Analysis of the economic implications of a carbon tax

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Abstract

A carbon tax should be considered among the range of instruments available to the South African government, economy and society, as part of a broad portfolio of mitigation actions. A carbon tax was one of the most effective wedges or mitigation options analysed for the Long-term mitigation scenarios (LTMS) for South Africa. The LTMS strategic option 'Using the market' reduced emissions roughly as required by Science, for several decades. The LTMS research indicated that the effectiveness increases, up to certain tax levels. South Africa might consider a tax starting around R100-200 / t CO_2eq, escalating in future.

Our paper presents results on research on a carbon tax in South Africa conducted in 2008 and was presented at the Climate Change Summit 2009. The efficiency with which a carbon tax achieves the goal of reducing GHG emissions depends on responsiveness and substitutability. This is shown more fully on the supply-side, while further work will be needed to fully understand the response to a carbon tax on the demand side.

Careful design of a carbon tax (or other economic instruments considered) will be important to ensure that it is effective in meeting its objective – reducing GHG emissions. We propose a price discovery and adjustment mechanism that sets a band around the desired 'peak, plateau and decline' trajectory.

Equity demands that poor households, in particular, be shielded from any burden. Off-setting incentives, such as food subsidies or reduced VAT on basic goods, should in finance measure that which will ensure that the package of tax and incentives is a net benefit to the poor – and not to treat the tax as a revenue-raising instrument. With appropriate design, a carbon tax can be a powerful instrument of mitigation in South Africa, and at the same time, contribute to socio-economic objectives.

Keywords: carbon tax, South Africa, economic instruments, climate change mitigation, greenhouse gas emissions

1. Why a carbon tax?

Why might South Africa consider a carbon tax? The purpose would be to reduce greenhouse gas (GHG) emissions. A carbon tax would achieve this through two broad effects – a demand effect, reducing energy demand due to higher prices, and a substitution effect, with switching from more to less carbon-intensive fuels. There are other ways of achieving this end, but a carbon tax is a highly effective means of doing so – if experience of actual taxes in other countries and modelling of potential taxes in South Africa is any guide. The classic argument advanced by many economists against taxes is that they are distortionary. However, as David Pearce has long pointed out, since environmental taxes seek to redress market failures, they do not share the distorting properties of many other taxes (Pearce 1991).

The aim of this paper is to provide an overview of the implications and impact of a carbon tax in the South African context – it aims to serve as an introduction rather than an exhaustive analysis, and therefore does not draw any comparative conclusions on the suitability of a carbon tax by comparison with alternative instruments such as cap and trade systems. Before turning to the specific topic of this paper, a carbon tax, some background is given on economic instruments and carbon markets. Following this, existing attempts to model the impact of a carbon tax on the South African economy are discussed, followed by a discussion on policy challenges and some existing proposals.

2. International experience with carbon taxes

In the negotiations of the Kyoto Protocol, the European Union was a strong proponent of a carbon tax, harmonised across the globe. The American approach favoured emissions trading, based on the experience with SO_2 trading in the North-Eastern states. The Protocol ultimately included international emissions trading as one of its three flexible mechanisms (UNFCCC, 1997). It is one of the ironies in the history of climate negotiations that the Bush administration withdrew from Kyoto in 2001, and that Europe is now leading the implementation of the largest emission trading scheme.

Carbon taxes have mostly been implemented in Scandinavian countries, and a few other European countries. Where they have been implemented, it has often been in concert with other policy instruments. Nonetheless, the argument continues to be made for a carbon tax as a 'pure' economic instrument. A key rationale is the (at least theoretical) greater efficiency of achieving environmental outcomes through the price mechanism.

2.1 Scandinavia

Finland (1990), Sweden (1991), Norway (1991) and Denmark (1992) led the way in implementing a carbon tax. According to a review by Anderson, an important factor favouring this shift was that 'Concerns regarding climate change coincided with priorities to reduce income taxation, and combined to a tax shifting exercise' (Anderson, 2008: 63). In terms of the basis for the tax, there were different and varying approaches. Finland originally based its tax on carbon content, but later combined this with energy content in a 60:40 ratio. In the Finnish case, some transport fuels (marine navigation and commercial aviation emissions) were exempted. Sweden set its tax according to the average carbon content of the fuel. Biofuels and peat were exempted, but also fuels for electricity generation. Assessing the effectiveness of the tax, Sweden reported mitigation in the order of between 0.5–1.5 million tons CO_2 per year. Revenues were US$6 billion or 3 percent of GDP in 1995. Further details of each tax, the levels set and experiences gained has been described elsewhere (Tyler et al., 2008).

Among the Scandinavian countries, Denmark's approach of combining a carbon tax with subsidies for energy efficiency appears to have had the best results, noting that its electricity sector is more carbon-intensive (Anderson, 2004). Anderson in his earlier study concluded that, 'on balance, the studies appear to show that emissions have been curbed when compared to business-as-usual forecasts, while absolute CO_2 reduction remains the exception'; consistent studies were not available across countries to draw more specific conclusions (Anderson 2004: 3502).

European experiences also led to a 'relatively broad consensus about the properties of revenue-neutral environmental tax reform' (Anderson, 2008:64). 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.

2.2 Other parts of Europe

Anderson examined six European countries that implemented Environmental Tax Reforms (ETR) and showed reductions in fuel demand and GHG emissions, on average by 3.1 percent in 2004 against the counter-factual baseline (Anderson, 2008). The size of the reduction in fuel demand depended on the tax rate, its basis, and the availability of substitute fuels. A notable exception was the German ETR, which was not efficient in reducing GHGs – because it excluded coal. Another feature of the European experience relate to exemptions. Energy-intensive industries in particular will argue the case of exemptions from a broad carbon tax. Anderson notes the complicated schemes have been designed to balance, cap, or reduce the tax. Member states apply to the European Commission for approval, essentially for lower tax rates. While the burden on energy-intensive industries 'remains negative … due to many exemptions, the actual burden is rather modest' (Anderson, 2008: 79). From an economic perspective, however, the exemptions are distortionary.

