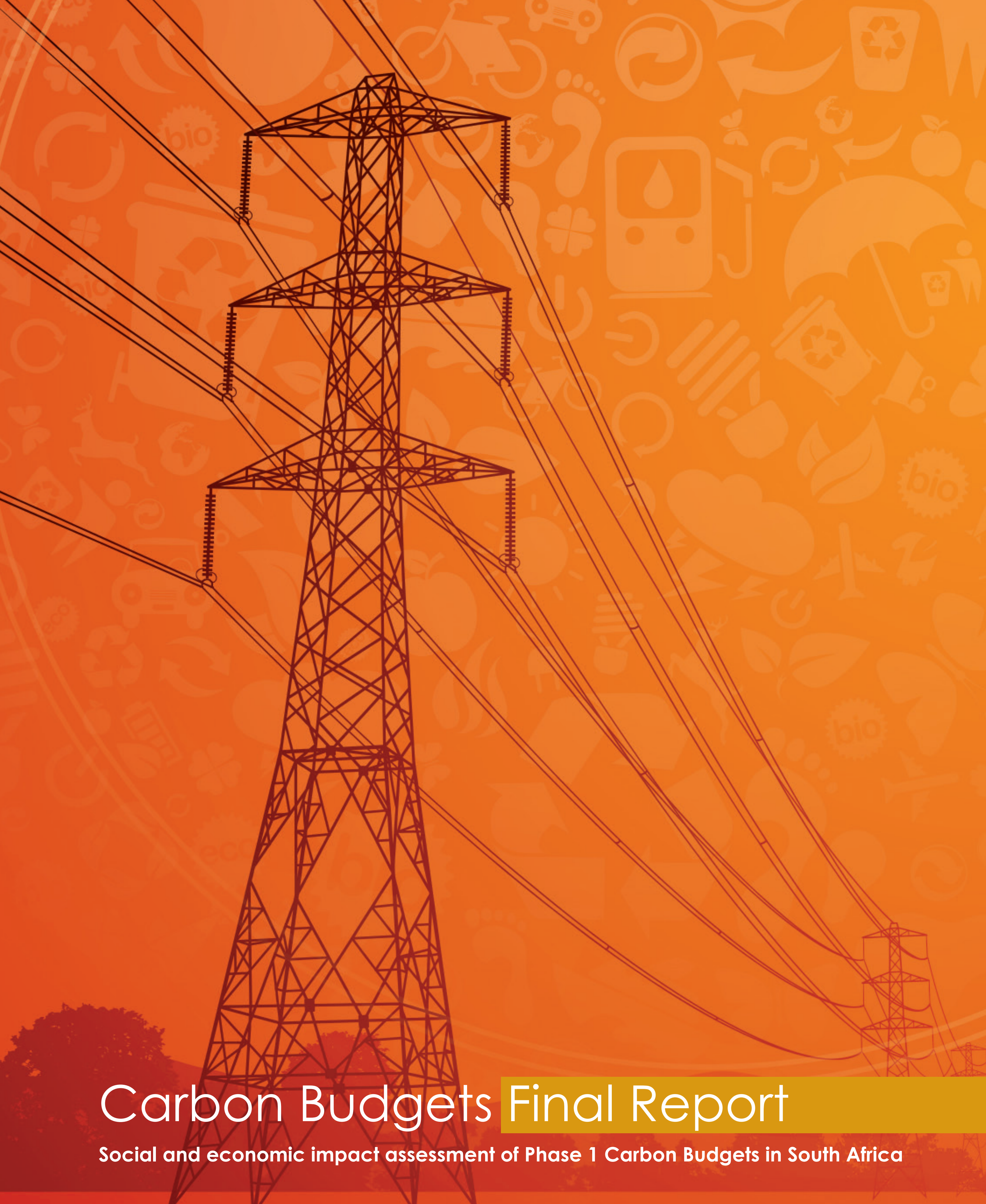


Carbon Budgets Final Report

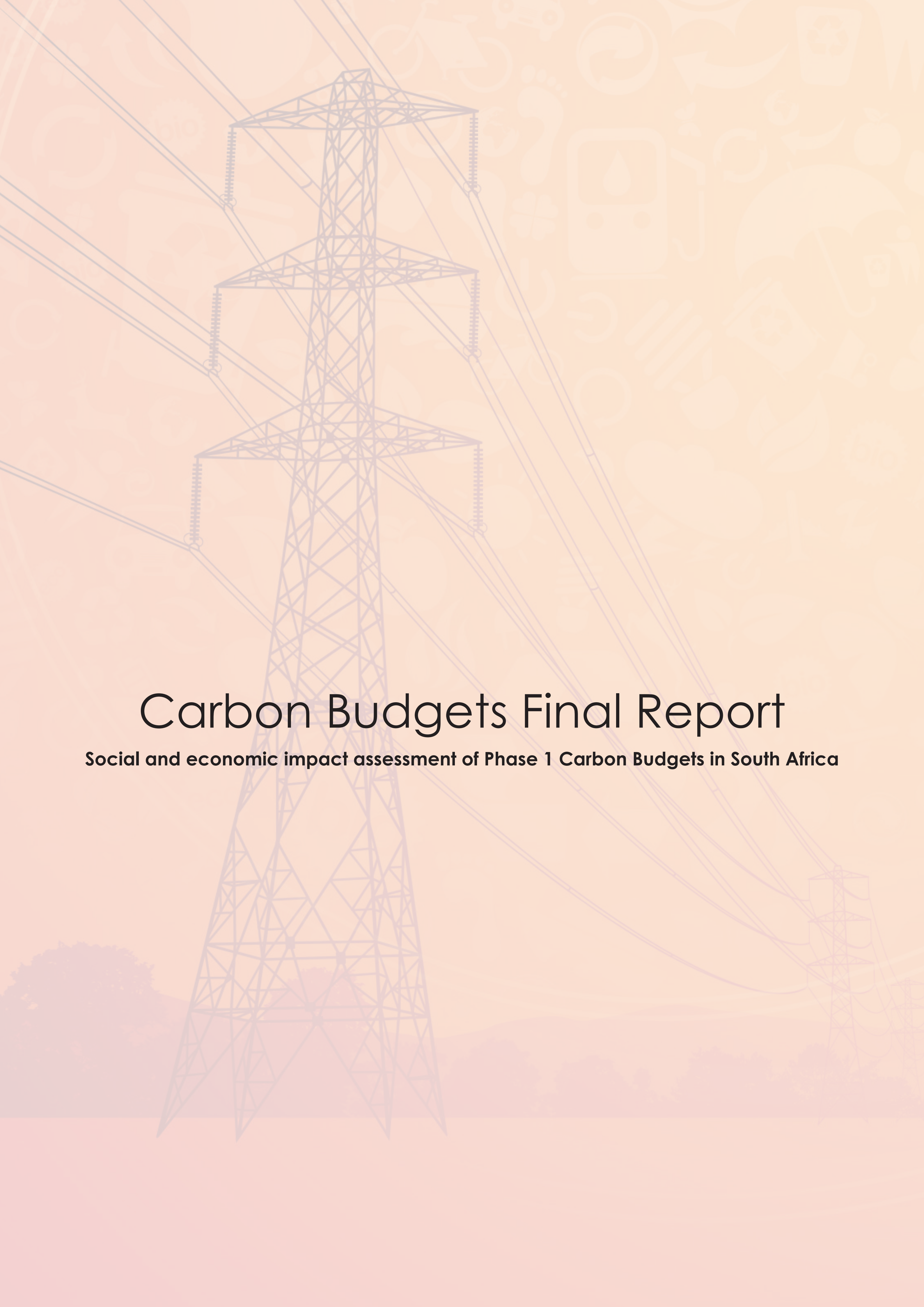
Social and economic impact assessment of Phase 1 Carbon Budgets in South Africa

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

2030 NDP

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
of the Federal Republic of Germany



Carbon Budgets Final Report

Social and economic impact assessment of Phase 1 Carbon Budgets in South Africa

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LIST OF ACRONYMS

BUSA	Business Unity South Africa
CBA	Cost-benefit analysis
CCS	Carbon capture and storage
CDM	Clean Development Mechanism
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CPC	Central Product Classification
CTL	Coal-to-liquid
DEA	Department of Environmental Affairs
DoE	Department of Energy
DPME	Department of Planning Monitoring and Evaluation
DPSA	Department of Public Service Administration
EIA	Environmental Impact Assessments
EPA	Environmental Protection Agency (US Federal Government)
GDP	Gross Domestic Product
GHG	Greenhouse gas
GTL	Gas-to-liquid
IPCC	Intergovernmental Panel on Climate Change
JSE	Johannesburg Stock Exchange
MATS	Mercury and Air Toxics Standard
MPA	Mitigation Potential Analysis (DEA, 2014)
Mt	Megatonnes
NAAQS	National Ambient Air Quality Standard
NAEIS	National Atmospheric Emissions Inventory System
NEMA	National Environmental Management Act
NOx	Mono-nitrogen oxides
NSPI	Nova Scotia Power Incorporated
PPI	Producer Price Index
PPP	Pollution prevention plan
QALY	Quality-adjusted life years
SAM	Social Accounting Matrix
SIC	Standard Industrial Classification
SO_2	Sulphur dioxide
tCO_2	Tonnes of carbon dioxide
WTP	Willingness to pay

EXECUTIVE SUMMARY

INTRODUCTION

This report outlines a methodology for identifying and analysing the social and economic impact of Phase 1 Carbon Budgets in South Africa – considering both qualitative and quantitative impacts. The results from social and economic analyses are combined to provide a holistic view of the likely socioeconomic impacts of the first phase of carbon budgets in South Africa. This information, and lessons learnt while implementing the study, are drawn on to provide recommendations for the design and implementation of the next phase of carbon budgets.

All costs associated with Phase 1 Carbon Budgets are considered in accordance with the guidance provided in the Department of Planning, Monitoring and Evaluation (DPME)'s guidelines on socio-economic impact assessment (DPME, 2015). This includes costs related to the implementation and administration of Phase 1 Carbon Budgets, costs of compliance with Phase 1 Carbon Budgets, and costs linked to behaviour change caused by Phase 1 Carbon Budgets. Unanticipated costs are also considered. A cost-benefit analysis (CBA) is used to systematically identify relevant costs and benefits related to Phase 1 Carbon Budgets. The report goes beyond identifying and quantifying impacts, and also includes lessons that can be used to reduce socioeconomic impacts during the second phase of carbon budgets.

METHODOLOGY AND COSTS CONSIDERED

Given that the decision to implement Phase 1 Carbon Budgets had already been taken before the study commenced, and that this was explicitly outside of the scope of the project, the rationale for Phase 1 Carbon Budgets is not considered in this report. The benefits (in terms of reducing climate change impacts and helping South Africa meet its stated climate change mitigation goals) are also not considered, as Phase 1 Carbon Budgets essentially function as a pilot to prepare for the implementation of a future mandatory phase of carbon budgets. The current phase of carbon budgets is thus not intended to directly reduce greenhouse gas (GHG) emissions, but rather to put the systems and procedures in place that can lead to emission reductions in the next phase.

Figure 1 Potential impacts of carbon budgets

<table>
<tr><th>Costs</th><th>Benefits</th></tr>
<tr><td colspan="2">Economic impact of company actions</td></tr>
<tr><td colspan="2">Co-impacts of mitigation actions</td></tr>
<tr><td colspan="2">Impact of company actions on tax revenues</td></tr>
<tr><td colspan="2">Local impact of company spending</td></tr>
<tr><td colspan="2">Local impact of changes in scale of company operations</td></tr>
<tr><td>Cost of administering carbon budgets</td><td></td></tr>
<tr><td>Inflationary impact of company actions</td><td></td></tr>
<tr><td>Unanticipated costs to companies</td><td></td></tr>
</table>

Note: Impacts that straddle both columns can be costs or benefits, depending on local conditions.

The relevant potential impacts of carbon budgets that can be considered either benefits or costs from a societal perspective, and which should therefore be considered when estimating the socioeconomic impact of carbon budgets, are shown in Figure 1.

SOCIO-ECONOMIC IMPACT ASSESSMENT

All the companies interviewed indicated that Phase 1 Carbon Budgets would not cause them to undertake any investment in mitigation actions beyond what was already planned. Responses were mixed regarding the impact of carbon budgets on investment decisions beyond mitigation, but all companies agreed that Phase 1 Carbon Budgets are not directly affecting non-mitigation investment decisions. Carbon budgets were only one of a number of new environmental regulations requiring the attention of companies, with more attention being attracted by those measures already in place or imminent. Factors such as increasing electricity and labour costs were also viewed as having a more direct impact on the attractiveness of investment opportunities. Several companies did, however, mention that one reason carbon budgets are not yet influencing investment decisions is that there is simply insufficient clarity on what the mandatory system is going to look like. The longer this situation persists, the more likely it is that carbon budgets will add to the perceived riskiness of local investments. In summary, no activities that would lead to **economy-wide impacts** and could be unambiguously attributed to carbon budgets were identified. Consequently, the introduction of Phase 1 Carbon Budgets is not believed to have led to any economy-wide impacts.

Costs linked to the allocation and administration of Phase 1 Carbon Budgets were incurred by both the Department of Environmental Affairs (DEA) and carbon budget companies. Allocation costs related to the opportunity cost of time spent to agree carbon budgets between the DEA and carbon budget companies. Additional cost is likely to be incurred to provide the necessary capacity to fulfil additional monitoring and reporting requirements linked to Phase 1 Carbon Budgets. Most companies believed it would be costly to agree pollution prevention plans (PPPs) with the DEA, but none had any idea how much time or effort would be required.

Six companies believed the requirement to submit annual PPP reports would incur significant cost, and two companies mentioned they would require additional professionals in the form of energy engineers, carbon managers, monitoring specialists, statisticians and other skilled professionals to enable them to statistically analyse and forecast their emissions (and the expected impacts of mitigation impacts) more accurately. The two companies mentioned that they would need to put these systems in place and refine them over time, in order to be comfortable that they would be able to comply with mandatory carbon budgets in the next phase.

Only one of the two companies was able to provide an estimate of its additional capacity needs to deal specifically with carbon budgets (it would require two additional professionals), while the other company mentioned that the additional professionals would deal with all GHG-related policies and not only the carbon budgets. Given that only one cost point was received, monitoring and reporting costs were not scaled up to reflect all Phase 1 Carbon Budget companies. The total cost of employing these two additional professionals was, however, calculated to highlight the fact that monitoring and reporting costs are likely to dwarf allocation costs (the estimated cost of employing the two additional employees was estimated to be between R5.3 million and R7.2 million). Consequently, it is expected that **income tax revenues** will decline as a result of the expected additional monitoring and reporting costs during Phase 1. Due to a lack of information, It is not possible to accurately quantify this impact for all carbon budget companies, which would be equal to the company income tax rate of 28% being applied to the additional expected costs). But based on information from the company mentioned above, it is expected that tax revenues will decline by at least R1.5 – R2 million as a result of Phase 1 Carbon Budgets.

Greenhouse gas mitigation activities can have either positive or negative effects on socioeconomic goals such as economic development, human health, food and energy security, biodiversity and access to energy. Such externalities (often termed trade-offs, knock-on effects or ancillary impacts) can also be termed "co-impacts". Given that the companies interviewed are not expected to implement any additional mitigation actions or to change investment patterns as a direct result of being allocated carbon budgets, no **co-impacts** are expected as a result of Phase 1 Carbon Budgets.

Since no actions to reduce GHG emissions attributable solely to Phase 1 Carbon Budgets were identified, it is not expected that Phase 1 Carbon Budgets will lead to an increase in production costs or inflation. As mentioned above, companies did experience costs related to the allocation of carbon budgets, but these costs were relatively small, once-off and not related to companies' production costs (being related mainly to the opportunity cost of time). There may be real costs related to the additional reporting commitments created by PPPs, but it was not possible to quantify these costs due to only one cost estimate being obtained. Also, given that these costs are likely to relate to companies' fixed rather than variable costs, they would have to be very large before they influence output prices. These costs are therefore not expected to be passed on by companies to their customers, and Phase 1 Carbon Budgets are not expected to have any impact on **inflation**.

No mitigation actions or investments that are likely to change the scale or location of production activities were identified, and Phase 1 Carbon Budgets are therefore not expected to influence the **local impact of company spending**, or lead to any impacts linked to a **change in scale of company operations on local communities** (such as an influx of migrant workers from outside the local community that could put additional pressure on bulk services or other social, health and environmental infrastructure).

In summary, the value of the costs related to Phase 1 Carbon Budgets that could be quantified are shown in Table 1. It is expected, however, that the true cost of Phase 1 Carbon Budgets could easily be larger than that shown in Table 8. The compliance cost of the one company (out of a possible 31 companies that could receive carbon budgets) that was able to provide an estimate of the additional capacity required to undertake monitoring and reporting for Phase 1 Carbon Budgets to the total cost estimate (see Table 5), and assuming that this additional costs leads to a reduction in company profit and hence tax revenues (at the company tax rate of 28%), contributes the bulk of the quantified costs of Phase 1 Carbon Budgets. Should more companies employ additional staff or consultants to undertake monitoring and reporting activities linked to the carbon budgets, the total cost could thus increase significantly.

Table 1 Total cost of Phase 1 Carbon Budgets

Phase 1 carbon budget costs	Average company cost scenario	Maximum company cost scenario
Costs of administering carbon budgets	**R8,755,456**	**R11,219,230**
DEA allocation costs	R1,011,499	R1,011,499
DEA monitoring costs	R1,397,928	R1,397,928
Company allocation cost	R994,029	R1,643,011
Company monitoring and reporting cost - indicative only*	R5,352,000	R7,166,792
Tax revenue foregone - indicative only*	**R1,498,560**	**R2,006,702**
Total quantifiable cost – conservative estimate	**R10,254,016**	**R13,225,932**

*Notes: *Based on estimated cost for one company only. This is therefore a minimum estimate of the expected costs for Phase 1 Carbon Budgets.*

^Allocation costs are once-off and monitoring and reporting costs are cumulative annual costs.

LESSONS FOR PHASE 2

Based on the findings of the engagements with companies and the DEA, several lessons related to minimising the socioeconomic impacts of Phase 2 of the carbon budgets were identified.

Lessons related to the budget allocation process

The budget allocation process should be as standardised, simple and streamlined as possible to reduce the time and effort required by companies and the DEA to agree budgets. This includes:

- The **process for identifying entities to which budgets would be allocated** needs to be clear and unambiguous.
- Clear upfront communication of the **approach to be used in the setting of the carbon budgets** needs to be provided, with a consistent approach being used across industries (or at least across entities within each industry).
- A **standardised data template** which clearly details the data required from carbon budget entities is required. This would include the units in which data should be presented, the approaches used by entities for calculating and projecting emissions, and how uncertainty in information is to be communicated.

- Once the budgets have been established by DEA **all calculations**, including considerations relating to the level of mitigation that is expected of companies, must be communicated to the entities in a timeous and transparent way.
- A formal process to **challenge carbon budgets** that are considered unrealistic or overly restrictive by companies must be established.
- The **rules for adjusting carbon budgets** should be clearly set out, including both the conditions under which it is allowed to adjust carbon budgets, and the rules that must be followed to undertake the adjustment. This should include details of any mechanisms (such as trading or the use of offsets) that could lead to the level of a company's actual emissions legitimately diverging from its official carbon budget emission levels.
- Because of the **sensitivity of the data involved**, several authorisations will be required before the data for most companies can be released. This needs to be built into the timing and planning for Phase 2 to allow adequate time for the necessary authorisations to be obtained.

Lessons related to the resources required to allocate and administer the budgets

The internal resources currently dedicated to managing carbon budgets within the DEA will not be sufficient to implement a mandatory system, particularly if the number of carbon budget entities increases, and when the necessary rigour increases due to the budgets becoming mandatory. There is likely to be a significant increase in engagement from the DEA in preparation for the next phase of carbon budgets. This will require a lot of planning and appropriate resources to support this engagement process, to avoid significant increases in the time inputs required from both parties.

Unless the process for allocating carbon budgets is significantly simplified, an interdisciplinary team will be required to handle their allocation, including mitigation policy experts, technical experts (including chemical engineers), sector experts, and economists or trade experts. Additional resources will thus be required to administer the mandatory phase of carbon budgets.

Lessons related to data confidentiality data

A significant risk to preparation for the mandatory phase of the carbon budgets, and one that companies fear could increase the cost of Phase 1 Carbon Budgets if not addressed, relates to protecting the confidentially of data. Of particular concern are legal and reputational risks linked to the Financial Markets Act (insider trading provisions) and the Competition Act (collusion and cartel behaviour sections). In order to overcome risk related to the treatment of confidential data, protocols for the handling of confidential data by the DEA should be clearly articulated. These should include specifying how and where data are stored, who has access to the data, and under what (if any) conditions these data can be disclosed to parties other than the specific individuals within the DEA that are administering the carbon budget system.

Lessons related to alignment of instruments

Several pieces of legislation and policy related to greenhouse gas mitigation and reporting are under development or being refined in South Africa, including the National GHG Emission Reporting Regulations, National Pollution Prevention Plan Regulations, energy reporting regulations and energy management plans under the DoE, atmospheric emission licences and the forthcoming carbon tax. At present, these are not completely aligned in terms of reporting and compliance requirements. The study identified concerns about the additional administrative burden (and hence cost to entities related to compliance) resulting from this misalignment. Companies suggested that reporting should be streamlined and simplified to minimise the cost implications thereof.

