious implications for its environmental effectiveness and economic efficiency. An alternative would be to choose a point of emissions obligation which dilutes market power. For example, targeting emissions at the point of consumption of electricity bypasses this market concentration problem (potentially through a White Certificate Trading Scheme). Including the dominant companies at the level of business units rather than the whole firm is also an option, however, this seems likely to be open to abuse in practice as firms will always seek to benefit their own units wherever possible, and it may therefore be difficult to effectively monitor and enforce. This issue presents a substantial challenge to the implementation of an ETS in South Africa, which is anticipated to require careful design in order to overcome. Whilst a tax is also susceptible to the lobbying of dominant market players in its design, it is inherently more transparent than an ETS.

Complexity and institutional requirements
A carbon tax represents an additional tax in a suite of taxes already administered by government. In South Africa the institutions necessary to levy a tax are already in place and the South African Revenue Services, which would be responsible for administering a tax, is one of the most capacitated and efficient of government departments. On the other hand, an ETS is a complex and sophisticated policy instrument, requiring the establishment of new monitoring and compliance systems, institutions, exchanges, registries and trading platforms. Credibility is a key contributor to the effectiveness of an ETS so sufficient skills and capacity to administer the scheme is critical. Lack of familiarity with trading schemes by governments can lead to significant disruptions (such as the premature and unmanaged release of emissions data to the market in the EU ETS, which resulted in the price crash of 2007).

These considerations, together with the lack of policy precedent for ETS in South Africa, suggest that a significant level of skill and institutional capacity would be required to implement an ETS effectively, and this will be problematic in South Africa. Some economists have also commented that, in the light of the recent global financial crisis, it may be wise to reassess the prudence of implementing a global emissions trading scheme. The expansion of carbon markets and complex derivative instruments based on tradable emissions permits, although desirable as a means of risk mitigation for firms (see above), also has the potential to be a destabilising influence on the economy (Shapiro 2007; *The Australian* 2009). The sub-prime crisis of 2008 provides a striking example of how unexpected events in the underlying market (the housing market in that case) can have enormous ramifications for financial markets when highly leveraged derivative products are allowed to blossom unchecked. It is certainly conceivable that, without adequate regulation, a similar crash could be triggered by events in the market for emissions permits, particularly since the future path of the carbon price is extremely uncertain and highly sensitive to unpredictable developments in technologies related to abatement.

Information requirements

A low-level (low enough not to cause any significant damage to economic activity) carbon tax can be imposed without any need to understand emissions at a firm-level, and the impact on sectors and firms can then be monitored over time as the tax is ramped up and data is generated. The first few years of such a tax could be designed as a data gathering exercise primarily.

A grandfathered trading scheme on the other hand requires the regulator to have accurate historical emissions data for all the firms covered by the scheme in order to determine permit allocation. This is a far more detailed level of data (aggregated to at least the sector level), than is currently available in South Africa. However, a trading scheme with a generous emissions cap could still provide the same information gathering benefit of a low tax level, and an auctioned ETS would supply information to policymakers immediately. The voluntary UK ETS was such an exercise, providing the government and participants with insights and practice in emissions trading, and simultaneously generating information.[3] Emissions trading also enables the cost of emissions reduction to be discovered through the market price, providing important information to policymakers.

Political attractiveness

Business and industry are typically opposed to a new tax, which is seen as presenting only an additional cost to production, and South Africa is no exception. Firms are also often concerned about the potential for government to begin using something which is meant to be an instrument to solve a specific market failure as simply a revenue-generation tool. By contrast, an advantage of an ETS is that the allowance allocation mechanism can be used as a tool to generate political support for the instrument. Grandfathering favours heavy emitters, with the most to lose through the introduction of carbon mitigation policy. It has also been suggested that grandfathering can militate against competitiveness and carbon leakage concerns by insulating firms against facing the full cost of their actions, at least in the initial phase of the scheme. Note that as a scheme moves to a fully auctioned approach, it loses this initial advantage. If auctioning is not introduced, an ETS creates a clear constituency of participants who have a strong financial interest in the success of the scheme and in its continuing existence (Duval 2008).

Paradoxically, ETS can also encounter significant opposition from some sectors in society which see trading schemes as paying polluters to pollute. Indeed in initial

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3 This scheme was actually a 'reverse auction', where companies bid in volumes of reductions for incentive monies.

phases of an ETS when grandfathering is still playing a significant role in allowance allocation this can certainly be the case. The windfall profits earned by power companies under the EU ETS described above provide a prime example of this. Firms with inelastic demand for their products can pass on the price of permits to customers and make extra profit even if they engage in no abatement activities (Mendes & Santos 2008).

The lack of market experience

Recent developments in the South African electricity sector (crisis, proposed liberalisation, electricity price rise) have implications for the design of any economic instrument. The electricity price increase should act as a natural stimulus for the adoption of more efficient practices and technologies and so the introduction of a carbon price through either a tax or ETS should be considered carefully, as in the short term it may well be too much of a burden for firms to face on top of their increased energy costs.

An ETS is likely to work better when it is implemented in a sector already familiar with markets. Currently, the South African energy sector is characterised by few players and little liberalisation, suggesting a tax is more appropriate. However, the potential opening up of the electricity generation sector indicates that the prospects for an effective ETS may be substantially better in the medium-to-long term.

6. Tax or trading in South Africa?

This paper has attempted to shed some light on the inherent advantages and disadvantages of the two most widely used economic instruments to mitigate climate change, applied in a South African context. The analysis suggests that a carbon tax may be the most appropriate economic carbon mitigation policy instrument for South Africa at the current time. This conclusion is based most strongly on the simplicity of a tax, the problems of market concentration issues with an ETS and the value of price certainty for the extensive electricity sector investment which is anticipated over the next decade. Although the paper has concentrated more on the instruments in pure form, the analysis suggests that these arguments stand even when different hybrid forms of the instruments are considered.

Whilst the acceptability of a tax could be problematic, there are signs that international opinion is becoming more favourable to carbon taxes, and negotiated rebates for key constituents may make the instrument more palatable. However, as with grandfathering in an ETS, such rebates should not be offered indefinitely and should decrease over time approaching some date in the future where they will be removed completely. Over time, however, an ETS may become an increasingly appropriate instrument for the country, particularly if international emissions trading becomes a reality. South Africa is particularly emissions-intensive and therefore likely to be a net seller, resulting in forex inflows. Also, under a linked sheme, concentration issues could be overcome. The larger the market, theoretically the more efficient the market becomes, and the more stable the price.

It is clear from the analysis that the policy design process is at a very early stage in South Africa, and further research would be helpful on a range of issues, in order to allow policy-makers to make informed decisions. Some examples of potentially fruitful areas for future research include the following:

- A study of the likely shape of the South African marginal cost and marginal benefit curves looking at how these differ depending on whether international agreement is reached or if the country acts unilaterally, and the implications of this analysis for the choice of policy instrument.
- Further investigation of the potential for white certificate trading as a way to work around the problem of market power in an ETS, building on experience from the Power Conservation Programme.
- An analysis of the ways in which a carbon tax could evolve into an ETS over time and the optimal design of a tax which is intended to do this.
- Further consideration of international experience and literature, in particular looking at any analysis considering the application of mitigation policy in other countries with similarities to South Africa, such as South Korea and various South American countries.

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