2.3 Lessons for South Africa

Recycling of revenue, poverty and development: In Scandinavia, the desire to reduce income taxation may have created a favourable environment for the introduction of a carbon tax. In South Africa, tax relief has been given in years when it was possible, and while the South African Revenue Services (SARS) could still over-recover tax – this may change with the global financial crisis (Manuel, 2008). A priority that is not likely to change any time soon is that given to poverty alleviation and job creation (Manuel, 2008; AsgiSA, 2006). If revenues from a carbon tax can be combined with reduced taxes or incentives for the poor (e.g. subsidies for food-stuffs consumed primarily by the poor, or a basic income grant), the overall tax-incentive package would be better aligned with major development priorities.

Combining a tax with incentives and revenue-neutrality: This relates directly to another possible lesson for South Africa. Anderson's review noted a broad consensus that taxation should be revenue-neutral. Such an approach would not raise concerns about new taxes, especially when the purpose of the tax is not to raise revenues. Nonetheless, how the revenues are recycled – also taking into account priorities of poverty and employment – needs to be agreed. Structuring an overall tax-incentive package seems less likely to raise objections of 'ring-fencing' than a dedication of revenues to particular expenditure.

Potential for double dividends: With an integrated approach, a 'double dividend' can be achieved – improving social welfare while reducing environmental damages. This general proposition was supported and done by analysis for the LTMS process (Pauw, 2007; Winkler, 2007), which in turn, built on early findings of even a 'triple dividend' by other CGE modellers (van Heerden et al., 2006). A fiscally neutral package can reap positive benefits for employment.

Approach to energy-intensive sectors: Learning from the European experiences with carbon taxes, requests for exemptions from a general carbon tax should be anticipated. The more a firm spends on energy as a share of its total costs, the more sensitive it would be to a carbon tax, other things being equal. Energy-intensive industries, in particular, may ask for lower tax rates. On the positive side, energy-intensive industries are often capital-intensive, so that structural change to more labour-intensive (and less energy-intensive) sectors would have benefits for employment (Fisher and Grubb, 1997).

Rather than dealing with this on an *ad hoc* basis, a structured approach for energy-intensive sectors may be important. As an overall strategy for a low-carbon economy, it has been suggested that energy-intensive sectors be required to reduce their energy intensity, while protecting employment. This strategy would require a combination of reviewing existing policy promoting beneficiation, specific energy-intensity targets, international negotiations on best location for such industries, and diversification within these sectors (Winkler and Marquard, 2007). What is also seen from the international experience is that too many exemptions create an unequal playing field. And if the upshot of ad hoc adjustments was to exclude most emissions from coal (as in the German case), the tax is likely to become ineffective. This is discussed further in more detail in the section on design of a tax system.

3. Potential impact of a tax on the South African economy

The potential impact of a carbon tax on South Africa is uncertain; however, some modelling work has been done to explore the response of the economy and the energy system to the imposition of such a tax. Two energy modelling studies have been done, and two economy-wide modelling studies have been done: a partial equilibrium model of the whole energy system was developed for the Long Term Mitigation Scenarios project, and the impact of a carbon tax was modelled in some detail, which gives some indication of how the energy system would respond, and at what price levels. Another modelling study was completed as part of NERSA's third National Integrated Resource Plan for the electricity sector only, which contained a carbon tax scenario. As part of the LTMS project, the economy-wide implications of a carbon tax were explored using a CGE model, and in a separate study, also using a CGE model, taxes (van Heerden et al., 2006) also explored the economic implications of a carbon tax. These results are outlined.

3.1 Impact of a carbon tax on the energy system

3.1.1 The LTMS modelling framework

In the analysis for the LTMS (Winkler, 2007; Hughes et al., 2007; Winkler, 2007), a carbon tax was shown to be very effective in reducing GHG emissions, and was the largest emission reductions of all options analysed – the largest 'wedge' in graphical terms.[1] A carbon tax is actually a means of implementation rather than a mitigation option, since it would incentivise a range of mitigation options (for example, renewable energy, energy efficiency, etc). Like all bottom-up models, the modelling framework for the LTMS is dependent on the technological alternatives available in the model. In this section, we refer in particular to an escalating CO_2 tax as modelled for the LTMS process (Hughes et al., 2007; Winkler 2007).[2]

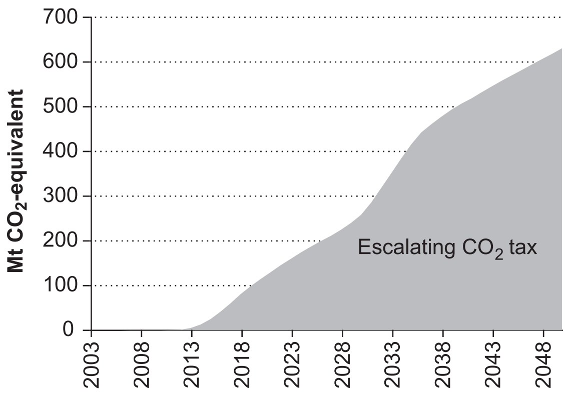

Figure 1: Emission reductions from an escalating CO_2 tax

The CO_2 tax was also the dominant element in the most successful strategic option for mitigation. Note that emissions trading was not explicitly modelled – in uses of Markal as a methodology for such an analysis, a carbon tax is often used as a proxy for emissions trading. However, other incentives, such as subsidies for renewables for electricity generation or solar water heaters, were assessed. Again, however, the methodology used in LTMS did not model trading of permits in any explicit way (Winkler, 2007).

GHG reductions resulted primarily as a result of shifting from coal-based energy carriers to others, particularly in the electricity sector (to nuclear and renewable energy), in the liquid fuels sector (from synfuels to crude oil refineries), and in industry (from coal to natural gas). In the Growth Without Constraints scenario (business as usual or the baseline scenario), coal dominates electricity production, contributes significantly to liquid fuels production, and dominates many thermal applications in industry. The results of the shift are portrayed in the figures below.