In order to avoid having to incur unnecessary costs to replace or duplicate monitoring and reporting systems for different mitigation instruments, and to prevent mitigation or other investment projects having to be abandoned or reversed as a result of GHG emissions being incorrectly estimated or costed, it is important that the emissions covered, calculation methodologies, reporting periods and allowable mitigation actions and strategies be aligned between the different instruments as soon as possible. The DEA has indicated that this approach is already underway, and that the National GHG Emission Reporting Regulations will set the monitoring and reporting rules for all instruments that require GHG emission reporting in future.

Lessons related to compliance mechanisms

Companies were unanimous in stating that the level and design of the compliance mechanisms linked to mandatory carbon budgets will be the single most important factor determining both the impact of carbon budgets on the South African economy, and their individual responses to carbon budgets.

Given the long development periods of many mitigation projects, it is also important that the compliance mechanisms that will be used to enforce mandatory carbon budgets be unambiguously described as long as possible before the commencement of the mandatory phase of carbon budgets. This includes specifying what level of tolerance will be allowed before compliance measures take effect.

CONCLUSION

Several possible positive and negative impacts related to Phase 1 Carbon Budgets have been identified. Only two – the cost of administering the instrument and a reduction in tax revenues – are believed to be relevant at present. This is not surprising, given that Phase 1 Carbon Budgets were intended to serve as a pilot process to put in place and refine processes and procedures that can underpin the development of a system of mandatory carbon budgets. Most stakeholders interviewed believed that Phase 1 Carbon Budgets are serving this purpose, and most of the processes to develop and monitor carbon budgets now seem to be in place. Both the DEA and the participating companies, however, emphasised that more detail and structure is required before the commencement of mandatory carbon budgets. Based on experience to date, it is viewed as an acceptable start to the carbon budget process, provided that lessons learnt are acted upon and rules and processes are codified and presented unambiguously before the start of the mandatory phase of carbon budgets.

In total, it is estimated that the quantifiable administration cost related to Phase 1 Carbon Budgets will be between R10.3 million and R13.2 million. It is expected, however, that the true cost of Phase 1 Carbon Budgets could easily be larger than this if the costs which cannot currently be quantified for all carbon budget companies (namely additional monitoring and reporting costs and the value of tax revenue foregone – which were estimated based on the cost to one company only) are taken into consideration.

Furthermore, investment in new reporting systems, although not relevant to the current analysis which was undertaken mainly to focus on several mitigation instruments (and not exclusively the carbon budgets), is also significant and is not included in the impact of Phase 1 Carbon Budgets.

1. INTRODUCTION

This report outlines a methodology for identifying and analysing the social and economic impact of Phase 1 Carbon Budgets in South Africa – considering both qualitative and quantitative impacts. The results from economic and socioeconomic analyses are combined to provide a holistic view of the likely socioeconomic impact of the first phase of carbon budgets in South Africa. This information, and lessons learnt while implementing the study, are drawn on to provide recommendations for the design and implementation of the next phase of carbon budgets.

The section that follows provides a description of the methodology and scope of the study. A summary of international experience of the socioeconomic impact of carbon budget-type instruments is provided in Section 3, while Section 4 describes the design and coverage of Phase 1 Carbon Budgets. Section 5 reflects on the extent to which Phase 1 Carbon Budgets have succeeded in laying the groundwork for future mandatory carbon budgets. Section 6 constitutes the bulk of the report, and considers the socioeconomic impact of Phase 1 Carbon Budgets. Section 7 then summarises relevant impacts to provide a consolidated quantitative view of the impact of Phase 1 Carbon Budgets. Section 8 draws lessons from the analysis and stakeholder interviews to provide recommendations on how the mandatory phase of carbon budgets can be designed to minimise its socioeconomic impact. A short conclusion is provided in Section 9.

The report also contains several appendices providing additional information on the international experience with instruments similar to carbon budgets and how various carbon budget impacts can be considered and quantified.

2. METHODOLOGY AND SCOPE

2.1 Methodology and scope

All costs associated with Phase 1 Carbon Budgets are considered in accordance with the guidance provided in DPME (2015), including the costs related to the implementation and administration of Phase 1 Carbon Budgets, costs of compliance with Phase 1 Carbon Budgets, and costs linked to behaviour change caused by Phase 1 Carbon Budgets. Unanticipated costs are also considered. A cost-benefit analysis (CBA) is used to systematically identify relevant costs and benefits related to Phase 1 Carbon Budgets. The report goes beyond identifying and quantifying impacts, and also includes lessons that can be used to reduce socioeconomic impacts during the second phase of carbon budgets.

Given that the decision to implement Phase 1 Carbon Budgets had already been taken before the study commenced, and that this was explicitly outside of the scope of the project, the rationale for Phase 1 Carbon Budgets is not considered in this report. The benefits in terms of reducing climate change impacts and helping South Africa meet its stated climate change mitigation goals are also not considered, as Phase 1 Carbon Budgets essentially function as a pilot to prepare for the implementation of a future mandatory phase of carbon budgets. The current phase of carbon budgets is thus not intended to directly reduce greenhouse gas (GHG) emissions, but rather to put the systems and procedures in place that can lead to emission reductions in the next phase. Consequently, in order to place the social and economic impacts of carbon budgets in context, the extent to which the first phase of carbon budgets has succeeded in putting in place systems and processes to support the next mandatory phase of carbon budgets is considered.

Qualitative impacts have been assessed through in-depth interviews with affected companies, while a Social Accounting Matrix (SAM) multiplier model has been developed to allow future quantitative impacts to be investigated. The study investigates the impacts of carbon budgets on multiple levels, including the administrative cost of carbon budgets to companies and the DEA, the costs and benefits accruing to affected companies and sectors, and the wider impact of carbon budgets on investment patterns. In order to allow for the application of the user-friendly SAM model to investigate macroeconomic impacts on the South African economy[1], the interview guide

1 The project team developed a tool for the DEA to use to measure the impact of companies' implemented mitigation options in the future. This tool takes the form of a Social Accounting Matrix (SAM) model that has been developed in Analytica software for a parallel project that is being undertaken by the project team for the DEA, entitled ***Development of a user-friendly Greenhouse Gas (GHG) mitigation potential analysis model(s)***. This tool will allow the DEA to model the impact of any mitigation option planned or undertaken by carbon budget companies. More information on this tool is provided in the Appendices.

used to engage with companies considers the inputs required for the modelling in detail (see Appendix 6).

2.2 Company selection and stakeholder engagement process

DEA provided the project team with a list of 11 companies whose negotiations regarding carbon budgets had progressed sufficiently to warrant being interviewed. Every company was interviewed by at least two project team members over the period March–May 2016. The interview guide used is provided in Appendix 6. Qualitative insights on the allocation process and administrative costs of carbon budgets for both regulated companies and the DEA were gleaned from interviews and used to derive lessons learned and recommendations for Phase 2 Carbon Budgets.

In general, companies were happy to be interviewed and saw the value in sharing their experience with the DEA. Companies responded promptly to requests for interviews, and none declined to be interviewed. Only one company requested that a non-disclosure agreement be signed before it would be interviewed. Seven companies have requested the opportunity to review the interview notes taken by the project team, but the project team nevertheless still retains full editorial control over the notes.

Throughout the interviews it became apparent that carbon budgets for several companies had not yet been finalised. However, most of these companies believed that negotiations were close to completion at the time of the interviews, and some companies received letters from the DEA describing their final budget allocation subsequent to being interviewed.

Only one company from each regulated sector was selected for interview, which has raised concerns over sample selection bias. However, the intention of the study was never to contact a representative sample of companies (something that would in any event not have been possible given the relatively early stage of the budget allocation process when the project interviews were undertaken), but to draw insights into the likely socioeconomic impacts of Phase 1 Carbon Budgets based on the experience of the vanguard of carbon budget companies.

However, based on the interviews conducted, company experience across sectors has been relatively uniform. This implies that company experience should not vary much beyond the general differences highlighted in the report (i.e. the implementation of carbon budgets becomes significantly more complicated as the complexity of production processes increases and market conditions become more variable). Once the coverage of carbon budgets increases to additional companies, however, a sampling strategy to avoid selection bias will become important.

2.3 Characteristics of companies interviewed

A sample of 11 companies was interviewed as part of the study. At the time of their interviews, seven companies believed they had agreed their carbon budgets with the DEA (although one of the companies had not yet received its formal allocation letter from the Department). Three companies believed they were close to finalising carbon budgets, and only one company believed there was a risk it would not be able to agree a carbon budget with the DEA.

The companies interviewed represent a mix of organisations supplying local and/or mainly international markets, and while some faced significant competition from imports, others were relatively insulated against foreign competition. For some companies the extent to which they supply local or foreign markets (and to which they are exposed to competition from imports) differs across their range of products. Companies of different size were included in the interviews. Some companies have multiple plants (and include vertically integrated companies – some of which are multinationals), while others have just one plant. Africa and Asia constituted the largest export markets for the companies interviewed, while Asia was the main source of import competition.

Most companies experienced some variation in output over time due to market demand fluctuations, with one company mentioning that its production, while relatively stable, varied in response to the availability of inputs. Production processes varied from relatively simple with fixed emission intensities, to complicated integrated processes where emission intensities could vary significantly based on current conditions.

All the companies interviewed were approached by the DEA to participate in Phase 1 Carbon Budgets, and were chosen on the basis that they had concluded (or were close to concluding) the process of being allocated carbon budgets by the DEA. All the activity sectors highlighted in the Ministerial declaration of GHGs as priority pollutants were represented by the companies interviewed (with the exception of carbon black production – where no company emitting more than 0.1 megatonnes (Mt) of CO_2e annually was identified). Some companies, however, represented more than one activity sector.

The emission levels of companies are considered confidential and were not shared with the project team, but one company mentioned that it was not above the threshold for inclusion in Phase 1 Carbon Budgets based on its direct emissions. This company was thus included clearly because it is in the same sector as a company that has sufficiently large direct emissions to be allocated a carbon budget.

No companies that voluntarily approached the DEA to request inclusion in Phase 1 Carbon Budgets were interviewed. These companies are typically smaller emitters, and none of them had progressed far enough in their carbon budget engagements with the DEA for the DEA to consider them suitable for inclusion in the study.

3. IMPACT OF CARBON BUDGETS: INTERNATIONAL EXPERIENCE

Carbon budgets are a form of direct regulation which compels companies to meet a prescribed cumulative GHG emission target. If designed well, direct regulation can result in improved environmental outcomes. However, this type of regulation is typically relatively rigid, and there is therefore a need to carefully consider how the design of regulatory instruments will affect cost-effectiveness, administrative costs, distributional impacts, incentives for innovation, and barriers to entry for new, efficient companies.

South Africa's Carbon Budgets constitute cumulative five-year emission caps for companies. The first phase (2016–2020) is voluntary and includes no compliance mechanism for companies that exceed their carbon budget over the period. The DEA has, however, indicated that the next and subsequent phases of carbon budgets will be mandatory and will include compliance mechanisms (DEA, 2014; DEA, 2015). A more detailed description of Phase 1 Carbon Budgets is provided in Section 4.

Finding international experience comparable to inform the likely impact of Phase 1 Carbon Budgets is complicated by the fact that no other international regulation exactly matches the design of local carbon budgets. No other national, multi-year carbon emission cap that prescribes emission limits at the company level was identified.

Therefore, in order to gain insights from the international literature, two main types of direct regulation were considered: regulatory caps for other pollutants, and regional GHG emission caps. Emission caps on other pollutants are similar to Phase 1 Carbon Budgets in that they targeted company-level emissions; while regional carbon emission caps include multi-year GHG emission caps. Examples of regulatory caps on other pollutants considered were the Los Angeles air quality regulations from 1979–1992; restrictions on SO_2 and NO_x emissions in Japan, Germany and the US; restrictions on NO_x and SO_x emissions in Canada; the Utility Mercury and Air Toxics Standard (MATS) in the US; the National Ambient Air Quality Standard (NAAQS) in the US; and amendments to the US Clean Air Act in 1990. The regional carbon emission caps considered were the UK's Carbon Budgets and the Canadian province of Nova Scotia's GHG emission caps.

The review considered the impact of regulations on several variables, including the impact on company decisions and investments, the impact on society, and the economy-wide impact. The international experience is mixed, although at present there do not seem to have been any major impacts. However, a major determinant of the size and direction of impacts is the local context in which the regulations are implemented – caution should thus be applied when generalising the results of the international experience to South Africa.

In terms of impacts on company decisions and investments, higher operating costs were generally offset by increased and earlier investment in innovation (which is believed to be driven by increased policy certainty). The impact on society is more mixed, with varying estimates of employment impacts being observed – ranging from no discernible impact to temporary (albeit quite large) negative impacts. For regulatory caps on other pollutants, the impact on employment is typically outweighed by positive health impacts, but regional carbon emission caps are associated with an increase in electricity prices that can lead to increased household fuel poverty in the short term. In the longer term this impact is dependent on assumptions of the extent to which the cost of carbon will be internalised in energy prices, and it is believed that early action to reduce GHG emissions may avoid larger price increases in the future.

The economy-wide impact to date of the regulations reviewed has been small, but potential negative impacts on competitiveness and overall price increases in the short term have been identified. It was, however, highlighted in the literature that negative competitiveness impacts in the short term could be outweighed by the investments that led to these impacts conferring a significant competitive advantage in a future carbon-constrained world.

It is difficult to attribute impacts purely to the instruments considered, as the regulations involved have typically been implemented in conjunction with multiple other environmental policies. For a more detailed overview of the international experience relating to the impact of carbon budgets, please see Appendix 1.

4. OVERVIEW OF SA CARBON BUDGETS

Company-level carbon budgets were introduced in the National Climate Change Response Policy as a mechanism to translate South Africa's mitigation commitments into emission targets for sub-sectors and companies. A carbon budget is defined in the *Carbon Budget Design Document* as (DEA, 2015):

… a greenhouse gas (GHG) emission allowance, against which direct emissions arising from the operations of a company, during a defined time period will be accounted. The term "carbon" in carbon budget is shorthand for carbon dioxide, and further, for all GHGs accounted for in the latest South African inventory (2010).

The first phase of carbon budgets in South Africa (2016–2020) is being implemented as a voluntary pilot to allow companies and the DEA the opportunity to prepare for a second mandatory phase (to commence in 2021). Phase 1 does not include compliance measures, and the most important element of this phase is considered to be enhanced reporting requirements. The decision to start with a voluntary phase was influenced by variability in company-level emissions data, a lack of experience in allocating carbon budgets, and the desire to build sufficient capacity in both the DEA and companies to successfully implement a carbon budget system before such a system is made mandatory.

Carbon budgets were allocated to a selection of companies in the form of a cumulative maximum emission allowance for the five-year carbon budget period. The *Carbon Budget Design Document* states that while five years is a sufficiently long period of time to allow companies the flexibility to take into account fluctuations in market conditions and output while planning to meet their carbon budgets, it is also short enough to allow the DEA to respond to developments in local and international conditions (DEA, 2015). The companies which were approached to participate in Phase 1 Carbon Budgets were selected from a set of target sectors containing entities emitting more than 100 000 tonnes of GHG per annum, or producing the "same primary product" as a company within this category. Companies which did not meet these criteria, but still wished to participate, could voluntarily enter into negotiations with the DEA to be allocated carbon budgets.

Phase 1 Carbon Budgets included the following design features:

- carbon budgets were allocated to companies to support both current operations and existing expansion plans;
- there was no consideration of any national or sectoral mitigation targets when carbon budgets were set;
- companies are expected to report annually on their progress in terms of meeting their carbon budgets, and report at the end of Phase 1 on whether they have remained within their carbon budgets – but there will be no legal consequences if companies exceed their carbon budgets;
- companies are not expected to undertake any additional mitigation actions not already planned when carbon budgets were allocated;

- no transfer of unused portions of carbon budgets from the first to subsequent phases will be allowed;
- no transfer of portions of their carbon budgets between companies will be allowed during Phase 1 (although trading will be considered in subsequent phases);
- only emissions from a company's own operations (Scope 1 emissions) will be included in carbon budgets (but the possibility of creating a mechanism for dealing with Scope 2 emissions during subsequent carbon budget phases will be considered); and
- while the DEA intends to use the experience gained by implementing the first phase of carbon budgets to design the second and subsequent phases, all Phase 1 design elements will be re-evaluated when the next phase of carbon budgets is designed, and new elements may also be included in the next phase – the current design should thus be viewed as only indicative of the design of the second and subsequent phases of carbon budgets.

While there is no legal requirement for companies to remain within their carbon budgets, there are legal requirements requiring reporting of mitigation actions. The draft Pollution Prevention Plan Regulations issued in terms of the National Environmental Management: Air Quality Act (Act 39 of 2004) (Republic of South Africa, 2016) legally require companies to:

- describe interventions that will be implemented to reduce GHG emissions over the course of the next five years, and the expected mitigation impact that these actions will have, in a pollution prevention plan to be approved by the Minister of Environmental Affairs; and
- to submit annual progress reports that outline the mitigation actions that were implemented within the last year, and if relevant, details of any deviations from the approved pollution prevention plan and remedial action to address deviations.

The list of target sectors for carbon budgets is as follows:

- coal mining;
- production and/or refining of crude oil;
- production and/or processing of natural gas;
- production of liquid fuels from coal or gas;
- cement production;
- glass production;
- ammonia production;
- nitric acid production;
- carbon black;
- iron and steel production;
- ferro-alloys production;
- aluminium production; excluding foundries
- polymers production; and
- pulp and paper production.

Furthermore, the *Carbon Budget Design Document* states that "any company which produces electricity via the combustion of fossil fuels, for public or private consumption, excluding the use of back-up generators, will also be allocated a carbon budget" (DEA, 2015). The identification of companies to participate in Phase 1 of Carbon Budgets was complicated by a misalignment of the draft PPP regulations, the *Carbon Budget Design Document*, and the draft National Greenhouse Gas Emission Reporting regulations (DEA, 2015; Republic of South Africa, 2016; Republic of South Africa, 2016b). While the PPP regulations stipulate the "primary activity" to be of interest, the *Carbon Budget Design Document* stipulates that the "primary product" is of interest. There is a disconnect between the use of "product" and "activity", and even problems using the term "primary" without any guidance on the distinction between primary and secondary activities and/or products. Further, the mandatory reporting regulations stipulate that only activities which have emissions exceeding thresholds must be reported on, whereas PPPs and Carbon Budgets require reporting of all emissions.

The DEA did, however, clarify that its intention is that only companies allocated carbon budgets should be required to develop and report on PPPs during Phase 1 Carbon Budgets, and that the definition of "primary activity" will be defined carefully and unambiguously before the mandatory phase of carbon budgets.

The DEA used companies known to emit more than 0.1Mt of CO_2e annually to define activities that could be used to identify other large emitters, which in turn helped the Department select companies for participation in Phase 1. It was decided to include smaller companies to alleviate any negative competition impacts that could result from requiring only the largest companies in a sector to adhere to carbon budgets.

Industry associations, such as Business Unity South Africa (BUSA), and a list of companies that produce specific commodities (products) from the Department of Mineral Resources were utilised to identify companies fall within the designated sectors. The DEA recognised, however, that the use of industry associations was limiting as it resulted in the DEA not interacting with companies which were not part of associations, and mentioned that a more robust methodology for identifying companies to be allocated carbon budgets will have to be developed before the start of the mandatory phase.

The process outlined above identified 59 companies that the DEA approached to participate in the first phase of carbon budgets. 41 of these companies responded to the DEA and entered discussions to receive carbon budgets. The DEA subsequently received unsolicited requests from three companies to participate in Phase 1 Carbon Budgets. These unsolicited requests are understood to be driven, at least partly, by the carbon tax relief that will be afforded to companies with carbon budgets.

In total, it was understood that at the end of October 2016, 19 companies had been allocated carbon budgets, with 12 companies still in discussions with the DEA to agree carbon budgets. It was not possible to allocate carbon budgets to two of the three companies that approached the DEA to request carbon budgets, while the third is one of the 12 companies that were still in discussions with the DEA at the end of October 2016.

5. OUTCOME OF PHASE 1 CARBON BUDGETS ALLOCATION PROCESS

Phase 1 Carbon Budgets are still at an early stage of implementation, and several companies were still engaging with the DEA to finalise their carbon budgets when the research phase of the project concluded. The rules governing reporting on Phase 1 Carbon Budgets had also not yet been finalised. It is thus too early to judge the success of Phase 1 Carbon Budgets. Based on interviews with the DEA and the sample of carbon budget companies, however, it is possible to reflect on the extent to which the process has met participants' expectations to date.

Considering the experience of implementing carbon budgets from the perspectives of both the DEA and the participating companies, it seems that most of the processes to develop and monitor carbon budgets are now in place – but that considerably more structure and detail are required before the commencement of mandatory carbon budgets. All companies thought it was important to participate in the process to prepare for the mandatory phase, and all but one of the companies were comfortable with the process to date – although companies with simple processes and/or stable markets found the process easier than their counterparts with more complex processes and variable markets. Based on experience so far, it is viewed as an acceptable start to the carbon budget process, provided that lessons learnt are acted upon, and rules and processes are codified and presented unambiguously before the start of the mandatory phase of carbon budgets. Both the participating companies and the DEA acknowledged that considerable work is needed before the process will be sufficiently robust for a mandatory phase underpinned by a compliance mechanism, and the current process is rightly seen as a pilot (which was always the DEA's intention) rather than the first full phase of carbon budgets.