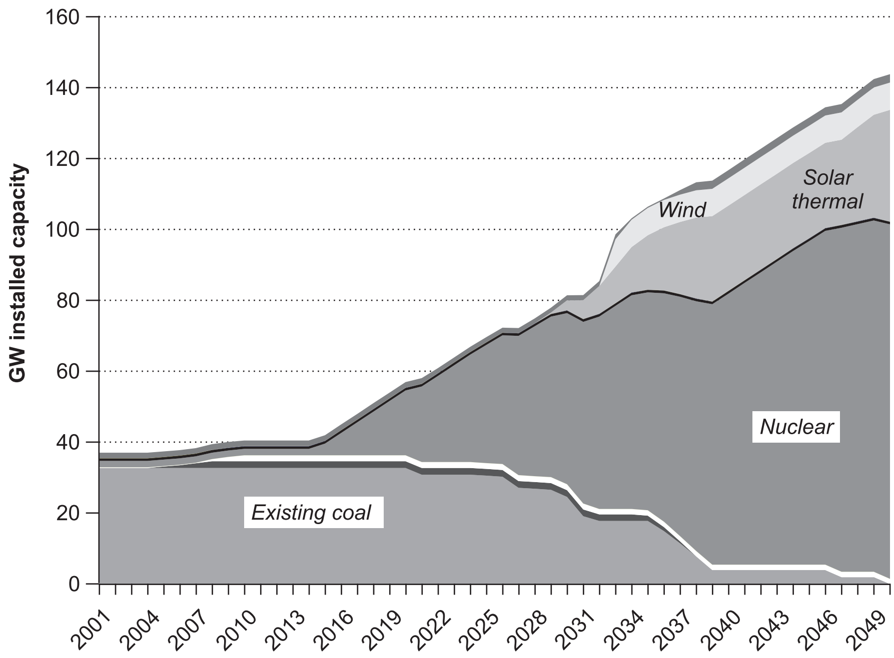

Figure 2: Electricity generating capacity by plant type: escalating CO_2 tax

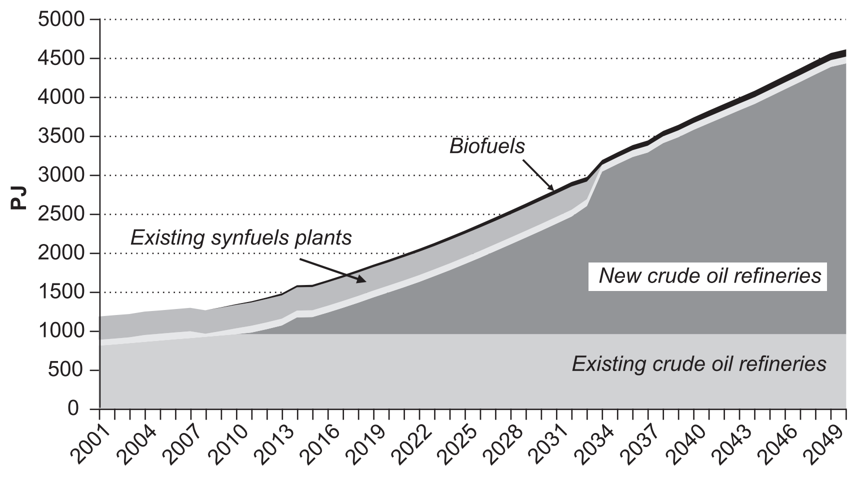

Figure 3: Output from refineries and synfuel plants: escalating CO_2 tax

The model has a high sensitivity to the tax level, but the response of the model to increases in the tax level is not even, and is highly dependent on available alternatives and the cost of these in each sector. For instance, in the electricity sector the alternatives to the cheapest technology (coal) are viable as are relatively low tax levels, whereas synfuels become unviable at a slightly higher level, and alternative carbon-free transport technologies such as electric vehicles (with a non-carbon electricity source) only become viable with a very high tax level (at current costs). Thus, the response of the energy system to different levels of carbon tax is dependent on existing alternatives, and the development of new technologies will increase the responsiveness of the system. The modelling framework does *not* take into account shifts in the structure of the economy, which would result from structural changes in energy prices. These are uncertain and would probably increase the impact of tax.

As a result, from what is known about the structure of the energy system, the carbon intensity of its components, and the cost of existing components and alternatives, the modelling results give clues about an optimal level for a carbon tax, subject to key policy goals. Figure 4 illustrates the modelled response of the energy system to different tax levels in 2003 Rands. This is illustrated in Figure 4, in which it can be seen that the marginal impact of higher tax levels declines from R140 up. There are significant gains from R140 to R400, but the marginal gains after this are insignificant, and the gain

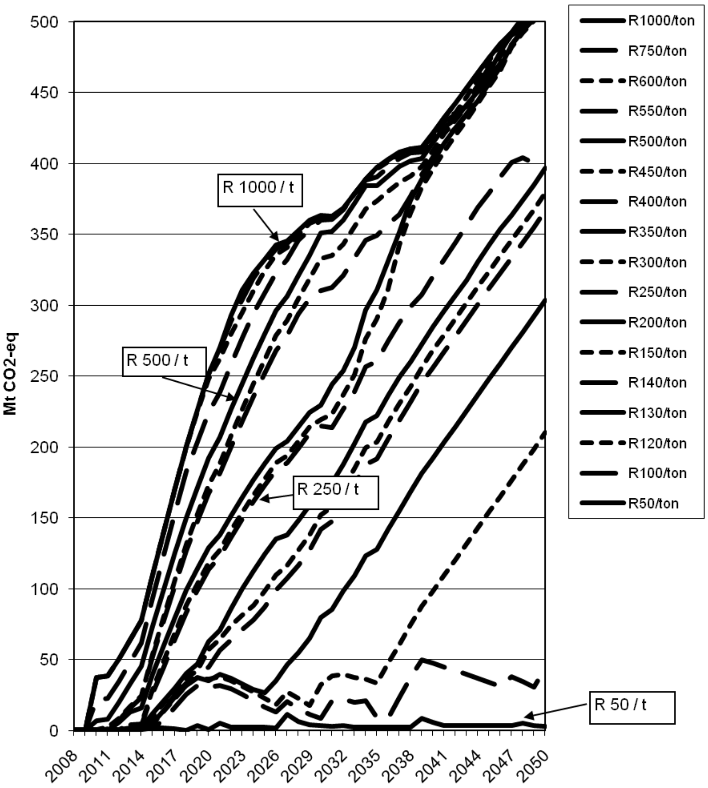

Figure 4: Mitigation impact of different tax levels

from R750 to R1000 is negligible. The problem of setting the level of the tax with a particular mitigation goal in mind (a key policy problem) could be approached in this way, as well as the design of appropriate supportive programmes aimed at enhancing the responsiveness of the economy to the tax. The responsiveness would change over time, as new technologies became available, and as the structure of the economy changed. Thus, the process of setting the required tax level would have to be sensitive to these developments.

3.1.2 Modelling of electricity sector for NIRP3

The third National Integrated Resource Plan[3] (NIRP3) considered analysis of a carbon tax as a well, providing analysis from a separate process (NERSA, 2008). Having developed a reference case and a number of diversified plans, a sensitivity analysis[4] was conducted, introducing carbon tax. The plans were not re-optimised, but rather re-run with the tax to indicate sensitivity of each resource plan to a possible future environmental tax.

In the first analysis (Stage 4), it was found that a 'R100/ton CO_2 tax is not enough to overcome the higher capital and fixed O&M costs associated with nuclear technology', but that increasing tax levels to R200 / ton did overcome the cost barriers. A further round of analysis (NIRP3, Stage 5) extended the analysis, considering not only nuclear (diversified plan 2), but also gas (diversified plan 1) and renewables (diversified plan 3) as alternatives; and reporting changes in revenue requirements. The nuclear plan (2) showed the greatest response to the carbon tax, but also the highest Present Value Revenue Requirement (PVRR). Renewables (3) was still the most economical plan on a PVRR basis. The analysis found that 'the carbon tax does not impact on the relative ranking based on that criteria', i.e. PVRR.

For the purposes of this paper, the result of interest are the tax levels. A significant difference was found by NIRP3, with R100 / ton CO_2-eq not sufficient to overcome cost barriers, but a much more marked effect at R200 / ton (2006 Rands).

3.2 Economy-wide modelling

3.2.1 Economy-wide modelling for LTMS

The Markal modelling results considered the direct effects in the energy sector only. Economy-wide analysis, using computable general equilibrium (CGE) analysis was also conducted in support of LTMS (Pauw, 2007). The CGE analysis converted a given level of a CO_2 tax to a comparative tax on coal, crude oil or natural gas used as intermediate inputs in production processes. By including simulation of a CO_2 tax in a CGE context, the indirect effects across the economy are also captured.

In other words, the modelling includes direct effects (shifts in electricity generation from coal to renewables and nuclear; or away from synfuel), but also indirect effects. For example, renewable energy technologies like solar thermal plants would require more of some inputs (e.g. glass for mirrors) and less of others (e.g. coal). In this example, suppliers of glass would see increased demand for their product, increasing output and employment in that sector; while coal mines would see less demand. Economy-wide modelling indicates the net effect and provides information on effects on economic output and employment, among others.

Taxes generate revenues. The way in which revenues are recycled turns out to be critical to the overall socio-economic effects. Revenue from a CO_2 tax can be used in a variety of ways by government:

- to reduce its deficit;
- to further mitigation, if recycled in the form of production subsidies for nuclear/renewable energy and biofuels; or
- in ways aimed at off-setting the potential effects of higher energy prices on the poor, through food subsidies, reduced VAT or income tax or increased welfare transfers.

The economic impact of the tax depends to a significant extent on the form of revenue recycling. The CGE analysis found that, in a range of R25-R75 per ton (in 2003 Rands) of CO_2-eq, it appears possible to off-set negative economic effects of the tax through complementary policies (Pauw, 2007). Welfare effects (assuming food-price recycling) stay positive up to R100 for semi-skilled and R200 for unskilled workers. At R100, wage changes are still slight (and ambiguous in sign).

3.2.2 Dynamic economy-wide modelling for LTMS

A methodological improvement, suggested in meeting with senior economists, was implemented in response to enquiries from the Forum of South African Directors-General (FOSAD). The original analysis (section 3.2.1) was a comparative static, i.e. increased investment in one period did not increase capital stock in the next, since there was no time and investment was exogenous. The dynamic variant of it allows for capital stock to be updated in the model, so that increased investment enhances the productive capacity of the economy over time. There was no specific analysis of different tax levels.

Many of the detailed findings of the comparative static analysis were confirmed. The relevant LTMS strategic option is 'Use the market', driven by a CO_2 tax. For Use in the market, the accounting for investment makes a major difference. Impact on GDP is mildly positive (0.73%) instead of the previous -2%. The earlier result was due to large increases in energy prices which seriously hurt the economy; in the dynamic analysis these price increases are now overshadowed by higher investments. The impact on jobs is shown to be very small, but positive, in the dynamic analysis; whereas in the static modelling, an increase in jobs for low-skilled had its counterpoint in decreases for skilled workers. Income from employment increases for all household groups. The differences in welfare effects are marginal in the static analysis, but taking into account dynamic effects, all households are better off. For low-income households, the reinvestment of revenues is important to ensure their welfare does not suffer. Various options (food subsidies, reducing the VAT rate, general welfare transfers) for recycling revenue have been examined in both economy-wide studies.

3.2.3 Economy-wide modelling and 'triple dividends'

Earlier analysis using a computable general equilibrium (CGE) model to analyse environmental taxes on energy investigated the potential for revenue recycling. The analysis suggests that a reduction in food prices may pay 'triple dividends' in mitigating unwanted effects of environmental taxes (Van Heerden *et al.,* 2006). Taxes considered were on GHGs, fuel inputs, electricity use, or energy. Revenue recycling could occur in one of three ways: (i) a direct tax break on both labour and capital, (ii) an indirect tax break to all households, or (iii) a reduction in the price of food. The study concluded that with a 'food tax handback', all four policies had the potential to reduce CO_2 emissions, grow GDP and reduce poverty (Van Heerden et al., 2006). However, in establishing an updated GHG inventory, the authors depart from the standard IPCC methodology and rely entirely on energy balances. Future work will combine the analysis with the complementary work in the article (Van Heerden et al., 2006), improving the rigour of GHG analysis while adding the benefit of indirect economic effects from CGE modelling.

4. Policy issues in designing a tax for South Africa

South Africa has not implemented a carbon tax. Some see the announcement by the Finance Minister of a 2c/ kWh levy on non-renewable energy (Manuel 2008) as the first carbon tax – and it would have the same effect. Current proposals from the Treasury, which are outlined in more detail below, are contained in an internal government policy paper released for public comment in 2006 (National Treasury, 2006) on environmental fiscal reform. The tax would form part of an overall response strategy to climate change, and would relate to both an overall policy shift towards sustainable development, and also to other relevant policy domains (for instance, energy security). We review the overall context before focusing on some key policy issues, of which the most important in South Africa are probably 1) how the initial tax level is set, and what mechanisms can be put in place to adjust the level; and 2) whether to apply the tax across the whole economy, or whether to develop special dispensations for potentially vulnerable groups (energy-intensive users and poor households). Thereafter, we briefly discuss the Treasury proposals.