Both the DEA and the participating companies believed that the credibility developed during Phase 1 Carbon Budgets can be carried forward to the second and subsequent phases to simplify the implementation of a carbon budget system in the future. It is hoped that this report can assist the parties to draw on each other's experiences in order to develop a more robust carbon budget system in future.

6. SOCIO-ECONOMIC IMPACT ASSESSMENT

A cost-benefit analysis (CBA) was undertaken to combine all relative quantitative and qualitative information into a single coherent framework to assess the impact of Phase 1 Carbon Budgets. As mentioned in Section 2.1, direct or indirect mitigation benefits as a result of Phase 1 Carbon Budgets were explicitly excluded from consideration.

The relevant potential impacts of carbon budgets that can be considered either benefits or costs from a societal perspective, and which should therefore be considered when estimating the socioeconomic impact of carbon budgets, are shown in Figure 2.

Figure 2 Potential impacts of carbon budgets

Costs	Benefits
Economic impact of company actions	
Co-impacts of mitigation actions	
Impact of company actions on tax revenues	
Local impact of company spending	
Local impact of changes in scale of company operations	
Cost of administering carbon budgets	
Inflationary impact of company actions	
Unanticipated costs to companies	

Note: impacts that straddle both columns can be costs or benefits depending on local conditions

The likely nature of the impacts, and how to estimate their size, is discussed in detail in the sections that follow.

6.1 Principles to guide costing of impacts

Cost-benefit analysis (CBA)[2] provides a useful tool to evaluate the social and economic impacts of Phase 1 Carbon Budgets. The cost-benefit analysis methodology provides insights into the expected costs and benefit of an intervention, whether it is likely to have unanticipated consequences (either positive or negative), and whether it could be better designed to yield greater net benefits.

The goal of a CBA is to introduce as much analytical rigour and evidence-based reasoning as possible into decision making. In practice, there are often limits as to how rigorous such processes can be made – for example, if public interest considerations feature in a CBA, these may be subjective in nature, and not all effects of a given initiative can always be usefully quantified. Nevertheless, by providing a framework for analysis, the CBA should provide as-good-as-possible guidance for decision making in real-world, information-constrained settings. DPME (2015, p. 7) states that the role of CBA within a socioeconomic impact assessment is to go beyond a quantitative weighting of costs relative to benefits, and to "help decision-makers to understand and balance the socioeconomic impacts of proposals".

The key principles of the CBA process should include the following:

- Wherever possible, provide quantified monetary estimates of costs and benefits.
- Distinguish between once-off and ongoing costs and benefits. If possible, the net present value of streams of ongoing costs and benefits that occur over relatively long periods of time should be determined and used as a basis for comparison.
- Identify each mechanism whereby the given initiative is expected to have a social or economic impact as clearly as possible, and distinguish between the effects of different mechanisms.
- Include assumptions made in the analysis, and sources of risk to the conclusions derived.
- Limit use of estimates of second-round or later-round effects – in other words, unless the initiative being examined is likely to have substantial second-round effects, only first-round effects should be included, and care should be taken not to over-emphasise later-round effects if they are included. This is because the first-round effects of any economic activity are the easiest to measure accurately, and thus are likely to give less subjective results.
- Avoid double counting of economic impacts, by including in the calculation only the value added or lost at each stage of the production/consumption process.

In order to make sure that the economic impact of carbon budgets is calculated as accurately as possible,

2 This section is based on the experience of DNA Economics in cost-benefit analysis. For further information on cost-benefit analysis and impact assessment, see HM Government (2011) Impact Assessment Overview. Available [online]: http://www.bis.gov.uk/assets/biscore/better-regulation/docs/i/11-1110-impact-assessment-overview.pdf and European Commission (2009) Impact Assessment Guidelines. Available [online]: http://ec.europa.eu/governance/impact/commission_guidelines/docs/iag_2009_en.pdf .

it is important to ensure that only impacts that can be **attributed** to carbon budget policies are considered. Investments made or costs incurred in relation to activities that are useful from a carbon budget perspective (such as, for example, investment in GHG emission monitoring systems), but which were made primarily in response to another policy or regulatory driver, should not be considered unless there is clear evidence that carbon budgets have further increased the quantum of these costs or investments.

In summary, CBA provides a useful tool for combining all the available quantitative and qualitative information about a subject into a coherent assessment framework. The process of implementing the CBA methodology often provides more useful information than the formal CBA outcome itself. The CBA process typically identifies important information gaps that prevent a full-scale CBA from being implemented, and it also highlights the critical assumptions that will influence the outcome of a CBA. This allows assumptions to be interrogated to ensure they are defendable. Also, by highlighting existing data gaps, the CBA process prompts valuable insights into the processes required to generate the missing information. This will enable much more robust and detailed evaluation frameworks to be put in place, which will increase the accuracy of future CBAs or impact assessments.

The sections that follow investigate the costs and benefits that may be linked to Phase 1 Carbon Budgets, and considers which impacts can be quantified at present.

6.2 Economic impact of company actions (positive or negative)

6.2.1 Approach

A significant proportion of the greenhouse gas emissions from industry arise from production processes. Many of the mitigation actions available to industry thus have the potential to have positive or negative economy-wide impacts. Positive impacts come about as a result of investments into more efficient, lower greenhouse gas-intensive production activities which can increase the output and profitability of companies and sectors, and these investments also stimulate demand for goods and services directly. Negative impacts come about where mitigation actions add to investment and operational costs without increasing a company's output – in which case profitability and investment in the long term could be reduced.

There is both a size and timing element to mitigation actions and related investments. If companies put planned investment on hold in favour of future investment in cleaner technologies or facilities, a real cost to the economy will arise as the additional output resulting from the investment is foregone during the period for which the investment is delayed, whereas investments made earlier than anticipated will increase total output. In order to understand the economic impact of mitigation action it is important to consider the full cost and impact of mitigation actions.

Information that will be useful to calculate the economic impacts of mitigation action includes the following:

- Products that are affected (classified according to Standard Industrial Classification (SIC)[3] codes to facilitate modelling):
  - This could be a very specific line of products, or it could be a number (or all) of a company's products.
- Nature of impact on production of products:
  - output could increase or decrease;
  - quality of the product could be affected; and
  - product mix could change – which could involve the production of new products not currently produced by the company or sector.
- Cost of mitigation action:
  - cost and timing of investment/capital cost;
  - how investment cost has been financed;
  - impact of mitigation action on operational cost:
  - change in input costs; and
  - impact on fixed and variable costs of company.
- Timing of the mitigation action:
  - when the action/investment will be undertaken, and when it will be fully operational (during long ramp-up periods, expected impacts will be scaled to avoid

3 SIC is South Africa's system of industrial classification, which is compiled and maintained by Statistics South Africa (StatsSA).

- overestimating the impact in the period before the action is fully operational); and
- whether the timing of the mitigation action has been influenced by the fact that the company has been allocated (or is expected to be allocated) a carbon budget.

- Characteristics of the mitigation action:
  - labour requirements of implementing mitigation action (in rands and number of employees) – both positive and negative impacts; and
  - breakdown of labour requirements by skill level.
- Timing and prioritisation of mitigation action:
  - it is important to know whether carbon budgets have led to a change in the timing and type of mitigation actions.
- Opportunity cost of mitigation action:
  - It is important to understand whether mitigation action been undertaken instead of other investments that had been planned before carbon budgets were introduced; and if so what would the other investment have looked like?

In addition to the direct cost impact of mitigation action on companies and sectors, the impact of additional costs on **competitiveness** is also important (higher costs which are passed on may reduce the demand for a company's goods or services). This information can be used to further scale the economic impact of mitigation action. If a sector faces significant international competition in either local or export markets, it is feasible that costs linked to mitigation may change the output and growth prospects of a sector – it could lose market share in export markets, or there could be increased penetration of imports into the South African market. In this case, the direct impact on the output of a product driven purely by investment activities considered above may have to be adjusted, as the sector may not be able to operate at full capacity.[4] If a company believes it will be more competitive due to cost savings, the output from the local sector might increase, whereas if a company believes it will lose market share due to increased cost and a loss of competitiveness, the output of the local sector might be reduced. Information useful to analyse the impact of mitigation action on competitiveness is as follows:

- Extent to which impacted products are traded, influenced by:
  - Are markets for products local or international?
  - What percentage of local market is served by imports, and what percentage of local production is exported?
- Local and international market share of a company.
- Impact of mitigation actions on production costs.
- Costs passed on by suppliers that are subject to carbon budgets.

In order to estimate the economic impact of actions undertaken in response to carbon budgets, an economy-wide **Social Accounting Matrix (SAM) model**, developed to allow the DEA to update and refine the mitigation potential analysis (MPA), has been customised for use in considering the economy-wide impacts of carbon budgets. Details of this model, and how to apply it to calculate the economy-wide economic impact of actions taken in response to carbon budgets, are provided in Appendix 4.

An illustration of the output from the model for a mitigation option included the MPA is shown in Table 2 (DEA, 2014). The mitigation option in question is the use of a state-of-the-art power plant for self-provision of electricity in the iron and steel sector. The output does not, however, take changes in competitiveness into consideration, and would need to be adjusted to reflect the impact of expected changes to the competitiveness of the sector.

4 Changes in the output of local producers are unlikely to have an economy-wide impact as long as the size of the relevant sector remains constant, although this could have implications for the local impact of mitigation actions – which will be addressed in Section 6.7.

Table 2 Example of output from socioeconomic impact model (R million and jobs)

	Economy-wide operating cost impact	Economy-wide capital cost impact	Direct surplus impact	Total impact
Output at basic prices	14.4	10 055.2	2 228.5	12 298.0
GVA at basic prices	-31.9	3 078.7	795.4	3 842.2
GDP at market prices	-26.8	3 768.4	1 002.1	4 743.7
Compensation of unskilled employees	0.4	94.2	22.1	116.7
Compensation of semi-skilled employees	3.5	693.9	138.8	836.2
Compensation of skilled employees	-7.7	902.4	213.2	1 107.8
Gross operating surplus	-28.9	1 388.2	421.3	1 780.6
Fixed capital stock	-173.3	7 471.1	2 406.7	9 704.5
Unskilled employment (number of jobs)	9.2	2 026.0	581.3	2 616.5
Semi-skilled employment (number of jobs)	28.2	8 041.3	2 019.5	10 089.0
Skilled employment (number of jobs)	1.9	5 192.0	1 451.0	6 644.9
Total employment (number of jobs)	39.3	15 259.3	4 051.9	19 350.5
Low-income household income	-1.7	153.8	49.9	202.0
Medium-income household income	-0.3	79.3	23.6	102.6
High-income household income	0.1	100.7	28.8	129.6
Total household income	-1.8	333.8	102.2	434.2
Total fiscal impact	0.1	1 125.4	339.7	1 465.3
Imports	20.5	5 870.5	827.4	6 718.4

Source: SAM Model in the MPA Analytica Model developed by The Green House and DNA Economics

Note: Unless units are shown in brackets in first column, all values are in R million

6.2.2 Economy-wide impact of Phase 1 Carbon Budgets

All of the companies which had finalised carbon budgets at the time of their interviews felt that it would be possible to adhere to their carbon budgets without undertaking any additional mitigation action. Any mitigation action required to remain within their carbon budgets was already included in their existing plans and capital allocations. Some companies had concerns that they may exceed their allowable carbon budget emissions if their growth forecasts turn out to be conservative, but most companies believed they had the right to renegotiate their carbon budgets if this was the case, and none of the companies mentioned that they would curtail their output in order to remain within their carbon budgets.

Most companies interviewed emphasised that they are currently undertaking significant mitigation action as a result of factors other than carbon budgets (e.g. rising electricity prices, regulatory planning constraints, expected future costly mitigation instruments such as the carbon tax, and company sustainability targets). **All of the companies interviewed indicated that Phase 1 Carbon Budgets would not cause them to undertake any investment in mitigation actions beyond what was already planned.** One company suggested, however, that the carbon budgets were valuable in providing a justification for preventing mitigation actions that were already in the company's plans from being cancelled in order to direct budget elsewhere. Another company stated that it is currently implementing a Clean Development Mechanism (CDM) project that is not profitable, and that had it not been for the carbon budgets, the company would probably have terminated the project. There is thus likely to be significant options value attached to the project, and it was not considered a new mitigation action for the purpose of this analysis.

Responses were mixed regarding the impact of carbon budgets on investment decisions beyond mitigation, but all companies agreed that **Phase 1 Carbon Budgets are not directly influencing non-mitigation investment decision**s. Carbon budgets were only one of a number of new environmental regulations requiring the attention of companies, with more attention being attracted by measures already in place or imminent. Factors such as increasing electricity and labour costs were also viewed as having a more direct impact on the attractiveness of investment opportunities. Several companies did, however, mention that one reason carbon budgets are not yet influencing investment decisions is that there is simply insufficient clarity on what the mandatory system is going to look like. The longer this situation persists, the more likely it is that carbon budgets will add to the perceived riskiness of local investments.

6.2.3 Summary

No activities that would lead to economy-wide impacts and could be unambiguously attributed to carbon budgets were identified. Consequently, Phase 1 Carbon Budgets are not believed to have led to any economy-wide impacts.

6.3 Cost of administering carbon budgets (negative)

6.3.1 Cost of administration: DEA

Overview

In Phase 1 of the carbon budgets, the allocation process was undertaken by a four-person DEA team. The team comprised a Chief Director, two Directors and one Deputy Director. It is understood that three to four hours were required to review a company's submission, while two to three days of person time was typically used to engage directly with companies. It is understood that additional experts were used to assist with some company engagements, but no estimation of the amount of expert time utilised was provided by the DEA.

Once the PPP legislation has been promulgated, one person (a Deputy Director) will be responsible for agreeing PPPs and reviewing annual PPP reports, and 25% of this person's time will be earmarked for this process. A Director will oversee the process and review outcomes, and 10% of his/her time was budgeted for this purpose. Progress towards remaining with a company's carbon budget will be monitored by extracting cumulative emissions data from the National Atmospheric Emissions Inventory System (NAEIS) (which would have been generated from companies' mandatory GHG emission reporting). During the first phase of carbon budgets PPP information will not be included in the NAEIS. It is envisaged that PPP information will be included in NAEIS during the mandatory phase of carbon budgets, once sufficient safeguards have been built into the system to ensure access to confidential information is restricted.

This resource allocation to the PPPs is based on the assumption that the PPP information will be less contentious than Phase 1 Carbon Budgets, and will draw on the carbon budget allocation process already undertaken. The DEA also wants to move to a system akin to the implementation of environmental impact assessments (EIAs), in which very clear guidance is provided as to how PPPs (and carbon budget monitoring more broadly during the next phase) should be undertaken in order to reduce the administrative effort required by DEA. The DEA also indicated that it is considering simplifying PPP and annual progress report templates to make it easier for companies to create and report on PPPs during Phase 1 Carbon Budgets.

Quantifying administration cost

The main cost incurred by the DEA to create and administer Phase 1 Carbon Budgets is the opportunity cost of DEA staff. This cost was quantified using the information provided above, and the guidance provided in DPSA (2016),[5] and is shown in Table 3. As indicated above, these costs exclude the cost of experts that supported the core DEA team.

5 Salary band 11/12 was used for Deputy Director, 13 was used for Director, and 14 was used for Chief Director, to determine the hourly rate used to quantify the cost of DEA time. Long-term rates (including all overheads and no mark-up) were used. The four days (24 hours) of time to engage with each company was allocated uniformly to all four members of the allocation team, and of the four hours to interrogate companies' carbon budget submissions three hours were allocated to the Deputy Director, half an hour to the two Directors (jointly) and half an hour to the Chief Director. The upper limit of time requirements provided by the DEA was used to compensate for the fact that only companies that had been allocated carbon budgets, or which could still be allocated carbon budgets, were included in the analysis. In total 44 companies entered discussions with the DEA to agree carbon budgets (41 responded to the DEA's approach and a further three companies contacted the DEA without having first been approached by the DEA), but the level of interaction between the DEA and the 13 companies that did not receive carbon budgets varied significantly. Consequently, it was decided not to include those companies in the analysis.

Table 3 Carbon budget administration cost – DEA

Position	Time allocation	Rate/hour	Number of companies	Cost of time
Allocation costs	**Hours**	**Rand**		**Rand**
Chief Director	6.5	R1,486	31	R299,429
Two Directors	12.5	R1,240	31	R480,500
Deputy Director	9.0	R830	31	R231,570
Once-off costs				*R1,011,499*
Monitoring costs	**Percentage**	**Annual salary**	**Number of years**	
Director	10%	R976,738	5	R488,369
Deputy Director	25%	R727,647	5	R909,559
Cumulative annual costs				*R1,397,928*
Total DEA cost				**R2,409,427**

Note: 1) Number of companies include 19 companies with carbon budgets at the end of October 2016, and 12 companies still in discussions with DEA that could be allocated carbon budgets.

6.3.2 Cost of administration: Companies

Overview

All the companies interviewed were already tracking GHG emissions before they participated in Phase 1. The level of monitoring and disclosure of GHG emissions nevertheless varied between companies. Listed companies were more likely to publish their GHG emissions, while non-listed companies were less likely to do so – although one non-listed company indicated that while it did not publish the data, it disclosed the information to stakeholders when requested.

Five companies largely used the processes they already had in place to calculate their carbon budgets, and for these companies it was a relatively low-cost endeavour. A sixth company mentioned that while it was already measuring and reporting its GHG emissions (together with all its other air emissions), for the purposes of this exercise it recalculated its GHG emissions to ensure that it was sufficiently robust to disclose to the DEA (and auditable if necessary). The company did not, however, believe this caused it to incur any significant costs.

The remaining five companies indicated that preparing budgets to feed into the allocation process was costly to them, both in terms of personnel investment and money spent on external parties. Costs included building of data collection systems, training of staff at different facilities to provide the required data to the desired standard to head office, gathering the data in suitable formats, adjusting data to different reporting periods, and internal and external verification. One company noted specifically that alignment of reporting periods was its single biggest cost. That company suggested that it took a person-month of time for compliance with the different reporting regulations and budget preparation.

A company that is part of an international group mentioned that it spent around R500 000 to upgrade its emission monitoring system to separate out country-specific emissions, but it emphasised that this was in preparation for several mitigation instruments (such as the draft mandatory reporting regulations and the carbon tax) and not only the carbon budgets. Another company, which has been publishing its GHG emissions in its integrated annual report since 2009, mentioned that it took more than a month to prepare its carbon budget. Its existing reporting, which is informed by guidance from the World Business Council for Sustainable Development and is in line with the Global Reporting Initiative guidelines, is based on materiality and captures only significant GHG emissions from its operations. Emissions from minor sources, which together account for less than 2% of its total emissions, are not included.

The company nevertheless believed that the DEA wanted all emissions to be reported for the purposes of the carbon budgets.[6] Gathering these data required extensive interaction with technical experts within the business, and the data had to be approved by the executive committee before they could be released. Because this was a change from the company's previous reporting, and related to an instrument with which the executive committee was not familiar, the carbon budget information was

6 DEA (2015) did mention that emissions must be accounted for according to the then still forthcoming mandatory reporting regulation – which include significance thresholds for activities below which no emissions reporting is necessary. But the draft mandatory reporting regulations were released only after the process to allocate the company's carbon budget had been completed.

discussed by the executive committee several times before it was approved.

One company mentioned that it treated the allocation process as a trial run for the mandatory phase, and undertook several actions that it would not typically do when reporting its emissions. The company operates a very complicated process at several different plants and operational units. A lot of time was therefore required to be spent by operations people to refine emissions data and to develop growth forecasts. Three or four people from each site were involved in the data gathering, and the gathered data had to be signed-off by numerous levels of management before they could be released. At the group level, a further 10 individuals reviewed the data before they were submitted to the DEA. Weeks of analysis were required to develop, check and update data within the company before they were submitted to DEA. Plant personnel also sat with the DEA to explain the overall process and the role of individual plants and sub-processes. The company mentioned that it was unlikely that the process will be easier during the next three or four iterations due to the complexity of its plants and the level of integration between activities. As a result, the company is trying to be as transparent as possible. The company wants to ensure that the DEA understands how complex its processes are due to all the stages that are used to add value to the products it produces.

Companies were less clear on the costs they would incur to report on Phase 1 Carbon Budgets via PPPs, as the PPP regulations and guidelines had not yet been finalised. Most companies believed it would be costly to agree PPPs with the DEA, but none had any idea how much time or effort would be required. Six companies believed the requirement to submit annual PPP reports would lead to significant cost, and two companies mentioned they would require additional professionals in the form of energy engineers, carbon managers, monitoring specialists, statisticians and other skilled professionals to enable them to statistically analyse and forecast their emissions (and the expected impacts of mitigation procedures) more accurately. The companies mentioned that they would need to put these systems in place to refine them over time, in order to be comfortable that they would be able to comply with mandatory carbon budgets in the next phase. Only one of the companies was able to provide an estimate of its additional capacity needs to deal specifically with carbon budgets, while the other company mentioned that the additional professionals would deal with all GHG-related policies and not only the carbon budgets.

A further two companies were unsure as to whether PPPs would lead to additional administrative costs, whereas only three companies believed that the requirement to submit annual PPP reports was unlikely to lead to significant additional administrative costs.