4.1 Context: shifting to a low-carbon development path

As outlined in the introductory paper to this series, South Africa faces a particular challenge with mitigation, given that historically, the energy economy has been built around the minerals-energy complex (Fine and Rustomjee, 1996). This complex comprises mining, minerals processing, the energy sector, and associated industries linked to these sectors, based initially on mining, and then on beneficiation.

This historical structure of the economy also included comparatively low electricity prices. Policy on industrial development has promoted electricity-intensive investments, such as the smelting of aluminium at Coega or steel at Saldanha. Low electricity tariffs for industry are seen as a competitive advantage in attracting aluminium smelters to South Africa rather than other countries (Bond, 2000). The Coega Development Corporation (CDC) actively marketed the availability of electricity at 'very favourable rates' to attract investment (CDC, 2004).[5]

The world is moving toward a low-carbon economy and society (LCS, 2006; UK, 2003; UNDP & GEF, 2002). South Africa's own mitigation scenarios suggested that a 'transition to a low-carbon economy' was one of the fundamental transitions in the longer term (SBT 2007: 23). The risk of the current approach is that, while they may promote industrial development in the short run, they carry a high risk of 'locking in' the economy into energy intensive industries, when environmental, economic and social pressures may push South Africa in the opposite direction (Spalding-Fecher, 2001). The reason for the 'lock in' effect is that, once a major investment like a smelter is made, there are very limited opportunities to improve the energy efficiency or alter the production process. Recent investments in steel and aluminium bear this out – while the processes may be optimized for that technology, the wholesale switch to a more efficient technology is very costly after construction (Visser et al., 1999).

While growth trends in the economy in the last two decades have resulted in higher growth in the advanced manufacturing and services sectors (as part of an orthodox development path), significant investment in energy-intensive industries in the 1990s has limited this diversification, and several new mega-projects (including a new aluminium smelter) are now in the planning stage. From 2008 onwards, though, the electricity crisis and particularly narrow reserve margins meant that some projects were put on hold. In terms of the national response, conserving energy and increasing efficiency are given much higher priority (DME, 2008).

Forward-looking economic and industrial policies could target less energy-intensive economic sectors. 'An active industrial policy is required to diversity the economy forward from South Africa's mineral-energy complex into capital and intermediate goods' (Michie and Padayachee 1998: 634). This would represent a major shift in industrial policy and would take decades to complete, given large investments in infrastructure. However, given the 'lock-in' effect, short-term decisions (the next power station, the next smelter or not) are critical in changing the trajectory of South Africa's energy development path. 'Bending the curve' requires a long-term perspective, but also involves policy changes in the immediate future (Raskin et al., 1998; Zipplies 2009).

What interventions might shift the South African economy to less emissions-intensive sectors? Five possible strategies have been examined elsewhere (Winkler and Marquard, 2007), but are summarised here. The first strategy would be to adjust state incentives (including industrial incentive programmes and special dispensations on low electricity prices) to avoid attracting further energy-intensive investments on terms which would severely restrict future mitigation options, and shift these incentives to lower carbon industries. Secondly, South Africa might focus its mitigation efforts on non-energy-intensive[6] sections of the economy, assuming that their international competitiveness would suffer less. Thirdly, however, the energy-intensive sectors themselves should not be ignored – they would be required to reduce their energy intensity, while protecting employment. This third strategy would require a combination of reviewing existing policy promoting beneficiation, specific energy-intensity targets, international negotiations on best location for such industries, and diversification within these sectors (Winkler and Marquard, 2007). The fourth strategy might be economic instruments, such as a carbon tax or domestic emissions trading, which would be expected to affect the energy-intensive sectors most strongly. 'Putting a price on carbon' now has political support (ANC, 2007). The Treasury, having conducted a discussion of options for environmental fiscal reform (National Treasury, 2006), announced in 2008 that four options would come 'under scrutiny for implementation including the use of emission charges and tradable permits, tax incentives for cleaner production technologies and reform of the existing vehicle taxes to encourage fuel efficiency' (Manuel, 2008). While policy design will be elaborated further, an initial levy of 2c / kWh on the sale of non-renewable electricity is to be collected at source from the electricity generator. Fifth, the focus of industrial policy and investment strategy could shift to less energy- and emissions-intensive sectors of the economy. These five strategies are in many instances complementary – a carbon tax implemented on its own is likely to be far less effective, and would possibly have a negative impact on the economy without reducing emissions. The aim of developing an integrated suite of mitigation policies around a set of economic instruments would thus be to minimise the impacts of the transition from a high- to a low-carbon development path, and to maximise the benefits. Some specific aspects of this transition are discussed.

4.2 Key policy issues

A range of key policy issue and design questions will need to be addressed in considering the implementation of a carbon tax in South Africa. These would include:

- more detailed investigation in the effectiveness of a carbon tax in reducing GHG emissions;
- detailed investigation of tax-setting and adjusting mechanisms;
- equity, distributional impacts and addressing poverty and development;
- combining a tax with incentives and recycling of revenues;
- legislative compatibility;
- technical and administrative viability, including the tax base and definitions of taxable events;
- competitiveness effects and a structured approach to energy-intensive exporting sectors; and
- adjoining policy areas.

Within this broader set of issues, our initial analysis has focused on three specific issues. The first concerns the level at which the tax should be set to bring about the required level of emissions reductions; the second concerns the potential impact of a carbon tax on poor households, and what measures could be taken to avoid this; and the third key issue concerns energy-intensive industries, and what measures could be put in place to avoid negative impacts to the economy which may arise from applying a carbon tax.

4.2.1 Setting an appropriate tax level

Different methodologies have both suggested that increasingly higher tax levels see diminishing returns in terms of mitigation. Both Markal energy modelling (partial equilibrium) and CGE analysis suggests that, over a certain threshold, further increases in the tax level do not result in significant further mitigation, and beyond a certain level almost no further mitigation results. As discussed, the location of this threshold is critically dependent on available alternative technologies and their cost. Thus, as new technology becomes available, and as costs of alternatives drop (as they are expected to as low-carbon technology is developed and deployed globally), the optimum tax level will change.