In terms of new monitoring systems, five companies believed they would have to make additional investments in data monitoring or reporting systems to support PPP reporting, but only one of the five mentioned that this would be for the explicit purpose of PPP reporting (and this company was not able to provide a cost estimate). The other four companies all mentioned that the new systems were at least partly influenced by the DEA's mandatory GHG emission reporting requirements or the impending carbon tax. The investment in new reporting systems, although not relevant to the current analysis, is nevertheless significant. One company indicating that it is investing millions of rand to increase the quality of its GHG emission data for the purposes of the carbon budgets and mandatory reporting, while another indicated it had spent approximately R500 000 updating its GHG monitoring system before taking account of staff training costs.

Quantifying administration cost

The main cost incurred by companies to agree Phase 1 Carbon Budgets was the opportunity cost of time spent preparing and revising carbon budget information and engaging with the DEA. A summary of the costs incurred by the companies that mentioned they incurred significant costs to agree carbon budgets is shown in Table 4. Most companies provided only an approximation of the amount of time required to agree Phase 1 Carbon Budgets, and consequently in some cases the project team had to estimate the time used to quantify administration costs based on the information provided by the companies, knowledge of their operations, and the project team's past experience in undertaking similar exercises on behalf of companies. In order to quantify costs incurred, the average and maximum salaries paid in South Africa for a "Plant Engineer" were used as proxies for engineering or technical time spent (obtained from Payscale.com (2016a)[7]), and the average and maximum salaries paid for an "Engineering Group Manager" (obtained from Payscale.com (2016b)[8]) were used as proxies for head office or management time. Daily rates were determined by defining a working year to consist of 225 working days to account for public holiday and leave days. An estimate of both the average and maximum salaries for the two categories of employees is provided, since it is reasonable to expect that the size of the companies in question would mean that they probably pay towards the upper end of the local market for these skills.

Table 4, however, includes only comprehensive costs incurred by companies to develop and agree carbon budgets with the DEA. Future monitoring and reporting cost (as discussed below), and the cost of time expected to be spent on training staff as part of the initial process to try and make annual PPP reporting and future carbon budget allocation processes more efficient, were not included in the cost estimate.

Sufficient information was not available to estimate the possible cost of companies investing in monitoring systems and processes to generate the information required to report on their carbon budget process (via PPPs), the potential cost of developing and agreeing PPPs, any additional costs incurred to forecast GHG emissions, or to quantify the impact of additional reporting effort that could accompany the requirement to submit annual PPP reports on a systematic basis. Two companies mentioned that they would employ additional professionals to enable them to more accurately forecast the emissions implications of company actions. The additional staff would, however, deal with all GHG-related policies and not only carbon budgets.

Given that a quantitative instrument like carbon budgets places a premium on ability to forecast and control emissions, and that more than half the companies interviewed said they expected there to be additional cost related to monitoring and reporting emissions as a result of carbon budgets, there are likely to be significant monitoring and reporting costs linked to Phase 1 Carbon Budgets. However, only one company provided an indication of the additional capacity that would be required to deal exclusively with carbon budgets. The company indicated that it would require two additional professionals. Given that only one cost point was received, monitoring and reporting costs were not scaled up to reflect all Phase 1 Carbon Budget companies. The total cost of employing these two additional professionals is, however, shown separately in Table 5 to highlight the fact that monitoring and reporting costs are likely to dwarf allocation costs.[9]

Table 4 shows that the five companies jointly spent time worth between R350 000 and R600 000 to prepare and revise carbon budgets and engage with the DEA. Taking the average cost, and assuming that the total number of companies that can receive Phase 1 Carbon Budgets (31) incurred costs in the same proportion as the 11 companies interviewed (five divided by 11), this means that all **31 potential carbon budget companies probably jointly spent time worth between R1 million and R1.6 million during the carbon budget allocation process.**

The cost of hiring two additional staff to assist with the analysis and forecasting of emissions, as one company indicated it would do, is between **R5.3 million and R7.2 million over four years.**

7 Total pay for a Plant Engineer varies from R343 164 to R895 849 per annum. The national average salary is R669 000, based on a sample of 37 positions and 15 years' experience as at September 2015.

8 Total pay for an Engineering Group Manager varies from R250 416 to R1 484 066 per annum. The national average salary is R782 000, based on a sample of 77 positions and 15 years' experience as at September 2015.

9 Although there were 4.5 years left of Phase 1 Carbon Budgets when the company interviews were concluded, it is likely that it will take some time to recruit the two professionals, and for the purposes of the analysis it was assumed that the two additional professionals would be in place for the remaining four years of Phase 1 Carbon Budgets.

Table 4 Carbon budget allocation cost – companies

Cost of allocating carbon budgets	Time estimate	Level	Days	Rate (average)	Cost (average)	Rate (maximum)	Cost (maximum)
Company 1	25 days	Management	15	R3,476	R52,133	R6,596	R98,938
		Engineer	10	R2,973	R29,733	R3,982	R39,816
Company 2	22 day*	Management	11	R3,476	R38,231	R6,596	R72,554
		Engineer	11	R2,973	R32,707	R3,982	R43,797
Company 3	30 days	Management	10	R3,476	R34,756	R6,596	R65,958
		Engineer	20	R2,973	R59,467	R3,982	R79,631
Company 4	10 days*	Management	10	R3,476	R34,756	R6,596	R65,958
Company 5	22 days	Management	11	R3,476	R38,231	R6,596	R72,554
		Engineer	11	R2,973	R32,707	R3,982	R43,797
Total cost for 5 out of 11 companies					**R352,720**		**R583,004**
Allocation cost scaled up to reflect 31 companies					**R994,029**		**R1,643,011**

Note: * time estimate provided by company

Table 5 Carbon budget monitoring and reporting costs for one company (indicative only)

Monitoring and reporting cost	Full-time positions	Level	Years	Salary (average)	Cost (average)	Salary (max)	Cost (max)
Based on one company only	2	Engineer	4	R669 000	R5 352 000	R895 849	R7 166 792
Total cost for only company only (not scaled)					R5 352 000		R7 166 792

6.3.3 Summary

The DEA is believed to have spent time worth R1 million on the allocation of Phase 1 Carbon Budgets to up to 31 companies. In addition, the Department is expected to input time worth about R1.4 million in real terms (i.e. not including the impact of inflation) on monitoring Phase 1 Carbon Budgets from 2016 to 2020.

It is believed that companies spent time worth between R1 million and R1.6 million on the allocation of Phase 1 Carbon Budgets. Due to a lack of information, it is not possible to estimate how much companies will spend in total on additional skills to manage carbon budget compliance, preparing PPPs or investing in new or upgraded GHG emission monitoring or forecasting systems. What is clear, however, is that based on information from only one company, the monitoring and reporting cost of Phase 1 Carbon Budgets is expected to be much higher than the cost of allocating the carbon budgets. One company plans to spend between approximately R5.3 million and R7.2 million on hiring two additional staff to assist with the analysis and forecasting of emissions for carbon budget purposes over four years.

6.4 Co-impacts of mitigation actions (positive or negative)

Greenhouse gas mitigation activities can have either positive or negative effects on socioeconomic goals such as economic development, human health, food and energy security, biodiversity and access to energy. Such externalities (often termed trade-offs, knock-on effects or ancillary impacts) can also be termed "co-impacts".[10] Where the developmental impacts of mitigation activities are positive, these are often termed co-benefits. Some examples of possible mitigation actions and their associated co-impacts are shown in Table 6.

10 The term "co-impacts" is introduced in Cohen, et al. (2015).

Table 6: Examples of co-impacts of climate mitigation in the carbon budget sectors

Mitigation actions	Co-impacts
Implementation of low-carbon electricity supply alternatives	• Energy security and improved energy access. • Either positive or negative impacts on employment, depending on the technology being adopted and that being replaced. • Health benefits via reduction in air pollution and reduced coal-mining accidents. • Ecosystem impact through reduction of air pollution and coal mining. • Increased opportunities for education through access to lighting.
Adoption of less carbon-intensive processes and feedstocks	• Health benefits due to reduced local air pollution and better work conditions (fewer cases of asthma, lung cancer, etc.). • Ecosystem improvements via reduction in local air and water pollution. • Water demand reduction. • Either positive or negative impacts on employment, depending on the technology being adopted and that being replaced.
Transport sector actions	• Energy security (diversification and reduced dependence on oil and exposure to fluctuations in oil prices). • Health impact via reduced urban pollution and via reduced noise levels. • Positive ecosystem impacts via reduced levels of urban pollution.

Source: IPCC (2014)

Quantification of co-impacts is complicated and often subjective. Comparing co-impacts and considering trade-offs in order to prioritise mitigation actions can thus be challenging. For example, is a mitigation option reducing 10 tonnes of CO_2 but creating five jobs preferred to one that mitigates nine tonnes of CO_2 but creates six jobs? Making this choice requires information about the loss function of decision-makers. A second consideration related to co-benefit assessment is that there is not always an obvious direct measurement scale for impacts. For example, the health benefits of an energy technology which reduces local air pollutants may need to be measured in terms of the number of residents exposed to a certain level of those pollutants. Significant analysis and understanding of pollutant impacts on communities is required to understand the true benefit of such an exposure reduction – which in turn is highly context-specific. Having said that, there is an emerging international academic literature on this topic, and several co-benefits (including health benefits) can be quantified. Appendix 2 provides a more detailed overview of co-impacts, and also provides an example of how co-impacts can be analysed and quantified.

Given that companies interviewed are not expected to implement any additional mitigation actions or to change investment patterns as a direct result of being allocated carbon budgets, no co-impacts are expected as a result of Phase 1 Carbon Budgets.

6.5 Inflationary impact of company actions (negative)

The economy-wide impact model mentioned in Section 6.2 includes real prices, and does not provide an estimate of the possible inflationary impact of actions to remain within carbon budgets. Since the level of inflation affects economic policy-making, and in particular monetary policy, it is important to consider the possible impact that carbon budgets could have on inflation. In a relatively high-inflation environment like South Africa, an increase in inflation can trigger a tightening of monetary policy, which can in turn lead to a reduction in borrowing and investment.

Policymakers are typically more concerned about the impact of persistent increases in inflation than once-off inflationary shocks (which typically do not lead to a sustained increase in inflationary expectations over time). Since interventions to meet carbon budgets will typically be once-off, they are not likely to lead to sustained increases in inflationary expectations. For example, an intervention which reduces GHG emissions, requires ongoing cost to operate (in the form of electricity or other inputs), and does not increase a company's output or efficiency, will lead to a once-off increase in the company's operational cost and a once-off decrease in gross profit. Everything else being equal, however, there should be no change from this increased level of operational cost in the next period. Combined with pre-existing trends in inflation, however, it is possible that such a once-off jump could be of interest to policymakers (particularly if will be difficult for producers and consumers within the economy to distinguish the once-off increase from the pre-existing trend – which may lead them to believe that the existing trend is stronger than it actually is).

Appendix 3 outlines in detail how the inflationary impact of actions to remain within carbon budgets can be estimated. This includes understanding the expected impact of the actions of carbon budget companies on their costs, the likelihood that they will pass on these costs to their customers, and the expected impact that a price increase in the output from these companies will have on the overall South African inflation rate.

Since no actions to reduce GHG emissions attributable solely to Phase 1 Carbon Budgets were identified, it is not expected that Phase 1 Carbon Budgets will lead to an increase in production costs or inflation. As mentioned in the previous section, companies did experience costs related to the allocation of carbon budgets, but these costs were relatively small, once-off and not related to companies' production costs (being related mostly to the opportunity cost of time). There may be real costs related to the additional reporting requirements created by PPPs, but it was not possible to quantify these costs due to only one cost estimate being obtained. Also, given that these costs are likely to relate to companies' fixed rather than variable costs, they would have to be very large before they influence output prices. These costs are therefore not expected to be passed on by companies to their customers. **In summary, therefore, Phase 1 Carbon Budgets are not expected to have any impact on inflation.**

6.6 Impact of company actions on tax revenues (positive or negative)

Given that the companies included in the first phase of carbon budgets are some of the largest taxpayers in South Africa, there is a concern that a change in the size or scope of these companies may affect the amount of tax they pay.

The economy-wide impact model mentioned in Section 6.2 can provide an estimate of the impact of mitigation actions on tax revenues derived from broad-based, nationwide sources such as income and product taxes (VAT) through the "total fiscal impact" output variable. The model does not, however, consider local government revenue in the form of local rates and taxes. It is thus important to complement the output from the MPA SAM model with information regarding the impact of local rates and taxes.

No mitigation actions or investments related to production activities were identified as a result of Phase 1 Carbon Budgets, and that the administration cost relating to the allocation of carbon budgets related mostly to opportunity costs rather than additional expenditure. These factors are thus not expected to influence tax revenues. The additional salaries mentioned in Section 6.3.2, however, are expected to reduce company profits and income tax. As mentioned previously, it was not possible to scale this cost to the universe of companies that could receive carbon budgets. Considering only the additional staff cost of the one company that indicated it will employ additional staff directly as a result of Phase 1 Carbon Budgets, and applying the company tax rate of 28% to the additional salary costs, it is expected that tax revenues will decline by at least R1.5 – R2 million as a result of Phase 1 Carbon Budgets.

It is possible that any reduction in company tax could be offset by an increase in personal income tax, but without knowing what the current salaries of new employees were before they were employed by carbon budget companies, or indeed whether they were previously employed within South Africa, it will not be possible to estimate the change in personal income tax.

In summary, it is expected that Phase 1 Carbon Budgets will have a negative impact on income tax revenues as a result of additional monitoring and reporting costs over Phase 1. Due to a lack of information It is not possible to accurately quantify this impact, but based on information from one company it is expected to be at least R1.5 – R2 million.

6.7 Local impact of company spending (positive or negative)

If the scale or location of companies' operations change as a result of investments made to remain within carbon budgets, the change in company spending within a local community could have significant implications. In addition to the direct expenditure by companies to procure goods and services from local suppliers, companies may also be funding local corporate social investment or social responsibility initiatives. This could include, for example, local supply chain development activities, providing training or bursaries to the local community, or supporting or even directly providing local social, environmental or health services. It is also important to consider the impact of a company's labour remuneration on the local economy, and in particular the impact any change to this could have on local unemployment and purchasing power within the local economy (which is likely to sustain a different set of local business and municipal services than a company's direct procurement activities).

The impact of companies' local expenditure is, however, likely to be unique and context-specific. In order to consider the impact that carbon budgets could have on companies' local expenditure patterns, it would thus be necessary to identify instances where mitigation actions or investments undertaken as a result of carbon budgets are expected to significantly change the scale or location of companies' production activities. Once possible changes have been identified, it should be considered whether the magnitudes of these expected changes are expected to have significant impacts on local communities. This can be done by considering the size of each expected change in relation to local socioeconomic conditions. A given reduction in expenditure is likely to have a much larger impact in an area with few other large production or service facilities, relatively poorly funded or under-capacitated local government structures, a relatively undiversified local economy, and relatively poor transport or commercial links with other local communities.

The local impact of company spending is closely related to the co-impacts of mitigation action addressed in Section 6.3.3, but is intended to capture the local indirect impacts of changes in expenditure resulting from mitigation action, rather than the mitigation action itself. As mentioned above, mitigation actions can have direct health impacts by, for example, reducing air pollution. The relocation or downscaling of a production plant can, however, also have a direct impact on health care in an area if it is accompanied by the withdrawal of company-provided health care services to the wider local community.

No mitigation actions or investments that are likely to change the scale or location of production activities were identified, and Phase 1 Carbon Budgets are therefore not expected to influence the local impact of company spending.

6.8 Local impact of changes in scale of company operations (positive or negative)

In addition to the impact that a change in company expenditure could have on local communities, the activities that lead to the change in expenditure could also impact local communities directly. A large construction project, for example, could lead to an influx of migrant workers from outside the local community that could place bulk services or other social, health and environmental infrastructure under pressure. It could also lead to, for example, changed traffic and accident patterns, cause different forms of pollution (such as noise or visual pollution), and impact local property values and rents. A significant increase in migration could also have negative environmental impacts if waste collection and processing infrastructure, for example, cannot cope with the influx of people or activity. These and other impacts (which could be temporary or permanent) can affect local quality of life and the attractiveness of a location as a place to live, work or invest.

These impacts do not, however, necessarily have to be negative, and often involve complex trade-offs. Enhanced road infrastructure, for example, could detract from local scenery and thus negatively impact the local tourism industry, while at the same time facilitating easier access to remote areas which could boost local tourism.

No mitigation actions or investments that are likely to change the scale or location of production activities were identified, and Phase 1 Carbon Budgets are

therefore not expected to lead to any impacts linked to a change in scale of company operations on local communities.

6.9 Unanticipated costs to companies

During interviews with carbon budget companies several issues (which are discussed in further detail in the following sections) were raised that could lead to unanticipated costs to companies. Companies emphasised that it is important to highlight these risks to ensure that early action is forthcoming to avoid unnecessarily large socioeconomic impacts of Phase 1 Carbon Budgets.

These costs relate to the design and implementation of carbon budgets, and can thus be avoided if early action is taken. For this reason, they were not included in the estimation of the socioeconomic impacts of Phase 1 Carbon Budgets. The actions that will be required to avoid these costs are addressed as part of the lessons for the mandatory phase of carbon budgets in Section 8.

6.9.1 Costs linked to treatment of confidential data

A significant risk to preparation for the mandatory phase of the carbon budgets, and one that companies fear could increase the cost of Phase 1 Carbon Budgets, relates to protecting the confidentially of data. Of particular concern are legal and reputational risks linked to the Financial Markets Act (insider trading provisions) and Competition Act (collusion and cartel behaviour sections).

During company interviews it was pointed out that several of the industries that will have carbon budgets during the voluntary phase are relatively concentrated, and in most of these sectors it is relatively easy to translate emissions to production. So an emissions trajectory over time (such as expected annual emissions levels as reported in PPP) could easily be translated to expected future levels of output – which would be problematic from a Competitions Act perspective. One company highlighted the lack of detailed minutes of the engagements between itself and the DEA as proof of a lack of understanding of the sensitive nature of the data, and mentioned that company representatives could be exposing themselves in their personal capacity to fines or prison time in terms of the Competition Act. The interviewee seems to have been referring to section 73(a) of the Competition Amendment Act, which came into effect on the first of May 2016, and criminalises cartel-related and other prohibited practices (Ensor, 2016; Letsike, 2013). Information sharing can enable cartel-like behaviour, and the more disaggregated the production data provided, the more useful it would be in facilitating such behaviour. For this reason, one of the companies mentioned that is comfortable sharing a five-year average production forecast, but not detailed annual forecasts.

Companies also highlighted the fact that information on the annual status of investment projects, as is currently required as part of PPP reporting, is commercially sensitive and could influence share prices if it became public. Anyone with access to this information could thus easily be suspected of insider trading under the Financial Markets Act (2012) if suspicious share trading patterns arise (JSE, 2016). Furthermore, companies believed that the level of disaggregation of investment projects related to mitigation required under carbon budget reporting means that non-disclosure agreements will have to be entered into with at least some companies every time information of this nature is shared (such as for every annual PPP report), and negotiating the terms of the non-disclosure agreement could be time-consuming. It was explained that PPPs are in essence investment plans, and could even include new operational models. Consequently, the information is commercially very sensitive. Because of the much closer link to production over time, GHG reporting is thus very different from reporting under air quality legislation (which is much less sensitive).

If data confidentiality is not ensured, or if entities perceive (even incorrectly) that sensitive data may have been leaked for financial gain (in the case of insider trading) or been shared with competitors (which could facilitate anti-competitive behaviour), significant risks, delays and potential costs to the carbon budget process may be encountered. At worst this could lead to fines or other behavioural remedies being levied on companies for perceived contraventions, and at best to real costs to companies and regulators as suspicions of illegal activity are investigated. Suspicion of untoward behaviour could also affect companies' share prices and/or their cost of capital, and/or may even jeopardise their business dealings.

6.9.2 Costs influenced by alignment of instruments

Several pieces of legislation and policy related to greenhouse gas mitigation and reporting are under development or being refined in South Africa, including the National GHG Emission Reporting Regulations, National Pollution Prevention Plan Regulations, energy reporting regulations and energy management plans under the DoE, atmospheric emission licences and the forthcoming carbon tax. At present, these are not completely aligned in terms of reporting and compliance requirements. The study identified concerns about the additional administrative burden (and hence cost to entities related to compliance) resulting from this misalignment. Companies suggested that reporting should be streamlined and simplified to minimise the cost implications thereof. One specific note was made that continuous monitoring of emissions was not favoured by companies due to the excessive cost implications thereof.

Companies felt strongly that information relating to alignment would be crucial to plan activities to remain within carbon budgets, and to enable the true co-impacts of mitigation actions to be considered, thereby minimising the financial implications for their operations. This includes not only how reporting requirements, reporting deadlines and processes are to be dealt with (and ideally aligned) under the different instruments, but also how policy measures targeting one policy objective but impacting other policy objectives will be considered (if at all). Companies expressed a fear that they may have to incur additional monitoring costs, or even have to replace new monitoring systems and instruments, if the systems they put in place based on the latest available guidance turn out to be unsuitable for one or more of the mandatory reporting regimes mentioned above. The possibility was also raised that projects may have to be abandoned (or scrapped when they are already operational) if assumptions relating to how GHG emissions will be treated under any of the different mitigation instruments turn out to have been incorrect – leading to development or investment costs having to be written-off by companies. The total cost of GHG emissions, or the financial return linked to emission reductions, under the different instruments can be influenced by how the emissions are measured (which could impact the total amount of emissions linked to a project), the extent to which certain mitigation actions and options are acknowledged under different instruments, at what point emissions become costly, and what are the compliance costs of not meeting the requirements of some instruments.

6.9.3 Costs influenced by compliance mechanism design

Companies were unanimous in stating that the level and design of the compliance mechanisms linked to mandatory carbon budgets will be the single most important factor determining both the impact of carbon budgets on the South African economy, and their individual responses to carbon budgets. This is particularly true given that many mitigation actions have long development periods, and companies may have to start planning for these actions long before the mandatory phase of carbon budgets officially starts.

It is also important to consider the level of tolerance that is allowed before compliance measures take effect. This tolerance band is important, since very few companies believe they have complete control over their emissions over short time periods. Unforeseen events could thus lead to companies having to incur compliance cost despite having invested in additional skills to enable them to remain within their carbon budgets, or to undertake particularly costly mitigation actions such as curtailing production.

7. SOCIO-ECONOMIC IMPACT ASSESSMENT: SUMMARY OF RESULTS

Table 7 outlines the potential costs and benefits related to Phase 1 Carbon Budgets that were discussed in the previous section, and that will be jointly considered to provide an indication of the socioeconomic impact of Phase 1 Carbon Budgets. Items that straddle both columns in the table can lead to either costs or benefits, depending on the action in question. Cells representing Items that have been shown to be relevant are shaded.

Table 7 Framework for socioeconomic impact assessment of Phase 1 Carbon Budgets

Costs	Benefits
Economic impact of company actions	
Co-impacts of mitigation actions	
Impact of company actions on tax revenues	
Local impact of company spending	
Local impact of changes in scale of company operations	
Cost of administering carbon budgets	
Inflationary impact of company actions	
Unanticipated costs to companies	

Note: Relevant costs or benefits are indicated by shaded cells (red for costs and green for benefits)

Of the two main impacts identified, the cost of administrating carbon budgets could be only partially quantified, because an estimate of the additional compliance cost linked to Phase 1 Carbon Budgets was obtained from only one company. It was not possible to quantify the impact on tax revenues, since this is directly related to the increase in company compliance costs. Given the potential scale of these two types of cost, however, the cost estimate provided by one company was used to illustrate their likely impact on the total cost of Phase 1 Carbon Budgets.

The value of the costs that could be quantified are shown in Table 8. It is expected, however, that the true cost of Phase 1 Carbon Budgets could easily be of an order of magnitude larger than that shown in Table 8. The compliance cost of the one company (out of a possible 31 companies that could receive carbon budgets) that was able to provide an estimate of the additional capacity required to undertake monitoring and reporting for Phase 1 Carbon Budgets to the total cost estimate (see Table 5), and assuming that this additional costs leads to a reduction in company profit and hence tax revenues (at the company tax rate of 28%), contributes the bulk of the quantified costs of Phase 1 Carbon Budgets. Should more companies employ additional staff or consultants to undertake monitoring and reporting activities linked to the carbon budgets, the total cost could thus increase significantly.

Table 8 Total cost of Phase 1 Carbon Budgets

Phase 1 carbon budget costs	Average company cost scenario	Maximum company cost scenario
Costs of administering carbon budgets	**R8,755,456**	**R11,219,230**
DEA allocation costs	R1,011,499	R1,011,499
DEA monitoring costs	R1,397,928	R1,397,928
Company allocation cost	R994,029	R1,643,011
Company monitoring and reporting cost - indicative only*	R5,352,000	R7,166,792
Tax revenue foregone - indicative only*	R1,498,560	R2,006,702
Total quantifiable cost – conservative estimate	R10,254,016	R13,225,932

Notes: *Based on estimated cost for one company only. This is therefore a minimum estimate of what these costs could be.

Allocation costs are once-off and monitoring and reporting costs are cumulative annual costs.

8. LESSONS FOR PHASE 2

Based on the findings of the engagements with companies and the DEA, several lessons related to minimising the socioeconomic impacts of Phase 2 of the carbon budgets were identified. These are discussed below.

8.1 Lessons related to the budget allocation process

The Phase 1 allocation process was considered to be somewhat time-intensive, with companies being requested to submit the required data, the data being analysed by DEA on a case-by-case basis, further information being sought where necessary, and finally a budget being agreed on – with several iterations of these steps being seen in some cases. The allocation process included one or more meetings between DEA and company representatives. This approach required significant time investment from both companies and the DEA. In future phases of the budgets, where there will be more entities (including both private sector and public sector organisations) allocated budgets, and more importance placed on the outcomes of the allocation process (given that remaining within the budgets will be mandatory), the resource-intensiveness of the allocation process could increase proportionally.

One of the members of the DEA team is a Chief Director, who has been involved in most company meetings and is involved even in responding to data queries and providing follow-up communication. While this might be feasible for Phase 1, which involves only 43 companies (of which a maximum of 31 will be allocated carbon budgets), any subsequent phases could include many more companies, which would result in this degree of interaction by high-level DEA personnel being impractical.

The first lesson that can be gained from the study is the need to make the process of budget allocation as standardised, simple and streamlined as possible, which will help to reduce the resource costs to both parties of agreeing the budgets.

Considerations related to the carbon budget allocation process include:

- The **process for identifying entities to which budgets would be allocated** needs to be clear and unambiguous.
- Clear upfront communication of the **approach to be used in the setting of the carbon budgets** needs to be provided, with a consistent approach being used across industries (or at least across entities within each industry). This will also help provide justification for why the DEA requires the information it is requesting.
- A **standardised data template** which clearly details the data required to be submitted by the carbon budget entities is required. This would include the units in which data should be presented, the approaches used by entities for calculating and projecting emissions, and how uncertainty in information is to be communicated. This will allow entities to set up systems to communicate the necessary information.
- Once the budgets have been established by DEA **all calculations**, including considerations relating to the level of mitigation that is expected of companies, must be communicated to the entities in a timeous and transparent way.
- A formal process to **challenge carbon budgets** that are considered unrealistic or overly restrictive by companies must be established. Companies interviewed as part of this project suggested that it should be possible to lodge appeals on the basis of the inputs/assumptions used to set carbon budgets; procedural grounds relating to, among others, the engagement process followed; and the analysis that was used to determine carbon budgets. Given the direct impact of mitigation actions on company output and hence profitability, one company believed a more structured and independent process than was allowed for under the National Environmental Management Act was required. Also, given potential impacts on employment and other socioeconomic factors, it was proposed that the Department of Trade and Industry or the Department of Economic Development should be part of the appeals process, to ensure that these factors receive sufficient attention.
- Both the DEA and participating companies believed the **rules for adjusting carbon budgets** should be clearly set out, including both the conditions under which it is allowed to adjust carbon budgets, and the rules that must be followed to undertake the adjustment. This is to ensure that the economic impact of the budgets on companies is minimised. This should include details of any mechanisms (such as trading or the use of offsets) that could lead to the level of a company's actual emissions legitimately diverging from its official carbon budget emission levels.

In order to avoid uncertainty and unintended consequences, the process and rules relating to the transfer of carbon space when operations cease or change ownership, and how carbon budgets will be allocated to new entrants, also need to be codified.

- Finally, some of the companies interviewed during Phase 1 noted that because of the **sensitivity of the data involved**, several authorisations will be required before the data for most companies can be released. And during the mandatory process the number of authorisations required is likely to increase, since submissions will then be part of a legally required process. This needs to be built into the timing and planning for Phase 2, with companies not being unduly penalised for not complying if time periods for submissions are too short.

The procedures and considerations outlined above should be standardised across entities, or at least across entities within a sector, which will help to minimise the administrative requirements placed on the DEA, and also address some of the competition concerns related to the budgets.

8.2 Lessons related to the resources required to allocate and administer the budgets

The DEA is aware that its internal resources currently dedicated to managing carbon budgets will not be sufficient to implement a mandatory system, particularly when the number of carbon budget entities increases, and when the necessary rigour increases due to the budgets becoming mandatory. It is therefore trying to motivate for more resources to streamline the processes and reduce the impacts on entities.

Where there is a need to engage entities on the numbers, it is important that sufficient technical support is available to the DEA during engagements with companies to streamline the process and reduce the resources required to undertake the exercise by the DEA and the individual entities. It is also important that the individuals providing technical assistance are familiar with local conditions (either through having experience in energy and mitigation issues locally, or at least having been briefed about the local context in sufficient detail to effectively engage with companies). Unless the process for allocating carbon budgets is significantly simplified, an interdisciplinary team will be required to handle their allocation, including mitigation policy experts, technical experts (including chemical engineers), sector experts, and economists or trade experts.

For these reasons, carbon budget companies indicated that they expect a significant increase in engagement from the DEA in preparation for the next phase of carbon budgets. And from discussions with the DEA, it seems that the Department is indeed aware of the need for a more extensive engagement process while setting carbon budgets for the mandatory phase. This will require a lot of planning and appropriate resources to support this engagement process, to avoid significant increases in the time inputs required from both parties.

8.3 Lessons related to the treatment of confidential data

In order to overcome risk related to the treatment of confidential data, and to ensure that unnecessary costs are not incurred by companies, protocols to handle confidential data should be clearly articulated. These should include specifying how and where data are stored, who has access to the data, and under what (if any) conditions these data can be disclosed to parties other than the specific individuals within the DEA that are administering the carbon budget system. It is understood that the DEA already has such processes in place to ensure data are kept confidential, but these need to be communicated to companies. It is also recommended that the engagement process must be very well documented to avoid suspicion of impropriety. At a minimum, a record of all information shared (listing the detailed information shared, the purpose of the data shared, and whether the information sharing was in response to a request from the DEA) and detailed minutes of meetings (to be signed-off by both the companies and the DEA) should be kept to streamline any cases where there is a disagreement on past communications.

8.4 Lessons related to alignment of instruments

In order to avoid having to incur unnecessary costs to replace or duplicate monitoring and reporting systems for different mitigation instruments, and to prevent mitigation or other investment projects having to be abandoned or reversed as a result of GHG emissions being incorrectly costed, it is important that the emissions covered, calculation methodologies, reporting periods and allowable mitigation actions and strategies be aligned between the different instruments as soon as possible. The DEA has indicated that this approach is already underway, and that the National GHG Emission Reporting Regulations will set the monitoring and reporting rules for all instruments that require GHG emission reporting in future.

8.5 Lessons related to compliance mechanisms

Given the long development periods of many mitigation projects, it is also important that the compliance mechanisms that will be used to enforce mandatory carbon budgets be unambiguously described as long as possible before the commencement of the mandatory phase of carbon budgets. This includes specifying what level of tolerance will be allowed before compliance measures take effect.

While the issue of compliance mechanisms was not explicitly addressed during engagements with the DEA (apart from the DEA indicating that there will be compliance measures for the second phase, and the issue being clearly linked to how the carbon budgets and the carbon tax will interact), the DEA indicated that it would be developing guidance as to the level of tolerance (margin of error) it would allow before a company is considered to have exceeded its carbon budget.

9. CONCLUSION

Several possible positive and negative impacts related to Phase 1 Carbon Budgets have been identified. Only two – the cost of administering the instrument and a reduction in tax revenues – are believed to be relevant at present. This is not surprising given that Phase 1 Carbon Budgets were intended to serve as a pilot process to put in place and refine processes and procedures that can underpin the development of a system of mandatory carbon budgets. Most stakeholders interviewed believed that Phase 1 Carbon Budgets are serving this purpose, and most of the processes to develop and monitor carbon budgets now seem to be in place. Both the DEA and participating companies nevertheless emphasised that more detail and structure is required before the commencement of mandatory carbon budgets. Based on experience to date, it is viewed as an acceptable start to the carbon budget process, provided that lessons learnt are acted upon and rules and processes are codified and presented unambiguously before the start of the mandatory phase of carbon budgets.

In total, it is estimated that the quantifiable administration cost related to Phase 1 Carbon Budgets will be between R10.3 million and R13.2 million. It is expected, however, that the true cost of Phase 1 Carbon Budgets could easily be larger than this if the costs which cannot currently be quantified for all carbon budget companies (namely additional monitoring and reporting costs and the value of tax revenue foregone – which were estimated based on the cost to one company only) are taken into consideration.

Furthermore, investment in new reporting systems, although not relevant to the current analysis which was undertaken mainly to focus on several mitigation instruments (and not exclusively the carbon budgets), is also significant and is not included in the impact of Phase 1 Carbon Budgets.

10. REFERENCES

Arora, S. & Cason, T., 1995. An Experiment in Voluntary Environmental Regulation: Participation in EPA's 33/50 Program. *Journal of environmental economics and managment,* Volume 28, pp. 271-286.

Australian Bureau of Statistics. , 2009. *Producer Price Indexes, Australia, Dec 2009.* [Online] Available at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/6427.0Explanatory%20Notes1Dec%20 2009?OpenDocument

Bell, M. et al., 2008. *Ancillary human health benefits of improved air quality resulting from climate change mitigation,* s.l.: Environmental Health Journal.

Bellù, L., 2012. *Social Accounting Matrix (SAM) for analysing agricultural and rural development policies: conceptual aspects and examples,* Rome: Food and Agriculture Organization of the United Nations.

Bellù, L. G., 2012. *Social Accounting Matrix (SAM) for analysing agricultural and rural development policies: conceptual aspects and examples,* Rome: Food and Agriculture Organization of the United Nations.

Berman, E. & Bui, L., 2001. Environmental regulation and labor demand: evidence from the South Coast Air Basin. *Journal of Public Economics,* Volume 79, pp. 265-295.

Bollen, J., Guay, B., Jamet, S. & Corfee-Morlot, J., 2009. CO-benefits of Climate Change Mitigation Policies: Literature Reivew and New Results. *OECD.*

Bollen, J., Guay, B., Jamet, S. & Corfee-Morlot, J., 2009. *CO-benefits of Climate Change Mitigation Policies: Literature Reivew and New Results,* s.l.: OECD.

Bollen, J., van der Zwaan, B., Brink, C. & Eerens, H., 2009. Local Air Pollution and Global Climate Change: A combined cost- benefit analysis. *Resource and Energy Economics ,* Volume 31, pp. 161-181.

Bye, B. & Klemetsen, M., 2014. *The impacts of alternative policy instruments on environmental performance: a firm level study of temporary and persistent effects,* Oslo: Centre for Research on Environmentally friendly Energy (CREE) Working Paper 14.

Cai, W., Wang, C., Chen, J. & Wang, S., 2011. Green economy and green jobs: Myth or reality? The case of China's power generation sector.. *Energy Economics.*

CCC, 2008. *Building a low-carbon economy - the UK's contribution to tackling climate change,* London: The Stationary Office.

CCC, 2012. *Energy prices and bills – impacts of meeting carbon budgets,* London: Committee on Climate Change.

CCC, 2013. *Fourth Carbon Budget Review – part 2: The cost-effective path to the 2050 target,* London: Committee on Climate Change.

Cloete, B., Robb, G. & Tyler, E., 2010. *Study to provide an overview of the use of economic instruments and develop sectoral plans to mitigate the effects of climate change,* Johannesburg: NEDLAC.

Cloete, B., Tyler, E., Constantinou, A. & Ramkolowan, Y., 2013. *The interface between a carbon budget approach and a carbon tax,* Pretoria: Department of Environmental Affairs.

Coglianese, C., Nash, J. & Olmstead, T., 2002. *Performance-based regulation: prospects and limitations in health, safety and environmental protection,* Cambridge, MA: John F. Kennedy School og Government: Regulatory Policy Program Report No. RPP-03.

Cohen, B. et al., 2015. *Incorporating Co-Impacts into Climate Mitigation Planning: Experiences from Latin America,* Cape Town: MAPS.

DEA, 2014. *GHG National Inventory Report: South Africa 2000-2010,* Pretoria: Department of Environmental Affairs.

DEA, 2014. *South Africa's Greenhouse Gas (GHG) Mitigation Potential Analysis,* Pretoria: Department of Environmental Affairs.

DEA, 2015. *DEROS Explanatory Note No. 4 Carbon Budget Design Document First Phase (2016-2020),* Pretoria: Government Printer, Republic of South Africa.

Dechezleprêtre, A. & Sato, M., 2014. *The impacts of environmental regulations on competetiveness,* London: Global Green Growth Institute & Grantham Research Institute on Climate Change and the Environment, Policy Brief.

Department of Environment, 2009a. *An Approach to Regulating Electricity Sector Greenhouse Gas and Air Pollutant Emissions in Nova Scotia: A discussion paper,* Halifax: Government of Nova Scotia.

Department of Environment, 2009b. *Emissions Caps to Improve Environment.* [Online]
Available at: http://novascotia.ca/news/release/?id=20090226001

Department of Environment, 2013. *Amendments to Greenhuse Gas & Air Quality Emissions Regulations,* Halifax: Government of Nova Scotia.

DPME, 2015. *Socio-economic imact assessment system (SEIAS): Guidelines.* [Online]
Available at: http://www.dpme.gov.za/keyfocusareas/Socio%20Economic%20Impact%20Assessment%20System/SEIAS%20Documents/SEIAS%20guidelines.pdf
[Accessed 9 March 2016].

DPSA, 2016. *Department of Public Services and Administration: Hourly Fee Rates For Consultants - With effect from 1 April 2016.* [Online]
Available at: http://www.dpsa.gov.za/dpsa2g/documents/gics/Fees%20April%202016.pdf
[Accessed 1 September 2016].

Ensor, L., 2016. New measures criminalise cartel practices. *Business Day*, 22 April.

Fadaee, M. & Lambertini, L., 2015. Non-tradeable pollution permits as green R&D incentives. *Environ Econ Policy Stud,* 17(1), p. 27–42.

Freeman, A. M., 1979. Hedonic Prices, Property Values and Measuring Environmental Benefits: A Survey of the. *The Scandinavian Journal of Economics,* 81(2), pp. 154-173.

Fullerton, D., 2001. *A framework to compare environmental policies,* Cambridge, MA: NBER Working Paper Series, Working Paper No. 8420.

Fullerton, D., 2008. *Distributional effects of environmental and energy policy: an introduction,* Cambridge, MA: NBER Working Paper Series, Working Paper Number 14241.

Gaioli, F. et al., 2002. *Valuation of Human Health Effects and Environmental Benefits of Greenhouse Gases Mitigation and Local Air Pollution Abatement Options in the Buenos Aires Metropolitan Area,* s.l.: Integrated Environmental Strategies .

Gollop, F. & Roberts, M., 1983. Environmental Regulations and Productivity Growth: The Case of Fossil-fueled Electric Power Generation. *Journal of Political Economy,* 91(4), pp. 654-674.

Goulder, L. & Parry, I., 2008. Instrument Choice in Environmental Policy. *Resources for the Future*.

Government of Canada, 2007. *Regulatory framework for air emissions.,* Ottawa: Her Majesty the Queen in Right of Canada, represented by the Minister of Environment,.

Government of Canada, 2008. *Regulatory Framework for Industrial Greenhouse Gas Emissions,* Ottawa: Her Majesty the Queen in Right of Canada, represented by the Minister of Environment,.

Gummer, J., 2014. *Committee on Climate Change - Blog: Carbon budgets and the UK economy.* [Online]
Available at: https://www.theccc.org.uk/2014/09/10/carbon-budgets-and-the-uk-economy/

Haines A, e. a., 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: overview and implications for policy makers.. *The Lancet.,* Volume doi:10.1016/S0140-6736(09)61759-1.

Harrington, W. & Morgenstern, R. D., 2004. *Economic Incentives versus Command and Control,* Washington, DC : Resources for the Future.

Helfand, G., 1991. Standards versus Standards: The Effects of Different Pollution Restrictions. *The American Economic Review,* 81(3), pp. 622-634.

ICF International, 2013. *Assessment of Competitiveness Impacts of Carbon Budgets on Electro-intensive Sectors to 2030,* London: Committee on CLimate Change.

IMF, 2010. *Producer Price Index Manual: Theory and Practice.* [Online]
Available at: https://www.imf.org/external/pubs/ft/ppi/2010/manual/ppi.pdf

Intergovernmental Panel of Climate Change (IPCC), 2014. *Climate Change 2014 Mitigation of Climate Change,* New York: Cambridge University Press.

Jaffe, A. B. & Palmer, K., 1997. Environmental Regulation and Innovation: A Panel Data Study. *The Review of Economics and Statistics,,* 79(4), pp. 610-619.

JSE, 2016. *Insider Trading and other Market Abuses (Including the Effective Management of Price Sensitive Information).* [Online]
Available at: https://www.jse.co.za/content/JSERulesPoliciesandRegulationItems/Insider%20Trading%20Booklet.pdf

Kearney, M., 2016. *Types of Impacts That Can Be Measured With Input-Output Analysis* [Interview] (7 July 2016).

Klemetsen, M., Bye, B. & Raknerud, A., 2013. *Can non-market regulations spur innovations in environmental technologies: A study on firm level patenting,* Oslo: Statistics Norway, Research Department Discussion Paper No. 754.

Konar, S. & Cohen, M., 2000. *Why do Firms Pollute (and Reduce) Toxic Emissions?,* Paris: The Organisation for Economic Co-operation and Development (OECD).

Lahley, W., 2014. The Contributions of Utilities Regulation to Electricity Systems Transformation: The Case of Nova Scotia. *Energy Regulation Quarterly*, November.

Lehr, U. & Edler, D., 2012. Green jobs? Economic impacts of renewable energy in Germany.. *Energy Policy.*

Letsike, T., 2013. *The criminalising of cartels – How effective will the new Section 73A of the Competition Amendment Act be?.* [Online]
Available at: http://www.compcom.co.za/wp-content/uploads/2014/09/THE-NEW-SECTION-73A.pdf

Logan, A., Lewis, Y., Cohen, B. & Child, A., 2016. *User-friendly Mitigation Potential Analysis Model: Train the trainers Manual Part B,* Pretoria: The Green House & DNA Economics.