The challenge, therefore, is how to set the tax to get appropriate long-term mitigation, while preserving efficiency; or, in other words, how to set the lowest tax level which will achieve the required emissions reduction in the short, medium and long terms. The most preferable options would be to develop a flexible mechanism which can respond to new developments, but is also transparent enough to engender long-term investment in low-carbon technologies by investors.

Technically, the tax should escalate through the mitigation curve as mitigation options are required, but the precise costs of mitigation are only known after the fact; *ex ante* they can only be modelled or otherwise projected. Since these projections exclude changes in demand for GHG-linked services, there is a significant level of uncertainty. A possible solution to assist with price discovery, but also with a built-in automatic adjustment procedure, would be to define a band around a desirable emissions pathway. The 'peak, plateau and decline' trajectory outlined by Cabinet in considering the LTMS (van Schalkwyk 2008) is the obvious candidate for setting the desired pathway. A tax level would then be set around a level that is *expected* to achieve the desired result. Given that the exact response to the price signal is not known (needs to be discovered), this should be accompanied by an escalation (or decline) mechanism which adds, for example, 10 percent to the tax level if actual emissions are within a certain % outside the 'zone'. Conversely, if emissions turn out to reduce in practice by more than expected, the tax level would be lowered by 10 percent. Bands for greater changes (e.g. 20 percent, 30 percent) would be defined.

Figure 5 demonstrates the concept graphically. The green band represents the desired 'peak, plateau and decline' trajectory, and the bands on either side designate deviations from the trajectory. Actual emissions are indicated by the black line. Thus, in zone A, emissions depart from the desired trajectory and enter the +10% band, and during this period, the carbon tax escalates by 10 percent per year. In zone B, emissions depart further from the band into the +20% band, and the tax escalates by 20 percent per year. In zone C, the impact of a high carbon tax leads to a decline in emissions back into the +10 percent band, and the tax escalates by 10 percent. In zone D, emissions follow the desired band and the tax does not change, and in zone E emissions drop below the desired band and the tax is reduced by 10 percent per year.

The initial tax level is still very important, to prevent rapid change after the tax regime begins, as is the proposed emissions trajectory. From a strategic point of view, it is arguable that this will lead to a more cautious approach to investment in new car-

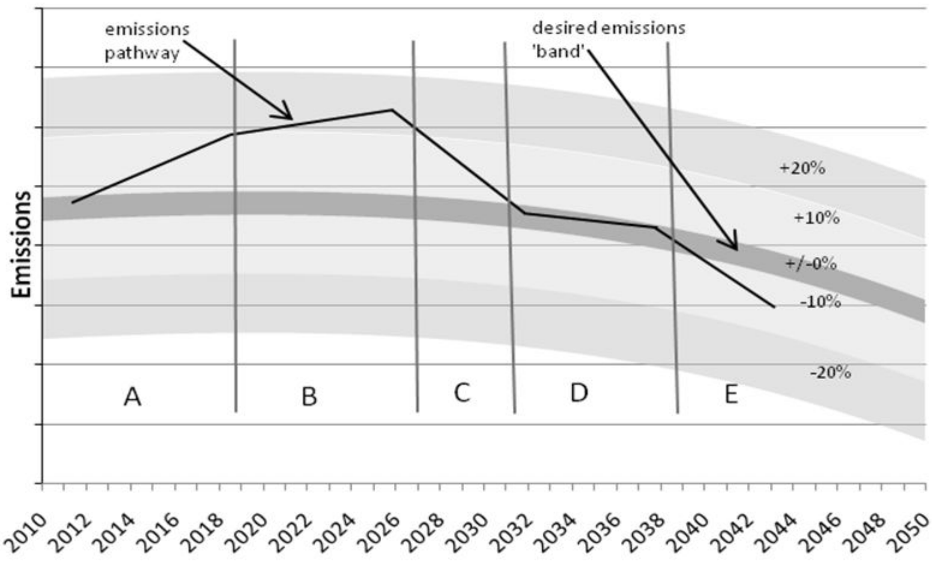

Figure 5: Conceptual diagram of a carbon tax adjustment mechanism

bon-intensive technology than a constant tax by firms, given the risk that other firms might increase their emissions and increase the general tax level. Thus, in some ways this arrangement would mimic a carbon market in that greater emissions levels would lead automatically to a higher carbon price, and vice versa, but without the short-term market volatility. While the behaviour of small firms would be fairly easy to predict, the strategic response of larger emitters (especially those who emit a significant percentage of total emissions) would have to be more carefully considered.

As a starting point, South Africa might consider tax levels of around R200/ton, which in nominal terms equates to around R140 in 2003 Rands (in the LTMS study). To give a sense of these tax levels, R200 / t CO_2eq is roughly comparable to an increase in electricity tariffs of 20c / kWh. For liquid fuels, it might translate to around 45 cents / litre for a tax of R200 per ton of CO_2. Current research indicates that this is not enough to incentivise non-fossil fuel sources such as renewable electricity generation, but current emissions trends indicate that the tax would rise rapidly using the above mechanism to a level which would. In the short term, the increase in price would be a powerful incentive for energy efficiency programmes.

4.2.2 Avoiding impacts of a carbon tax on the poor

A carbon tax would be likely to have two impacts on the poor. The first would be a direct impact on the cost of energy carriers used by poor households, directly on electricity, paraffin, LPG and coal, and indirectly through higher fuel prices in transporting bulk solid fuels such as coal and fuelwood, where applicable. The second would be indirect economic effects, either via higher input costs for services used by the poor (for instance, public transport), or via economy-wide impacts.

The impacts on the price of household energy carriers are relatively easy to predict, and would be also be easy to mitigate. If programmes to this end were implemented, households would actually be better off that they are now. The negative impacts of fuels such as paraffin, coal and wood on the welfare of poor households are well-known; the most desirable energy carriers for households which do not have this impact are electricity and LPG. The use of electricity by poor households has been dramatically extended through the accelerated electrification programme, but it was necessary to introduce further incentives (free basic electricity) to encourage wider electricity use in households, as affordability was a major problem. Imposing a carbon tax would make electricity even less affordable. So far, policy initiatives to encourage the use of LPG have failed. In the light of the negative impacts of paraffin and other inferior fossil fuels, there would be welfare advantages to imposing carbon taxes on these fuels if their use was further discouraged.