Neuhauser, A., 2016. Supreme Court Blocks Signature Obama Climate Rule. *US News & World Report*, 10 February.

OECD, 2001. *Command and Control Regulation.* [Online]
Available at: https://stats.oecd.org/glossary/detail.asp?ID=383
[Accessed 20 February 2016].

OECD, 2011. *Emission Permits and Competition,* Paris: OECD Policy Roundtables.

OECD, 2011. *Producer price Indices – Comparative Methodological Analysis.*. [Online]
Available at: http://www.oecd.org/std/prices-ppp/48370389.pdf

Payscale.com, 2016a. *Plant Engineer Salary (South Africa).* [Online]
Available at: http://www.payscale.com/research/ZA/Job=Plant_Engineer/Salary
[Accessed 6 September 2016].

Payscale.com, 2016b. *Engineering Group Manager Salary (South Africa).* [Online]
Available at: http://www.payscale.com/research/ZA/Job=Engineering_Group_Manager/Salary
[Accessed 6 September 2016].

Popp, D., 2006. International innovation and diffusion of air pollution control technologies: the effects of NOx and SO2 regulation in the US, Japan, and Germany. *Journal of Environmental Economics and Management,* Volume 51, pp. 46-71.

Porter, M. & Van der Linde, C., 1995. Toward a New Conception of the Environment-Competitiveness Relationship. *The Journal of Economic Perspectives,* 9(4), pp. 97-118.

Province of Nova Scotia, 2008. *Environmental Goals and Sustainable Prosperity Act: Annual Progress Report 2008,* Halifax: Government of Nova Scotia.

Province of Nova Scotia, 2015. *Taking Action on Climate Change.* [Online]
Available at: https://climatechange.novascotia.ca/sites/default/files/Climate-Change_English.pdf

Province of Nova Scotia, 2016. *Environmental Goals and Sustainable Prosperity Act: Progress Report 2014-2015,* Halifax: Government of Nova Scotia.

Quantec, 2016a. *Gross Fixed Capital Formation and Gross Operating Surplus 1995-2015.* s.l.:s.n.

Quantec, 2016b. *SA Standardised Industry Output Structure (1970-2014).* s.l.:s.n.

Republic of South Africa, 2016b. National National Greenhouse Gas Emissions Reporting Regulations (published for comment). *Government Gazette No 40054*, 7 June, pp. 4-24.

Republic of South Africa, 2016. National Pollution Prevention Plans Regulations (published for comment). *Government Gazette No 39578*, 8 January, pp. 15-20.

Round, J., 2003. Chapter 14: Social Accounting Matrices and SAM-based Multiplier Analysis. In: A. Luiz, P. da Silva, P. Bourguignon & R. Yazigi, eds. *Toolkit for Evaluating the Poverty and Distributional Impact of Economic Policies.* Washington DC: The World Bank.

Ruiz-Romero, S., Colmenar-Santos, A. & Castro Gil, M., 2012. EU plans for renewable energy. An application to the Spanish case. .. *Renewable Energy.*

Smith, A., Gans, W. & Yuan, M., 2013. *Estimating Employment Impacts of Regulations: A Review of EPA's Methods for Its Air Rules,* Washington, DC: U.S Chamber of Commerce.

Smith, R. B. P. a. V. K., 2001. The Use of Hedonic Property Value Techniques for Policy and. *International Yearbook of Environmental and Resource Economics,* Volume 6.

Statistics South Africa, 2016a. *Producer Price Index, Methods, Sources and Theory, v1.3.* [Online]
Available at: http://www.statssa.gov.za/cpi/documents/PPI_Methods_sources_and_theory_V_1.3.pdf.

Statistics South Africa, 2016b. *Producer Price Index, Methods, Sources and Theory, v1.4.* [Online]
Available at: http://www.statssa.gov.za/cpi/documents/PPI_Methods_sources_and_theory_V.1.4.pdf.

Statistics South Africa, 2016c. *Product-level PPI weights,* Pretoria: Statistics South Africa.

StatsSA, 2016. *P0141 - Consumer Price Index (CPI), July 2016,* Pretoria: Statistics South Africa.

Stavins, R., 2009. *What explains the recent popularity of market-based environmental solutions?.* [Online]
Available at: http://grist.org/article/the-making-of-a-conventional-wisdom/

Sun, L., 2004. *University of Victoria: Environmental Economics 330 - Topic 7: Command and Control Regulation.* [Online]
Available at: http://web.uvic.ca/~lilisun/Econ330.htm

Union of Concerned Scientists, n.d. *The Clean Power Plan: A Climate Game Changer.* [Online]
Available at: http://www.ucsusa.org/our-work/global-warming/reduce-emissions/what-is-the-clean-power-plan#bf-toc-0

Urge-Vorsatz, D., Herrero, S., Dubash, N. & Lecocq, F., 2014. *Measuring the Co-Benefits of Climate CHange Mitigation,* s.l.: Annual Review of Environmet and Resources.

van Seventer, D., Hartley, F., Gabriel, S. & Davies, R., 2016. *A 2012 Social Accounting Matrix (SAM) for South Africa,* Pretoria: United Nations University (UNU-WIDER) Working Paper 2016/26.

Venkatachalam, L., 2004. The contingent valuation method: a review. *Environmental Impact Assessment Review,* 24(1), pp. 89-124.

Walker, R., 2012. *The Transitional Costs of Sectoral Reallocation: Evidence from the Clean Air Act and the Workforce,* Berkleley, California: US Census Bureau Center for Economic Studies Paper No. CES-WP- 12-02. Available at SSRN http://ssrn.com/abstract=2000069 or http://dx.doi.org/10.2139/ssrn.2000069 .

Wilkinson, P. et al, 2009. Public health benefits to strategies to reduce greenhouse-gas emissions: household energy. *The Lancet,* 374(9705), pp. 1917-1929.

Woodcock, J. et al., 2009. Public Health Benefits of Strategies to Reduce Greenhouse gas Emissions: Urban land transport, T, 374(9705).. *The Lancet,* Volume 374 (9705).

APPENDIX 1 INTERNATIONAL EXPERIENCE

Phase 1 of Carbon Budgets represents the implementation of one of South Africa's first explicit regulatory instruments to mitigate climate change. In the first phase of Carbon Budgets, companies are set an absolute limit of direct GHG emissions (an emission cap) that should be adhered to over a five-year period. The term "carbon" refers to all GHGs acknowledged in the most recent GHG inventory, and the five-year period given to companies to adhere to their budget is motivated by the additional flexibility it allows companies in terms of planning and production fluctuations. The first phase (2016–2020) is voluntary and entails no sanctioning mechanism for companies that do not comply with their carbon budgets over the period. The DEA has, however, indicated that the next and subsequent phases of the regulation will include compliance mechanisms and mandatory participation for qualifying companies (DEA, 2014; DEA, 2015).

The mandatory nature of subsequent phases of Carbon Budgets means that this instrument can be seen as voluntary regulation followed by direct regulation. Direct regulation seeks to align companies' behaviours with social goals by using bans, standards, or top-down orders which define acceptable behaviour and then enforce compliance through threat of sanction. Direct regulation is markedly different from market-based (indirect) regulation, which utilises financial incentives and cost internalisation to steer desirable behaviour (OECD, 2001).

Looking for relevant international experiences with direct climate change mitigation regulation is complicated by the fact that the popularity of this type of regulation has been gradually overtaken by market-based instruments in the environmental sphere (Stavins, 2009). In a review of the literature, not one climate change regulatory instrument exactly the same as South Africa's Carbon Budgets was found. In other words, there does not exist any other national, multi-year carbon emission cap regulation that prescribes emissions limits on a company-by-company basis. Therefore, in order to gain insights from the international regulation literature, the research has been broken into two main types of direct regulation:

- regulatory caps for other pollutants; and
- regional carbon emission caps.

Each regulation type holds different similarities to South Africa's Carbon Budgets, which will be discussed in Section A 1.2. However, before this analysis takes place, Section A 1.1 will briefly discuss the general literature on direct regulation.

A 1.1 Direct regulation

Direct regulation, as described above, compels companies to abide by prescribed rules of behaviour through a threat of sanction. There is no perfect regulatory solution, as each has different benefits and costs in terms of efficiency, distributional impacts, and environmental effectiveness; thus the choice of regulatory option for specific activities should bear in mind both policy objectives and the wider context within which the instrument will be implemented (Fullerton, 2001; Bye & Klemetsen, 2014).

A 1.1.1 Emission caps and performance standards

Emission caps represent a form of direct regulation whereby emissions from a company's production process are restricted to a certain threshold, and if a company generates higher absolute emission levels then significant penalties must be paid. The emission cap can then be gradually lowered to help achieve national or sectoral emission reductions. Theory suggests that this form of regulation decreases the use of polluting inputs and increases the use of pollution-abating inputs, which makes the impact on production ambiguous but the impact on profit clearly negative (Helfand, 1991). The South African Carbon Budget system works in essence like a company-level, multi-year cumulative emission cap.

Performance standards are another form of direct regulation, that set a limit on the volume of emissions per unit of production. Companies must adhere to this emission-intensity limit either by investing in more efficient machinery or by reducing their use of fossil fuels. However, due to varying marginal costs of abatement among different companies, this form of regulation is rarely cost-effective unless the regulator can set company-by-company emission-intensity limits, and it lacks dynamic efficiency in that there is no incentive to keep reducing emissions once the standard is met (Cloete, et al., 2013). However, performance standards grant companies more flexibility compared to mandatory technology standards (which require the use of a particular technology) by allowing them to utilise a combination approach of changing production processes and/or investing in mitigation technology (Coglianese, et al., 2002; Goulder & Parry, 2008; Cloete, et al., 2010).

Environmental effectiveness is a measure of how likely a regulation is to lead to a reduction in emission levels relative to business-as-usual. Emission caps are generally more environmentally effective than performance standards because they directly limit the overall quantity of emissions allowed into the atmosphere, which means that the overall emission levels are known and there is a relatively high degree of certainty of meeting the desired emission levels (Cloete, et al., 2013). Performance standards provide less emission certainty, as it is difficult to predict the actual volume of GHG emissions that will be released within a period. In this respect, the outcome of performance standards on GHG emissions is closer to that of market-based (indirect) instruments, such as a carbon tax, which sets the price of emissions but lets the market decide the final quantity of emissions in the atmosphere (Cloete, et al., 2010).

A 1.1.2 Costs, distributional effects, and innovation

Direct regulation can be less cost-effective than indirect regulation (economic instruments) in terms of administrative costs for the regulator, due to the effort required to get company-level information from a large number of companies (Fullerton, 2001; Goulder & Parry, 2008). Overall cost-effective abatement can be achieved using direct regulation only if the regulator does not assign uniform emission caps to companies, but rather assigns different emission caps to companies based on their differing abatement cost structures (Sun, 2004; OECD, 2011). This is essentially what Phase 1 Carbon Budgets in South Africa is doing by interacting and negotiating with individual companies so as to give them each separate carbon budgets based on their historical production and latent cost structures. However, unless detailed historical information is available, the administrative costs of direct regulation are greater than those of market-based regulation due to greater complexity in monitoring and enforcement, and there is also an increased propensity for violators to take legal action to exploit this complexity and reduce the burden of regulation.

In terms of the economic cost of complying with regulation, however, direct regulation does not necessarily impose a greater cost on regulated entities than indirect regulation. Harrington and Morgenstern (2004), for example, examine 12 case studies exhibiting different regulatory instruments, and can neither confirm nor refute the hypothesis that direct regulation has greater compliance costs than indirect regulation.

When using direct regulation, the method for allocating emission quotas can be controversial and result in unanticipated consequences. Goulder and Parry (2008) analyse the differential effects of direct regulation versus indirect regulation, and come to the conclusion that direct regulation can result in better distributional impacts than indirect regulation. However, direct regulation that involves freely allocated non-tradeable quotas can also provide the companies given these quotas with windfall profits by causing a reduction of output, which creates scarcity in the market and justifies companies raising their prices while reaping extra-normal profits, all of which results in a regressive distributional impact (Fullerton, 2008).

The Porter Hypothesis states that strict environmental regulation induces innovation which can improve production efficiencies such that cost savings compensate for costs of both compliance and research and development (Porter & Van der Linde, 1995). Jaffe and Palmer (1997) find that companies' expenditures from complying with environmental direct regulation are highly correlated with their research and development expenditures in the following year, suggesting that regulation might indeed spur subsequent innovation activities. The free allocation of non-tradeable emission quotas has traditionally been thought a disincentive for investments into green research and development, yet different approaches to quota allocation can change the incentive structure, e.g. by using a lottery to allocate the total fixed quota exclusively to a winner, thereby creating a loser who has incentives to partake in research and development (Fadaee & Lambertini, 2015).

Freely allocated, non-tradeable quotas put an aggregate limit on the amount of emissions possible in the market, which presents a significant barrier to entry for potential new producers who might be more pollution-efficient than the incumbent companies which have been given rights to pollute (OECD, 2011).

Direct regulation can, if designed well, result in flexibility and environmental effectiveness. However, there are risks to this type of regulation, and there is therefore a need to carefully consider how the design of the regulation will impact a variety of outcomes including cost-effectiveness, administrative costs, distributional impacts, incentives for innovation, and barriers to entry for new, efficient companies.

A 1.2 International experience with direct regulation

A 1.2.1 Regulatory caps for other pollutants

This type of regulatory approach is virtually identical to South Africa's Carbon Budgets, except that they have been implemented for pollutants other than CO_2 (e.g. NO_x and SO_2). The discussion in this section is based primarily on air quality regulations and non-tradeable emission quotas.

i. Impact on companies

Direct regulations have been shown to reduce productivity and divert resources from short-term productive ends. Manufacturing companies facing the Los Angeles air quality regulation mandating reductions in pollution emissions spent on average over $500 000 on emission abatement from 1979–1992 just to comply with the regulation, with expenditure increasing as the regulation became stricter (Berman & Bui, 2001). SO_2 regulations in the Clean Air Act Amendments in the US electric power industry during 1973–1979 resulted in higher operating costs due to companies switching to higher-cost, low-sulphur fuels, and on average companies' productivity growth was reduced by 44% per year (Gollop & Roberts, 1983).

There is evidence that pollution caps impact companies' investment decisions (favouring abatement technology) and can support innovation. A study on company-level Norweigan regulation from 1993–2012 finds that non-tradeable pollution emission quotas can lead to new technology investment and result in cost-effective abatement by companies re-organising their underlying production processes (Bye & Klemetsen, 2014). Similarly, Klemetsen et al. (2013) use company-level Norweigan data from 1993–2010 and find that non-tradeable pollution emission quotas spur innovation, as evidenced by the number of related patent applications. Evidence from Japanese, German and US regulations on SO_2 and NO_x emissions supports the finding that domestic regulation spurs domestic environmental innovation, especially when foreign technology cannot be applied directly and requires adaptive research (Popp, 2006). A wide review of the literature confirms that regulation induces innovation in environmentally-friendly technology and reduces innovation in relatively more polluting technologies (Dechezleprêtre & Sato, 2014). Total pollution caps in Canada are believed to lead to increased productivity of affected industries due to companies investing in new technology to meet the emission thresholds (Government of Canada, 2007).

Direct regulation also sends an informational signal to companies by clearly signalling a policy stance. This leads companies to invest in new abatement technologies earlier than would otherwise have been the case (Bye & Klemetsen, 2014). Yet the informational signal is effective only once the regulation is in place. Based on a study on the plant-level employment effects of sudden increased air quality regulations in Los Angeles, Berman & Bui (2001) find no evidence of companies altering their behaviour in anticipation of the increased air quality regulation. A trend to over-compliance (reducing emissions to lower than mandated levels) for US companies subject to toxic chemical emission regulations is largely attributed to the requirement to publicly disclose toxic emission information in the regulation (Arora & Cason, 1995; Konar & Cohen, 2000). Unexpectedly, larger and more financially sound companies were found to be more likely to reduce toxic waste emissions beyond mandated levels, possibly partly due to investor pressure but also due to the ability to pay for emission reductions (Konar & Cohen, 2000).

ii. Impact on society

Findings of the impact of direct regulation on employment are inconsistent. A study investigating the impact of the Los Angeles air quality regulations during 1979–1992 concluded that the regulations had little impact on employment in capital-intensive manufacturing companies, and if anything may have slightly increased nett employment due to the labour demand of mitigation investments. Importantly, however, regulated companies were believed to face no competitors outside of the same regulatory regime (Berman & Bui, 2001). A wide-ranging literature review of environmental regulations by Dechezleprêtre & Sato (2014) finds that regulation can create a small, temporary negative effect on employment, especially for industries producing large amounts of pollution or using large amounts of energy, and within countries where companies can easily relocate production outside of the regulation's reach. Similarly, a report contesting the published claims of the US Environmental Protection Agency (EPA) that its environmental regulations have had relatively benign employment effects argues that the impact of the Utility Mercury and Air Toxics Standard (MATS) and the National Ambient Air Quality Standard (NAAQS) have much more severe employment effects than the EPA estimated. The report argues that the real effects are the equivalent of over 180 000 jobs lost in 2015, with over 50 000 more lost each subsequent year for MATS, and the equivalent of 609 000 jobs lost per year on average between 2013 and 2037 for NAAQS (Smith, et al., 2013).

In analysing amendments to the US Clean Air Act in 1990, some of which included company-level mandatory reductions in toxic air emissions, Walker (2012) finds that the employment costs are large and significant in terms of foregone earnings due to labour re-allocations and unemployment. However, these costs are far outweighed by the health benefits of the regulation. A regulatory impact assessment of national and sectoral NO_x and SO_x pollution limits in Canada also shows that economic costs are significant, but outweighed by the benefits of the regulation – even though many benefits are unquantifiable (Government of Canada, 2007). The study does, however, emphasise that the distributions of benefits and costs are important. If those benefitting from improved air quality are wealthy, while employment losses are disproportionately among the poor, this would lead to an undesirable regressive distributional impact.

iii. Impact on the economy

Dechezleprêtre & Sato (2014) find little evidence that environmental regulation impacts international competitiveness, yet they reason that this might change as countries' means of pollution control regulation become ever more divergent. The authors also argue that because of the knowledge-generating effect of innovation into environmental technologies, regulation might even induce economic growth. In determining the economy-wide impact of the Canadian NO_x and SO_x regulations, it is necessary to look beyond the production and cost impacts on directly affected sectors and into the more uncertain indirect impacts on future investment decisions, demand and supply, and related effects. It is likely that the regulations will cause slightly positive near-term impacts on gross domestic product (GDP) as regulated industries invest in less polluting technologies. Manufacturing and construction industries could also see an overall benefit as their product demand rises to meet the required capital investments in the regulated sectors. Furthermore, energy utilities could face increased costs but pass these costs through to customers which may, in turn, raise other industries' costs slightly (Government of Canada, 2007).

A 1.2.2 Regional carbon emission caps

Regional carbon emission caps are similar to South African Carbon Budgets in that they target GHG emissions such as CO_2 and entail multi-year compliance periods. However, these regulatory instruments specify emission limits on regional terms, which is much broader than the South African Carbon Budgets' focus on company-level emission limits. The discussion that follows will focus on the UK's Carbon Budgets and Nova Scotia's GHG emission cap. Canada's Clean Air Regulation also contains national emission caps, but this regulation is a performance standard (i.e. limits on tCO_2 per unit of output) rather than an absolute emission cap, and has thus been left out of the analysis, although the regulation is intended to transition to a fixed cap after 2020 (Government of Canada, 2008). The EPA's Clean Power Plan would also be an example of a regional carbon emission cap, as it would develop carbon emission reductions targets on a state-by-state basis in order to yield a 32% reduction in national electricity sector emissions (relative to 2005 levels) by 2030. The plan would aim to allow states flexibility in meeting targets by providing various options to reduce emissions; state targets would be developed with the context of each state in mind; and states would be allowed to join in multi-state or regional agreements to find the lowest-cost option for reducing carbon emissions (Union of Concerned Scientists, n.d.). However, early in 2016 the US Supreme court placed a pause on the implementation of the Clean Power Plan, as it ruled that the EPA had exceeded its authority in implementing the regulation (Neuhauser, 2016). Due to the uncertainty surrounding this regulation, it has been left out of the subsequent discussion.

i. Impact on companies

The Canadian province of Nova Scotia committed to reducing its GHG emissions to 10% below 1990 levels by 2020 through its Environmental Goals and Sustainable Prosperity Act of 2007 (Province of Nova Scotia, 2008). In order to help achieve this, the province set out increasingly stringent absolute GHG emission caps for its electricity utility, Nova Scotia Power Incorporated (NSPI), of 9.7 megatonnes (Mt) in 2010, 8.8Mt in 2015, and 7.5Mt in 2020 (Department of Environment, 2009b). The Nova Scotia emission cap regulation incorporates flexibility for the NSPI to meet its caps, through multi-year compliance period limits whereby annual caps are combined over a period of two or three years, and the utility must ensure that it is below these aggregate limits over this longer period to avoid the penalty of C$500 000 per day of non-compliance (Department of Environment, 2009a).

The impact on the NSPI due to its electricity sector emission cap has been seen mainly through investment. The regulations include an incentive for the NSPI to invest in electricity transmission infrastructure, such that the company may exceed its emission caps by up to 3% if evidence is shown of investment into infrastructure that supports the transmission of electricity generated in the province from renewable technology. This incentive impacts only the timing of emission reductions and not the total amount, as the 2020 cap of 7.5Mt and all subsequent caps may not be exceeded. This incentive was estimated to be capable of incentivising C$100 million investment into the province's electricity transmission infrastructure (Department of Environment, 2009a; Department of Environment, 2013). The GHG emission caps are believed to have also supported investment and innovation in green economy sectors such as energy efficiency and renewable energy (Province of Nova Scotia, 2015). Further, the amendments to the emission caps extending them to 2030 aim to provide regulatory certainty intended to incentivise the NSPI to make long-term electricity sector investments (Department of Environment, 2013). Nova Scotia's regional emission cap policy has thus promoted much company-level investment through its subordinate policies of electricity sector emission caps and renewable energy mandates, which have resulted in the stimulation of green sections of the economy. For example, the electricity system has been investing C$40 million per year since 2011 into energy efficiency and conservation, which has resulted within a relatively short period of time in a ratio of electricity savings to electricity consumed that is among the highest in North America (Lahley, 2014).

ii. Impact on society

The UK Committee on Climate Change (2008) describes the UK's carbon budget system as one of a range of the country's climate change response policy instruments. This system aims to put a nationwide cap on CO_2 emissions using a series of increasingly stringent five-year carbon budgets until 2050, when emissions must reach 80% of the UK's 1990 levels. The main social impact expected from the UK government's implementation of policies to reduce emissions and decarbonise its power sector is an increase in energy prices. In 2008 the carbon budgets were expected to cause the average household (using gas for heating and some cooking, and electricity for lights and appliances) an increase in energy expenditure of £40 in 2015 compared to 2011, and of £100 in 2020. This impact is, however, as a result of support for low-carbon electricity generation technology, rather than actions incentivised directly by the carbon budgets, as the UK carbon budgets do not impose absolute caps directly on regulated entities. However, these short-term higher energy costs from a transition to low-carbon electricity are seen as small in comparison to the long-term increasing costs of electricity generation based on business-as-usual gas usage. This is based on the assumption that an increasingly carbon-constrained world will necessarily lead to rising carbon prices, and that gas prices are inherently uncertain due to worldwide supply dynamics (CCC, 2012). Nevertheless, as energy prices rise so too will the number of households living in fuel poverty, and targeted interventions to increase fuel efficiency must be carried out in order to help mitigate this (CCC, 2013). Society could also face higher prices outside of energy products. Higher electricity prices faced by companies will induce them to pass on as much of the cost as possible to their consumers in the form of higher prices; however, the level of cost pass-through will be determined by how easily consumers can shift away from their products once prices rise, and purchase substitutes (ICF International, 2013).

The Nova Scotia electricity sector emission cap is expected to lead to an increase in electricity prices as the NSPI passes on the cost of investments in energy efficiency and conservation schemes, and investment in new renewable energy capacity. In 2013, Nova Scotia's GHG emissions were 9% below its 1990 emission levels. This has been achieved by the electricity sector regulation, as well as other policies requiring greater use of renewable energy by the NSPI, and energy efficiency across all Nova Scotian buildings and appliances (Province of Nova Scotia, 2016). In 2013, Nova Scotia made amendments to the GHG regulations to extend the caps through to 2030, requiring a 55% reduction in electricity sector emissions from 10Mt in 2007 to 4.5Mt in 2030 using four-year compliance periods. These amendments have been made in order to increase regulatory certainty and result in long-term emission reductions and more stable energy prices (Department of Environment, 2013).

iii. Impact on the economy

The price of energy faced by the commercial and industrial sectors in the UK is expected to rise steeply as a result of the government putting in measures to meet its carbon budgets, but the impact on the economy as a whole is expected to be small as energy costs are only a small portion of total costs for most industries (CCC, 2012). Mitigating some of the cost increase is the fact that meeting the UK's carbon budgets will also involve investment into more efficient products, which save people money over the long run, meaning lower total long-term costs. When combining the increase in energy cost with the increase in efficiency, the UK Committee on Climate Change estimates a slight reduction in the growth rate of GDP due to carbon budgets (Gummer, 2014).

Electro-intensive companies are also potentially at risk of having their competitiveness adversely affected due to the UK adhering to its carbon budgets. The impact on the competitiveness of these companies is dependent on how trade-exposed they are (if foreign competitors have less stringent regulations, then domestic trade-exposed companies could suffer); what proportion of total costs electricity accounts for; and how much of this cost they can pass through to customers (ICF International, 2013). In order to address the impact on companies significantly at risk of adverse competitiveness impacts, the UK government implemented a £250 million compensation package from 2013 to 2015 (CCC, 2012; ICF International, 2013). The UK Committee on Climate Change (2013) has as yet found no evidence of competitiveness concerns which have resulted in companies relocating production or large investments to other countries. In fact, it is hoped that the UK could increase the security of its energy supply by increasing low-carbon power generation, thereby making it less dependent on fossil fuel imports. In an increasingly carbon-constrained world where more and more countries implement low-carbon measures (and expect other countries to reciprocate), this early action may actually increase the long-term competitiveness of UK industry.

APPENDIX 2 CO-BENEFITS AND LOCAL IMPACTS

Developing countries face both developmental challenges and increasing pressure to commit to reductions in the emission of GHGs. There is nevertheless an interdependence between activities that aim to mitigate GHG emissions and development priorities identified by countries. Mitigation activities can have either positive or negative effects on socioeconomic goals related to economic development, human health, food and energy security, biodiversity and access to energy. Mitigation activities therefore often have externalities which directly impact on a country's development objectives. Such externalities (often termed trade-offs, knock-on effects or ancillary impacts) can also be termed "co-impacts".[11] Where the developmental impact of mitigation activities are positive, these can be termed co-benefits.

Co-benefits are defined by the IPCC AR5 as the positive side-effects of a government policy intended to achieve a mitigation objective. The benefits associated with the analysis of co-benefits are twofold. Firstly, they serve to support the case for implementing policies and actions aimed at addressing issues of climate change. Secondly, they empower policymakers, businesses and society alike to modify their design of greenhouse gas mitigation efforts towards maximising added development benefits.

The co-impacts associated with climate mitigation can be grouped into three broad pillars: economic, environmental and social. A summary of the key co-benefits from mitigation activities is provided in the sections that follow.

Different co-benefits may apply selectively based on the sector in which mitigation activities are undertaken. Summaries of the most likely economic, environmental and social co-benefits in each sector are provided in the sections that follow. A more extensive list of sectors is included than the sectors relevant to the first phase of carbon budgets, to allow for the possibility that the coverage of carbon budgets may be expanded during the second and subsequent phases.

11 The term "co-impacts" is introduced in Cohen, et al. (2015).

A 2.1 Economic co-benefits

A 2.1.1 Growth (GDP)

Measures aimed at reducing greenhouse gas emission can significantly contribute to an increase in economic growth. However, the impact will depend on the manner in which the mitigation measures are implemented. Should the selected measures be implemented with a carbon tax, then the impact on GDP will depend on the tax level. The impact on the average annual household income, distribution of wealth, prices, purchasing power, total investment and investment rate will also depend on the overall levels of improvement in productivity.[12]

A 2.1.2 Employment

Mitigation actions can have positive or negative implications for employment. The renewable energy sector is an example of one in which significant employment benefits have been demonstrated. Numerous studies in countries including China, the Middle East, Germany, Spain and the USA have shown that a switch to renewables, or increasing the share of renewables in the energy mix, has resulted in increased employment levels. For example, an increased share of renewable energy in China resulted in the power sector registering 472 000 net job gains in 2010. In addition, for the same amount of energy generated, solar photovoltaic energy generation creates up to 18 and 7 times more jobs than nuclear and wind respectively.[13] It is, however, important to consider jobs from a holistic perspective. The extent of employment creation depends on the design of the overall energy system – not only individual projects. From this perspective, employment is likely to be maximised by a combination of different technologies being deployed in the conditions to which they are best suited.

Indirect jobs (such as additional employment throughout the value chain of companies that supply renewable energy or other mitigation technologies) may also be created through the implementation of mitigation activities, with these indirect jobs often based in local communities.

12 Cohen, et al. (2015, p. 17)

13 See: Cai et al. (2011); van der Zwaan et al. (2009); Lehr et al. (2012); Ruiz-Romero et al. (2012).

A 2.1.3 Energy security and energy services

Several mitigation options focus on the energy sector, and can have the co-benefits of increased energy security. Energy security refers to "low vulnerability of vital energy systems", including ensuring sufficient resources to meet national energy demand and resilience of energy supply. Building a resilient energy supply is addressed preferably at the national level, but can have direct implications on access to energy sources for local communities, particularly in countries heavily reliant on energy imports, which are more vulnerable to energy shortages (due to higher prices or challenges in exporting countries). As such, climate policies can increase the efficiency with which energy is used. By reducing national energy demand, this also reduce reliance on imports while increasing the local reserve margin. Low-carbon energy sources like renewables are typically smaller and less concentrated geographically than large-scale fossil fuel generation capacity, which can increase the diversity of domestic energy supply and make it more resilient to supply to large-scale supply disruption (IPCC AR5 Report (2014), p. 546).

A 2.1.4 New technologies

The introduction of mitigation measures often entails the introduction of new and advanced technologies, thereby creating opportunities for businesses to import new technologies, develop local technologies, and promote the viability and adaptation of such technologies to local contexts by developing local expertise and skills. All of these opportunities have positive local co-benefits, and can provide opportunities to empower local communities to enter new markets through technological development.

A 2.2 Environmental co-benefits

The environmental co-benefits associated with reducing greenhouse gas emissions include the overall improvement of air quality, reduction in noise levels as well as the possible elimination of water pollution (waste water management and conservation) and land/natural resource preservation. These improvements are often closely associated with health benefits such as reduced morbidity and mortality due to enhanced air and water quality.

A 2.3 Social co-benefits

A 2.3.1 Health benefits

Some of the more significant co-benefits from greenhouse gas mitigation are the health co-benefits associated with a reduction in the emission of other air pollutants as a by-product of activities focusing on reducing greenhouse gas emissions. Such benefits may include reductions in respiratory infections, heart and lung disease, and other chronic illnesses. A number of international studies have aimed to quantify the health co-benefits from greenhouse gas emission reductions.[14]

A 2.3.2 Education

A second social co-benefit from reducing GHG emissions is the opportunity to develop and build a pool of educated and skilled individuals in the field of low-carbon technology and development. Effective climate policy involves building institutions and capacity for governance, and this is most effectively done through education and training. In addition, education and learning can play a key role in how well issues of climate change are understood and effectively managed at the local level.

A 2.3.3 Welfare and rural development

In a number of developing countries (such as Nepal, India, Brazil and parts of Africa), some renewable energy options are already cost-competitive options for increasing energy access. There may also be education co-benefits through improved access to energy services, as a result of extended "daylight" time for studying and working.

Furthermore, modern small-scale bioenergy technologies (such as advanced and more efficient cooking stoves, biogas for cooking and village electrification, biomass gasifiers, and bagasse-based co-generation systems for decentralised power generation) can provide energy for rural communities with energy services that also promote rural development.[15]

14 See, for example, Haines et al. (2009), Wilkinson et al. (2009), Woodcock et al. (2009), Bollen et al. (2009).
15 IPCC (2014, p. 885).

A 2.4 Co-benefits from a sectoral perspective

Different co-benefits may apply selectively based on the sector in which mitigation activities are undertaken. A summary of the most likely co-benefits in each sector is provided below.

A more extensive list of sectors is included than the sectors relevant to the first phase of carbon budgets, to allow for the possibility that the coverage of carbon budgets may be expanded during the second and subsequent phases.

A 2.4.1 Energy

Research has shown that the implementation of mitigation options in the energy sector can result in a variety of socioeconomic co-benefits for employment, energy security and improved access to energy in rural areas, among others. The energy supply sector is described as the largest contributor to global greenhouse gas emissions, and as such offers numerous options to reduce such emissions – particularly through renewable energies.

Table 9 Co-benefits from the energy sector

Energy Supply	Co-benefits for local communities
Nuclear replacing coal power	• Energy security. • Local employment impact. • Health impact via reduction in air pollution and reduced coal-mining accidents. • Ecosystem impact through reduction of air pollution and coal mining.
Renewable energy (wind, PV, solar, hydro, geothermal, bioenergy) replacing coal	• Energy security. • Local employment impact. • Irrigation, flood control, navigation, water availability. • Health impact via reduction in air pollution and coal mining accidents. • Contribution to (off-grid) energy access – rural electrification. • Ecosystem impact through reduction of air pollution and coal mining. • Educational benefits from rural electrification. • Enhanced livelihoods conditions at the household level (Cooke et al., 2008; Oparoacha and Dutta, 2011).
Methane leakage prevention, capture or treatment	• Energy security (access and rural electrification). • Occupational safety at coal mines. • Health impact via reduced air pollution. • Ecosystem impact via reduced air pollution.

Source: IPCC (2014, p. 72)

A 2.4.2 Building

The implementation of mitigation measures in the building sector reduces the consumption of fossil fuels and electricity. Some of the potential co-benefits from implementing mitigation measures in the building sector include: economic (employment, energy security, increased productivity, enhanced asset values of buildings, lower need for energy subsidies, and disaster resilience); social (increased fuel poverty alleviation, noise impact and thermal comfort, and increased productive time for women and children) as well as health and environmental impacts (reduced outdoor and indoor pollution, improved indoor environmental conditions, fuel poverty alleviation, ecosystem impact, and reduced water consumption and sewerage production).

Indoor air pollution can be significantly reduced by substituting traditional coal-fired cooking stoves with electric stoves, thus reducing GHG emissions and alleviating the negative health effects of pollutants such as black carbon. Substantial health gains can be expected from the deployment of energy-efficient technology, as indoor air pollution is estimated to cause 1.6 million premature deaths per annum. Traditionally these mitigation options are considered energy sector interventions, but from the perspective of local co-benefits it may be useful to consider them as being linked to housing or other buildings initiatives.

Table 10 Co-benefits from the building sector

Buildings	Co-benefits for local communities
Fuel switching, RES incorporation, green roofs and other measures reducing GHG emission intensity	• Health effects (reduced mortality and morbidity from improved indoor and outdoor air quality). • Employment creation. • Improved energy security. • Increased productive time for women/children due to replacement of traditional cooking stoves.
Retrofits of existing building (e.g. cool roof, passive solar). New green buildings. Efficient equipment.	• Disaster resilience. • Employment impact. • Energy security. • Higher asset values of buildings. • Health impact (due to reduced indoor and outdoor pollution and improved indoor environmental conditions) – reduction in incidence of asthma and respiratory allergies, 'flu, depression and stress. • Fuel poverty alleviation -some mitigation measures may improve the thermal performance of buildings and educating residents on appropriate energy management can largely alleviate fuel poverty.
Behavioural changes reducing energy demand	

Source: IPCC (2014, p. 80)

A 2.4.3 Industry

A wide range of mitigation actions can be deployed in industry. From an analytical perspective, however, it is useful to group broad types of mitigation actions together. When considering individual mitigation actions, it would then be necessary to map the mitigation option on the typology below to highlight the types of co-benefits to seek out. A summary of the co-benefits for the general industry sector is provided in Table 11.

Table 11 Co-benefits from greenhouse gas mitigation the Industry sector

Industry	Co-benefits for local communities
CO_2 and non-CO_2 GHG emission intensity reduction	• Health impacts due to reduced local air pollution and better work conditions (asthma, respiratory problems, cancer, etc.). • Ecosystem improvements via reduction in local air and water pollution. • Water conservation.
Technical energy efficiency improvements via new processes and technologies	• Employment impact. • Energy security. • Health impact via reduced local pollution. • Increased water availability and quality. • Improved safety, working conditions and job satisfaction.
Material efficiency of goods, recycling	• Employment impact in waste recycling market.

Industry	Co-benefits for local communities
Product demand reductions	
• Improved wellbeing via diverse lifestyle choices linked to more efficient consumption choices.	

Source: IPCC (2014, p. 86)

A 2.4.3 Transport

Table 12 summarises the range of co-benefits that are most likely to occur from mitigation activities in the transport sector.

Table 12 Co-benefits from the Transport sector

Transport	Co-benefits for local communities
Reduction of fuel carbon intensity: electricity, hydrogen, compressed natural gas, biofuels and other fuels	• Energy security (diversification and reduced dependence on oil and exposure to fluctuations in oil prices). • Technological spill-overs. • Health impact via reduced urban pollution and via reduced noise levels. • Ecosystem impact via reduced levels of urban pollution.
Reduction of energy intensity	• Energy security (reduced dependence on oil and less exposure to oil price fluctuations). • Health impact via reduced urban pollution.
Compact urban form and improved transport infrastructure; Modal shift	• Energy security (reduced oil dependence and exposure. • Productivity via reduced urban congestion and travel times, affordable and accessible transport. • Employment opportunities in public transport sector. • Health impact associated with non-motorised modes via increased physical activity, reduced noise levels. • Ecosystem impact via reduced levels of urban air pollution.
Journey distance reduction and avoidance	• Energy security via reduced dependence on oil and exposure to volatile oil prices. • Increased productivity via reduced urban congestion and travel times (results in lower transport costs and higher profits for firms, and increased economic performance – growth).

Source: IPCC (2014, p. 77)

A 2.5 Quantification of co-benefits

Several considerations are important when trying to quantify co-benefits. This section outlines these considerations.

A 2.5.1 Difficulties in measurement

There are challenges in quantifying and monetising (which is often the most popular approach to quantification as it allows aggregation across impacts) co-benefits, as these tend to be heavily dependent on local circumstances, implementation processes, and scale. Because quantifying co-benefits is often dependent on highly localised circumstances, there are also often no "generic" estimates that can be used in the quantification process. Some co-benefits are also more difficult to quantify than others, and, in general, quantification is a data-intensive exercise, often requiring primary research given the absence of readily available data. Furthermore, for some co-benefits, quantification fails to adequately capture the complexity or sufficiently represent the comprehensive value of the impact.

Co-benefits are nonetheless an important element of assessing the true (social) costs and benefits of climate action, and an analysis excluding an assessment of co-benefits (and co-impacts in general) may substantially underestimate the total cost (and benefit) of mitigation activities. The quantification of co-benefits is also useful in comparing different types of co-benefits accruing to various mitigation efforts, and can thus aid in informing policies and implementation.

Given the difficulties in measurement, it is important to first identify the most likely co-benefits that may arise from mitigation activities. A determination can then be made to allocate resources on quantifying co-benefits based on those that have been identified as most likely to be prevalent. The absence of data can also be addressed by approaches making use of less data-intensive methodologies, such as ratings scales and proxy indicators.

A 2.5.2 Indicators and methods for quantification

A range of methods is used to quantify the different types of co-benefits from mitigation actions. A summary of the possible indicators and appraisal methods for co-benefits from a reduction in GHG emissions is provided in Table 13. For reference purposes, Table 14 also provides a summary of studies where different co-benefits have been quantified.

Table 13 Measuring co-benefits

Co-benefit category	Co-benefit subcategory	Physical indicator	Monetary indicator	Appraisal method
Health benefits	Outdoor air pollution-related Indoor pollution-related Energy poverty-related Outdoor noise-related Transport and traffic-related Heat island-related	• Avoided cases of illness (such as asthma). • Avoided hospital admissions. • Reduced days away from school. • Reduced days off work. • Restricted activity days. • Years lived with disability. • Disability-adjusted life years (DALYs). • Quality-adjusted life years. • Years of life lost.	Avoided costs approach: cost of illness (cost per avoided case). Willingness to pay (WTP) for avoided case of death – value of a lost year and value of statistical life.	Revealed preferences – avoided-costs approach. Stated preferences approach (contingent valuation).
Energy poverty and distributional effects	Access to modern energy services	• Additional kWh of quality energy consumed. • Households with modern energy services (i.e. connections to grid).	WTP for an additional unit of quality energy (e.g. cost per kWh) or for having access to electricity (cost per household).	Consumer surplus estimation through stated preferences method (contingent valuation).
	Affordability of energy services	Decreased energy demand (kWh).	Per unit cost of energy (e.g. cost per kWh).	Energy prices.
Comfort and living conditions	Thermal comfort	• Increased indoor temperatures. • Increased percentage of floor area heated.	Foregone energy cost savings.	Energy prices.
	Elimination of unpleasant odours	Decreased incidence of unpleasant odours.	WTP for avoided incidence of unpleasant odours.	
	Exposure to external noise	Decibels (dBs) of external noise avoided.	WTP to reduce exposure to external noise (e.g. cost per dBs). Increase in rental or sale price of properties (cost, percentage).	Stated preferences (contingent valuation). Hedonic pricing.
Energy security		Units of imported energy avoided (e.g. barrels of oil or tonnes of coal).	Cost per unit of imported energy (cost per unit). WTP to secure the energy supply (cost per MWh).	Estimation of macroeconomic external costs of energy imports. Stated preferences (contingent valuation).
Productivity	Crop yields	Increase in crop yields (percentage).	Cost per unit of agricultural produce (e.g. cost per tonne).	Avoided cost and price of agricultural products.