Thus, the most sensible approach to this problem would be to address it in the context of household energy policy as a whole, and use pricing mechanisms to further encourage a shift from paraffin and coal to electricity and LPG in poor households. This could be done in several ways: 1) in exchange for setting tariffs for poor households at a lower level, a carbon tax rebate could be granted on electricity sold to poor households (assuming a clear criterion exists); 2) the existing system of hidden cross-subsidies could be extended, which would effectively imply a slightly higher carbon tax for other users; or 3) a block tariff proposed by a number of stakeholders, which would allocate free electricity in the first block, followed by inclining blocks. This would have to be designed so that low-income households (which consume less electricity) pay less for electricity, and that other households then meet the revenue requirement of the utility, i.e. another form of cross-subsidy, but one which also has the effect of discouraging excess electricity consumption by households. LPG would be much more difficult to exempt, given its alternative uses in non-poor households, commerce, industry and transport, but an exemption could be targeted at small cylinder sizes only. In addition, on the demand side, programmes such as the Kuyasa housing project, which improved the efficiency of households, result in considerable energy savings and welfare benefits. At the same time, it would be imperative not to extend tax exemptions or cross-subsidies to non-poor households as higher energy costs would provide a powerful incentive to energy efficiency.

Indirect impacts, either through increased cost of services such as transport or other economy-wide impacts are more difficult to assess. In the case of poor households, transport has a similar property to energy provision in that it is underprovided, unaffordable and also unsafe. Providing enhanced public transport has been shown to have significant sustainable development benefits as well as mitigation benefits, and there is currently no evidence that a carbon tax would outweigh the efficiency gains inherent in implementing an effective public transport policy. Economy-wide modelling of the impact of a carbon tax has been attempted by van Heerden on revenue recycling and 'triple dividends' (2006) and the impact on poor households (Pauw, 2007) (see section 3.2.1).

The van Heerden study (see section 3.2.3) argued that energy in South Africa is complementary to capital and that this factor together with tax recycling that increases unskilled labour demand can produce a double or even 'triple dividend'. They find that recycling environmental tax revenues through reduction in food costs is particularly effective in achieving CO_2 reduction, economic growth and poverty alleviation (van Heerden et al., 2006). Macro-economic analysis thus provides an indication that there may be synergies at the societal level; yet climate policy would affect individual sectors, with winners and losers. Hence a degree of trade-off is likely to remain.

4.2.3 Energy-intensive industries

There is probably a case to be made for singling out energy-intensive industries in South Africa. What criteria one might use to identify these industries is uncertain, but the most commonly-proposed criterion is that energy costs are above a certain threshold percentage of total input costs.[7] As a result, energy price fluctuations have a much greater impact on the profitability of these industries, particularly if commodities are being produced for export and thus compete on the international market. Steep increases in South African energy prices could render these firms globally uncompetitive. This vulnerability is made more likely by the fact that because of the prevalence of very low long-term energy prices (and often long-term contracts, especially for electricity, guaranteeing future very low energy prices), firms investing in energy-intensive industries invested in relatively energy-inefficient equipment; as a result, South Africa's economy is not only energy-intensive, but the energy-intensive sectors of it are comparatively inefficient (Den Elzen et al., 2007). In developing a carbon tax, the aim is to incentivise both producers and consumers to reduce carbon intensity. The problem is that we have no verifiable information about what impact such a tax would have on any particular industry, nor on what the potential for improving the energy efficiency (and/or carbon efficiency for direct emissions) of these industries is, and what the cost would be. Moreover, many of these industries would not pass on cost increases due to the tax to consumers because of the regulatory environment in which they operate (for instance, Sasol would not be able to pass on the cost of a carbon tax to consumers without a change in the liquid fuels regulatory system); this would weaken the impact of the tax, but in some cases still provide a strong incentive to producers. Thus, any special dispensation regarding energy-intensive users should involve the following elements:

- If there is a special allowance for energy-intensive users, it should exclude new investment or expansion of existing plants, as part of the aim of a carbon tax would be to incentivise a low-carbon development path. This would also prevent 'carbon leakage' from other countries with carbon taxes or cap-and-trade systems. New entrants would have to pay the full tax. This may create a barrier to entry, and the implications would have to be explored further, and considered in terms of competition legislation and industrial and trade policy, as well as WTO rules. A fixed period for special allowances would have to be defined for existing plants to prevent older and less efficient plants from being operated longer than in a non-tax scenario.
- Competitiveness of existing industries operating in the international market would need to be protected, but a process of discovery would be necessary to demonstrate that this is a real problem. Adequate incentives would still have to be provided to take up any significant opportunities for reducing the carbon/energy intensity of these firms.
- If possible, the price signal to consumers should

be preserved to incentivise a shift to consumption of lower-carbon goods and services.

- If there is no possibility of firms responding to a tax incentive (for instance, because of a lack of available technology alternatives), there is no point in imposing one, but this is unlikely in South Africa given the extremely low energy prices of the last 30 years.

To meet the above criteria, a possible solution is to offer a rebate to energy-intensive plants in exchange for a commitment to meet a specific energy efficiency or intensity target.

For technologies where there are international precedents (for instance, iron and steel, or pulp and paper), international best practice benchmarks would be set, and firms would have to launch independently monitored and verified programmes which achieved the international benchmark within a specified time period. There may be scope for offering a reduced tax rate to new entrants who conform to the benchmark. This is more complex in the case of specific South African technologies which do not have widespread application elsewhere; for instance, synfuels and deep-level gold mining. In the former case, since this is one of the only plants of its kind in the world, benchmarking would be much more difficult. Another alternative would be to impose an emissions reduction pathway at a firm level which would approximate any nationally-adopted emissions reduction pathway. In order to preserve the price signal to consumers, a tax might be imposed on locally-produced output, which approximated the impact of the carbon tax on the firm. An alternative might be to compel expenditure on energy efficiency up to the level of the avoided tax revenue. All new plants would not be eligible for this programme.

An obstacle to this kind of programme would be posed by the extent of emissions from energy-intensive industrial activity, either directly or indirectly (through electricity), which could potentially comprise (depending on the threshold) up to 40 percent of national emissions. This suggests that a much more limited programme of rebates be considered, focusing on industries with specific vulnerabilities to international competition, or with historically unorthodox cost structures (for example, synthetic fuels).

4.3 Options investigated by Treasury

National Treasury has considered the option of a carbon tax, in the form of a fuel input tax, as part of a broader consultation process on environmental fiscal reform. An initial discussion paper (Eunomia & UP, 2004) and a discussion document were developed (National Treasury, 2003). Following workshops based on this information, an internal government policy paper was released for public comment in 2006 (National Treasury, 2006).

These initial documents suggested that the energy sector is likely to receive attention in future developments, particularly in relation to electricity generation and air pollution. An input tax on fossil fuels used for electricity generation may be considered, as might an electricity consumption tax. At least one observer suggests that such taxes would be likely to generate significant revenues, larger than the loss in sales revenue to Eskom (Winkler, 2009). Net revenues could be used to compensate municipalities for their lost revenues under restructuring; to support transitions of affected sectors; or to promote specific projects with environmental benefits such as end-use energy-efficiency and renewable energy (see section 4.3).

Of particular interest were 'tax shifting' programmes that use revenues from environmental taxes to offset taxes on labour (Winkler, 2009). Taxes would have to be levied at the bulk level and explicitly exclude poor households (EDRC, 2003; Nedergaard, 2002). Such considerations also lead the discussion paper to favour a fuel input tax over another option initially investigated for the electricity sector, an electricity consumption tax (National Treasury 2006: Table 9).

The process has been more formalised following the Cabinet decision on LTMS (van Schalkwyk, 2008) and Minister Manuel's announcement in his 2008 budget speech that 'options that will now come under scrutiny for implementation include the use of emission charges and tradable permits, tax incentives for cleaner production technologies and reform of the existing vehicle taxes to encourage fuel efficiency' (Manuel, 2008).

5. Conclusion

A carbon tax should be considered among the range of instruments available to the South African government, economy and society. It should be considered as part of a broader suite of options, including regulatory and economic instruments. Even in the latter category, other options – cap-and-trade, trading of renewable energy or energy certificates are examined. Indeed, an even broader range of incentives and taxes should be part of the discussion.

A carbon tax was one of the most effective wedges or mitigation options analysed for the Long-term mitigation scenarios. The LTMS strategic option 'Using the market' reduced emissions roughly as Required by Science, for several decades. The LTMS research indicated that the effectiveness increases, up to certain tax levels. South Africa might consider a tax starting around R100-200 / t CO_2eq, escalating in future.

An escalating CO_2 would switch from coal to renewables and nuclear for electricity supply, and favour crude oil refineries over coal-to-liquids. Economic and industrial policy that redefines South

Africa's competitive advantage around climate-friendly technology and investments would be more resilient to a low-carbon future world.

The efficiency with which a carbon tax achieves the goal of reducing GHG emissions depends on responsiveness and substitutability. Substitutability is key – the degree to which consumers can switch to alternatives. Further work on the responsiveness of the South African economy and society to a carbon price signal is warranted.

A price discovery and adjustment mechanism would be useful to adjust the tax to an optimal emissions pathway over time. We propose a mechanism that sets a band around the desired 'peak, plateau and decline' trajectory, adjusting tax levels depending on reductions achieved – as measured *ex post*.

Many further questions will need to be addressed, if a carbon tax is to be implemented as part of South Africa's climate policy. Another critical set of questions not addressed in this paper regards the choice of economic instrument (broadly, tax or trading system or a hybrid), and its integration with other international instruments.

Economic instruments may be highly efficient in allocating scarce resources. They do not however, tend to do well to address distributional concerns. Equity demands that poor households, in particular, be shielded from any burden, e.g. higher energy prices. Off-setting incentives, such as food subsidies or reduced VAT on basic goods, could be financed to achieve such a goal. Another option would be to finance energy efficiency and renewable energy in social housing. The principle would be to make the package a net benefit to the poor – and not to treat the tax as a revenue-raising instrument.

Careful design of a carbon tax (or other economic instruments considered in this series) will be important to ensure that is effective in meeting its objective – reducing GHG emissions. With appropriate design, a carbon tax can be a powerful instrument of mitigation in South Africa, and at the same time contribute to socio-economic objectives.

Acknowledgements

This paper, derived from a report, is the result of collaboration between the Energy Research Centre (ERC), Environmental Policy Research Unit (EPRU) and Genesis Analytics. The ERC and EPRU are both research units at the University of Cape Town. The research by Genesis Analytics was commissioned by the ERC, drawing on National Research Foundation (NRF) funding which is gratefully acknowledged.

Notes

1. The notion of 'wedges' was developed by Pacala and Socolow (2004) to show that a range of existing technologies could deliver 1 GtC in emission reductions over the next 25 years. The challenge was to scale up technologies, provide policy guidance and channel investment. 'Wedges' in the LTMS context were adapted to mean emission reductions over time. If the reduction increase over time would show the graphs have the shape of a wedge. Mitigation actions and the resultant wedges are used somewhat interchangeably in this report.
2. The tax level starts at R100 / t CO_2-eq in 2008, rises to R250 by 2020, i.e. in a period when the rate of growth of emissions might need to be slowed, even if absolute emissions still rise. It is then kept at that level for a decade, approximating a case where emissions stabilise (since the tax still induces changes in the system). After 2030, it rises more sharply in a phase of absolute emission reductions. It is capped at R750, a level which is maintained for the last decade. All values are in real 2003 Rands.
3. The NIRP is an electricity sector planning exercise conducted by NERSA, the national energy regulator, which in theory considers supply and demand-side options for meeting projected electricity demand. Eskom conducts its own more influential integrated planning process (ISEP), and may well have modelled the impacts of a carbon tax, but this is confidential, and no information on this was available.
4. This analysis was conducted using the PAR software in a stochastic mode (that is, incorporating the stochastic risk variables) (NERSA, 2008). More complex effects that might be triggered by a carbon tax, such as changes in energy demand or the cost of fuel, were not included in the NIRP3 sensitivity analysis.
5. 'There are sufficient electricity and water resources to meet the future demands within the Industrial Development Zone. These utilities are available in bulk at very favourable rates'(CDC, 2004).
6. Energy-intensive industries could be identified by the percentage of their costs spent on energy.
7. Poor households have a similar property, in that energy costs are often a particularly high percentage of total household expenditure – this common property identifies these two groups as particularly sensitive to energy price changes.

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Received 16 March 2009; revised 25 September 2009