Source: Adapted from Urge-Vorsatz, et al. (2014, p. 560) and Cohen et al (2015)

Table 14 Studies quantifying different co-benefits

Co-benefit	Examples of co-benefits quantified	Studies
Health	Energy efficiency in homes. Low-carbon vehicles. Reduction in livestock production.	Wilkinson et al., 2009; Woodcock et al., 2009; Crawford-Brown et al., 2012; Garg, 2011; Xia et al., 2005; Aunan et al., 2004; Preval et al., 2010; Friel et al., 2009; Markandya et al., 2009; Bollen et al., 2009; McMichael et al., 2007; Younger et al., 2008; Aggarwala, 20008; Jack and Kinney, 2010; Pittel and Rubbelke, 2008; Van Vuuren et al., 2006; Groosman et al., 2011; Garg, 2011; Selvakkumaran and Limmeechokchai, 2013; Greishop et al., 2011; Dix-Cooper et al., 2012; Liddel and Morris, 2010; Neuhoff et al., 2013; Rojas-Rueda et al., 2011, Hosking et al., 2011.
Thermal comfort	Energy efficiency in homes and office buildings.	Sunikka-Blank et al., 2012; Jakob, 2006; Griego et al., 2012; Alberini et al., 2013.
Poverty and energy poverty	Energy efficiency in homes. Expansion of public transport. Renewable energy.	Tirado Herrero et al., 2013; Sunikka-Blank et al., 2012; Preval et al., 2010; Casilass and Kammen, 2012; Bollen et al., 2009; Urge-Vorsatz and Herrero, 2012.
Noise pollution	Modal shift to hybrid-electric vehicles (HEV).	King et al., 2011; RIVM, 2010; King et al., 2011; Nissenbaum et al., 2012; Bakker et al., 2012; Saidur et al., 2011.
Air pollution	Air pollution and climate policy. Alternative electricity generation.	Xia et al., 2015; Plachinski et al., 2014; Dhar and Shukla, 2015; Tirado Herrero et al, 2013; Diragahayani, 2013. Bollen et al., 2009; Rive, 2010; Shrestha and Shakya, 2012; van Vliet et al., 2012; Rafaj et al., 2012.
Biodiversity	Preventing deforestation. Renewable energy.	Strassburg et al., 2012; Phelps et al., 2012; Hamilton and Akbar, 2010.
Water	Afforestation. Fertiliser management. Use of wetlands.	Wilcock et al., 2008; Hamilton and Akbar, 2010.
Energy security	Low-carbon transport.	Dhar and Shukla, 2015; Banerjee et al., 2012; Maibach et al., 2007.
Employment	Renewable energy. Expansion of public transport.	Moreno and Lopez, 2008; Tourkolias and Mirasgedis, 2011; Porter et al., 2015.
GDP	Carbon cap and tax policy. Investment in transport infrastructure.	Bey et al., 2002; Melo et al., 2013; Bystricky et al., 2010; Ziegelman et al., 2000; Scott et al., 2008; Moreno et al., 2008; Caldes et al., 2008; Tourkolias and Mirasgedis, 2011; Openshaw, 2010; Silalertruka et al., 2011; Hillebrand et al., 2006; Tirado et al., 2011.

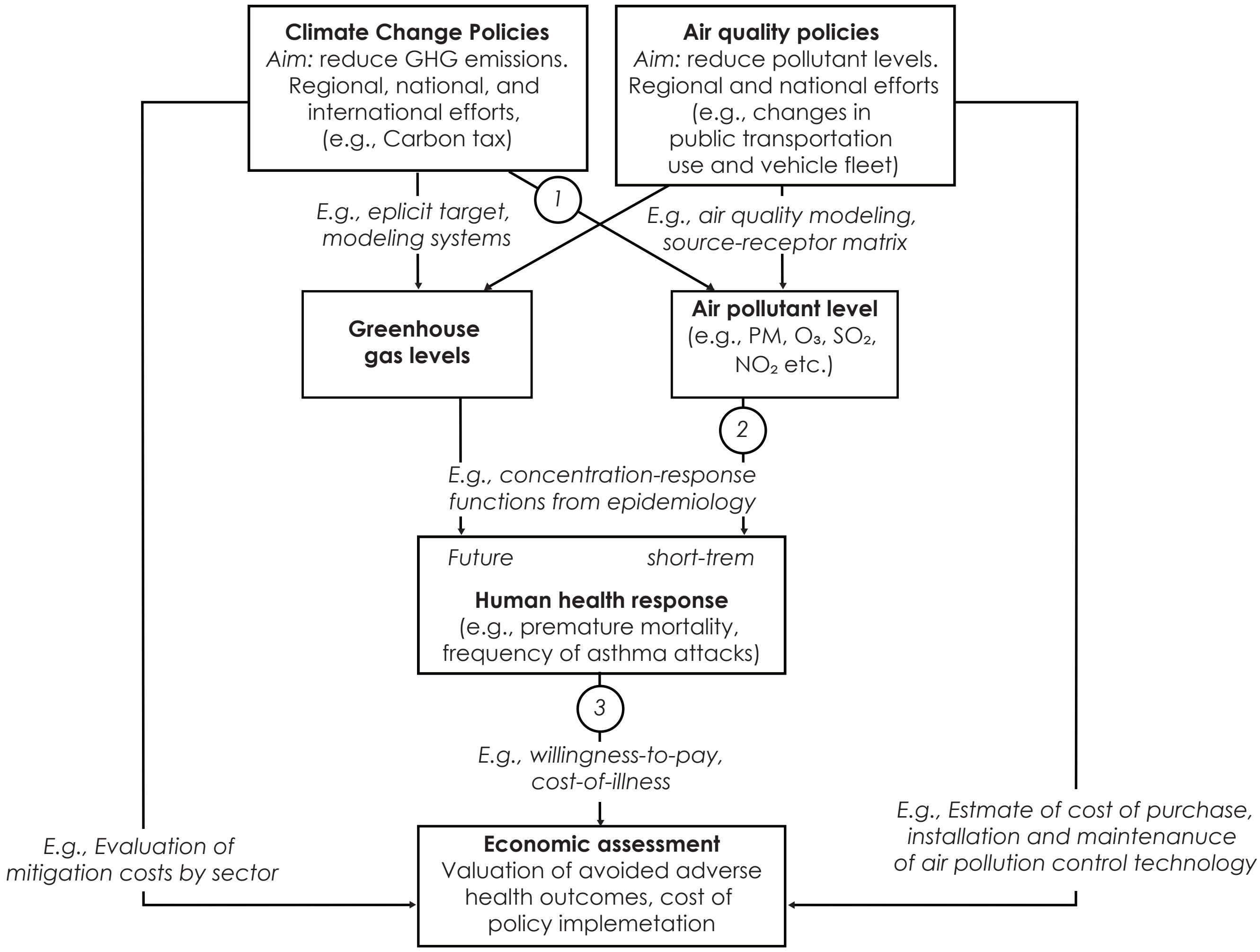
Source: Adapted from IPCC (2014) and Cohen, et al. (2015) – see source documents for details of individual references

A 2.6 Illustrating the measurement of health co-benefits

This section provides a more detailed illustration of how co-benefits can be measured, using health co-benefits as an example. Bell et al. (2008) identify the relationship between climate change and air quality policies, and provide a general framework of how health co-benefits from GHG emission reduction activities can be estimated. The three key steps, shown in Figure 3, involve:

1. *Estimating changes in air pollutant concentrations, comparing levels in response to GHG mitigation to concentrations under a baseline "business-as-usual" scenario.*
2. *Estimating the adverse health impacts avoided from reduced air pollution.*
3. *If monetisation is desirable, estimating the monetary benefit from these averted health consequences, often with comparison to the cost of the climate change mitigation measure.*[16]

Figure 3 Measuring the health co-benefits from a reduction in greenhouse gas emissions



Source: *Bell et al.* (2008)

The link between air quality changes and health is often based on epidemiological studies which can be classified according to several characteristics, including type of exposure (long-term versus short-term); coverage (cross-sectional or longitudinal); implicit function form (linear, log-linear, logistic etc.); and the population sub-

16 Bell et al. (2008).

set considered (children, adults, asthmatics, etc.).[17] Bell et al. (2008) note that concentration-response functions from epidemiological studies have been the primary basis for estimating health effects from a reduction in air pollutants. This effectively involves:

> *applying a mathematical relationship between pollution levels associated with various types of health endpoints, with an understanding of the relationships between the health effect and individual (or social) preferences for reducing the risk or incidence of this effect. The use of a concentration-response function without adjustment assumes that the underlying relationship between air pollution and health when and where the function was derived will hold in the future, perhaps in a different location. This integration involves matching as closely as possible the starting point of the valuation analysis to the endpoint provided by health science, that is a measure of pollution (e.g. ambient levels as a surrogate for exposure) to a health response (e.g. increased risk in hospitalisation). In addition, the approach requires knowledge of the population by cohorts that map to the health endpoints (e.g. asthmatics or those over 65 years) and assumptions regarding baseline health responses.*

An additional layer of complexity arises when a monetary value must be attached to the quantified health benefit. Probably the most important (yet controversial) monetary measure of the physical impact of air pollution in terms of the number of premature deaths is an estimation of the value of statistical life. The value of statistical life is assumed to increase with income, and estimates from the labour market literature sometimes cannot be directly applied to the local air pollution context, as the elderly typically benefit disproportionately from air quality policies that reduce particulate matter emissions, and it is these older individuals who are assumed to be willing to pay less to reduce mortality risk (as they will be purchasing fewer additional years of life expectancy).[18]

There are several alternatives to valuing health benefits, related to both mortality and morbidity. The most well-known are the human capital approach, the cost of illness approach, and the willingness to pay approach.

Cost of illness approach

This method totals medical and other out-of-pocket costs, and is used to measure acute and chronic health endpoints (i.e. different models are to be used for cancer progression and respiratory disease to estimate medical costs from these diseases over one's lifetime). However, this method fails to capture other consequences of illness such as psychological suffering and physical pain, and can thus result in an overall underestimation of the costs associated with the illness.[19]

Human capital approach

This approach estimates the value of life in terms of lost productivity, and is generally recognised as problematic and not based on modern welfare economics – where preferences to reduce death risks are not captured.[20]

Willingness to pay (WTP) approach

This method generates estimates of preferences for improved health by aiming to measure the monetary amount individuals would be willing to pay to avoid negative health effects.[21] This approach is generally based on either a contingent valuation method or hedonic pricing.[22]

Quality-adjusted life year

The quality-adjusted life year (QALY) approach attempts to account for the quality of life lost by adjusting for time lost from disease or death. This is approach is described as welfare-theoretic, and holds only under very restrictive assumptions, making it difficult to conceptualise the significance of any given QALY score.[23]

17 Gaioli, et al. (2002).
18 Bollen, et al. (2009, p. 15).

19 Bell, et al. (2008).
20 Bell, et al. (2008).
21 Bell, et al. (2008).
22 See Venkatachalam (2004) for an overview of contingent valuation, and Freeman (1979) & Smith (2001) for an overview of hedonic pricing.
23 Bell, et al. (2008).

APPENDIX 3 ESTIMATING THE INFLATIONARY IMPACT OF CARBON BUDGETS

A3..1 Definition of inflation

Inflation is defined as a "sustained" increase in price for a good or basket of goods, or alternatively is seen as the extent to which an individual's or economy's purchasing power is reduced due to a general increase in the price of goods and services. Specifically, inflation reflects ongoing changes in the price of a basket of goods and services. In broader terms, consumer and producer price indices are used as a measure of the change in price for a set of products, and often reflect both once-off and sustained price changes.

A3.2 The ability of firms to pass on costs

Firms which have carbon budgets in place may undertake activities and projects to reduce carbon emissions, at a cost to each firm. Under such circumstances, firms may pass through the costs of such activities through higher output (product) prices. However, the extent to which firms will, and are able to, pass on prices depends on a range of factors influencing the supply and demand for a product. These are discussed briefly below.

A3.2.1 Company costs

Firms face two kinds of costs; fixed costs (which stay the same regardless of how much is produced) and variable costs (which vary with production). An increase in a company's marginal (or variable) cost will always be passed on, although the extent of pass-through will depend on the nature of competition. However, the extent of the price increase may be less than the full carbon cost if marginal costs are not constant (since an increase in price will lead to a fall in demand and hence marginal cost may also fall).

The situation with regard to fixed costs is totally different. Economic theory suggests that firms will not increase prices in response to an increase in fixed costs, as a company's optimal price level is set in relation to its marginal costs. A company's decision whether or not to produce another unit of output depends on whether the price it will obtain for that unit will be greater than the (marginal) cost of producing the unit. If the price is higher than the cost, the company is better off producing that unit, even if it makes only a small contribution towards fixed costs. Conversely, a company will not increase its prices in response to an increase in fixed costs, as by doing so, it would be losing potentially profitable sales (if it is assumed that demand for a company's products is not perfectly inelastic) which could have contributed towards fixed costs (even if not contributing a fully proportional amount).

In reality, depending on the size of the fixed cost increase, firms may struggle to fund the payment of the fixed cost and may therefore need to increase prices in the short term to generate cash flow or pay back debt, even if doing so is not actually optimal from a profit-maximising perspective. Alternatively, an increase in fixed cost may be large enough to render a company unprofitable. If this is the case, then the same analysis as above would apply, depending on whether the company is a price-taker or not, and on whether all firms are impacted equally.

A3.2.2 Market power

Under conditions of perfect competition (and in terms of economic theory), firms set price equal to marginal cost, so would be forced to pass the full increase in cost through to customers. In the real world, where industries rarely fit the characteristics of "perfect" competition, we can think of a scenario where firms face considerable competition and hence are "price-takers", but do make a small positive margin over marginal cost. Thus in a perfectly competitive market, one would expect a large degree of pass-through, unless there are competitors in the industry (domestic or international) who do not face the same costs in trying to adhere to their carbon budget, or face it to a lesser extent.

On the other hand, if the company has a degree of market power (i.e. it is not a price-taker), then it will choose to pass on a portion of the cost and internalise a portion of the cost. The extent to which the cost increase is passed through depends on the elasticity of demand. If demand is inelastic (i.e. relatively insensitive to price), a higher proportion of the cost will be passed on; whereas if demand is highly elastic (i.e. declines steeply in response to a price increase), a lower proportion will be passed on.

It is clear that the ability of firms to increase prices in response to emission reduction activities is based on several inter-related variables. Identifying the extent to which firms can pass cost increases through to customers by raising prices therefore requires ascertaining the answers to several questions:

- What type of cost increase will be imposed on firms? Will it affect their fixed costs, variable costs or both? Increases in variable costs are more likely to be passed on, whereas increases in fixed costs are less likely to be passed on.
- How competitive is the relevant market? Are there many competitors or just a few (these may be domestic or international)? The more companies there are in a market, the more likely costs are to be passed on. But this is not an absolute rule, since even a monopolist (i.e. where there is only one company in a market) may pass on costs depending on the elasticity of demand for its product(s). See discussion of elasticity of demand below.
- Do all competitors face identical carbon costs? This will depend on whether products are homogeneous or differentiated, and whether production processes and inputs differ between competitors. Firms with higher carbon costs may constrain pass-through to be able to continue competing with firms with lower carbon costs.
- How elastic is demand for the product? The more elastic demand is, the less likely costs are to be passed on.
- Are there other substitute products which customers are not purchasing currently, but which may become more competitive if there is an increase in price? This is a special case of the previous point, since the elasticity of demand changes as prices change. So while there may seem to be few alternatives to a product at a low price, at higher prices consumers may switch to other products.

A3.3 South Africa's Producer Price Index

There are several different approaches to aggregating producer prices. South Africa's Producer Price Index (PPI) is aggregated based on a "stage of production" approach, and each commodity is allocated to the stage in which it is used. This method uses a "transaction flow" approach in which flows of commodities are categorised according to their economic destination. That is, goods are classified according to their use in the chain of production, typically as primary products, intermediate goods or finished goods. Unlike other approaches, commodities may therefore be included at more than one stage. Products are typically classified in stages of production using national accounting input-output tables.[24] South Africa's stage of production approach differs between input and output goods, and aggregates goods into five composite producer inflation indicators (which are published individually):

1. Manufacturing:
   a. Final manufactured goods;
   b. Intermediate manufactured goods.
2. Electricity and water.
3. Mining.
4. Agriculture, forestry and fishing.

With the exception of manufacturing indices, which have both input (intermediate) and output (final) inflation index indicators, all PPI indicators are output-based in terms of the stage of production. There is therefore no single producer price index for South Africa, though the final manufactured goods composite indicator is used as South Africa's "headline" inflation index for producer prices.

A 3.3.1 Product classification

The PPI uses two standards of classification: the Standard Industrial Classification (SIC), which classifies economic activity, and the Central Product Classification (CPC), which is used to classify and aggregate products.[25] As noted by Statistics South Africa (2016b):

> *Each type of good or service distinguished in the CPC is defined in such a way that it is normally produced by only one activity as defined in ISIC [and therefore also relates to only one SIC activity].*[26]

This therefore allows products to be classified both in terms of the stage of production and based on the sectoral classification used during the compilation of national accounts data by Statistics South Africa.

24 See OECD (2011), IMF (2010) and ABS (2009) for more on the stage of production approach to aggregating producer price indices.

25 Statistics South Africa currently uses SIC Version 5 and CPC Version 2.0 for classification.

26 The International Standard Industrial Classification of All Economic Activities (ISIC) is closely related to South Africa's domesticated industrial classification, SIC.

A 3.3.2 Industry and product weights

The PPI utilises national accounts (value added) and sales value survey data in order to derive the weights for products included in the PPI indices. Weights are derived to ensure that there is no double counting in aggregation.[27] As of 2016, Statistics South Africa uses price information for 273 product categories for the five PPI indices. Table 15 summarises the weights currently used in Intermediate Manufactured Goods, under which basic organic chemicals falls. The full list of product level weights is provided in Appendix 5.

Table 15 Sector weights for Intermediate Manufactured Goods PPI

Sector	Product description	Weights (2016)	
Basic and other chemicals (SIC 3341)	Basic organic chemicals (CPC 341)	4.25	8.19
	Basic inorganic chemicals (CPC 342)	3.94	
Basic iron and steel		15.82	
Basic precious and non-ferrous metals		15.01	
Glass and glass products		4.01	
Plastic products		20.12	
Recycling and manufacturing n.e.c.		3.46	
Rubber products		2.86	
Sawmilling and wood		21.14	
Textiles and leather goods		9.39	
Total weight: Intermediate manufactured goods		**100.00**	

Source: Statistics South Africa (2016c)

A 3.3.3 Concordance between PPI weights and carbon budget sectors

There is no direct relation between sectors identified by the IPCC and the standard systems of classification used for sectors and products. As a result, the concordance between producer price weights and the sectors identified for carbon budgets will be imprecise, and in some cases no concordance will be identifiable. The different levels of aggregation of IPCC sectors and standard classifications presents further challenges in providing a direct estimate of inflation impacts. A best-estimate concordance of the carbon budget sectors and the producer price weights is provided in Table 16.

There is a minority of sectors where the concordance is likely to be relatively clear, and assessing the inflationary impact for such sectors should be straightforward. There are also several sectors where there are multiple producer price products that are related to a specific carbon budget sector. For these sectors, product information for each producer product would be needed to identify the overall inflation impact in that carbon budget sector. There are sectors where concordance is less accurate, or where the sectoral concordance overlaps with multiple carbon budget sectors. For such sectors, in addition to detailed product-level information, a nuanced approach to mapping concordance would need to be undertaken. Finally, there are sectors for which no clear concordance is identifiable, and no overall inflation impact would be able to be assessed for these sectors.

27 More accurately, Statistics South Africa includes products in the industry-level group if they fall into the top 80 cumulative percentage for each industry-level group. The products included in the weights are based on Statistics South Africa's Large Sample Surveys.

Table 16 Possible concordance between carbon budget sectors and producer price indices

Carbon Budget sector	Level of concordance	Producer Price Index	PPI sector description	PPI product-level description	Product weight in producer index (index totals 100)	CPC Product Code
Coal mining	Likely concordance	Mining	Coal and gas	Coal	23.399	110100001
Production and/or refining of crude oil	Likely concordance	Final manufactured goods	Petrol	Petrol	5.510	333100001
Production and/or processing of natural gas	Likely concordance	Mining	Coal and gas	Natural gas	1.831	120200001
Production of liquid fuels from coal or gas	Likely concordance	Final manufactured goods	Other	LPG gases	0.209	334100001
Cement production	Likely concordance	Final manufactured goods	Non-metallic mineral products	Cement	1.100	374400001
Glass production	Multiple product-level weights within producer price sector	Intermediate manufactured goods	Glass and glass products	Safety glass	0.708	371150001
		Intermediate manufactured goods	Glass and glass products	Fibre glass	1.232	371290001
		Intermediate manufactured goods	Glass and glass products	Glass containers	2.069	371910001
Ammonia production	No concordance at either sector or product level, closest product level provided	Intermediate manufactured goods	Basic and other chemicals	Basic organic chemicals	4.254	341000001
Nitric acid production	No concordance at either sector or product level, closest product level provided	Intermediate manufactured goods	Basic and other chemicals	Basic organic chemicals	4.254	341000001
Carbon black	No concordance identified					

Carbon Budget sector	Level of concordance	Producer Price Index	PPI sector description	PPI product-level description	Product weight in producer index (index totals 100)	CPC Product Code
Iron and steel production. Ferro-alloys production.	Sector concordance includes multiple carbon budget sector products and multiple product-level weights within producer price sector	Intermediate manufactured goods	Basic iron and steel	Ferro-manganese	0.704	411120001
		Intermediate manufactured goods	Basic iron and steel	Ferro-chromium alloy	2.056	411130001
		Intermediate manufactured goods	Basic iron and steel	Flat rolled non-alloy steel products	6.737	412110001
		Intermediate manufactured goods	Basic iron and steel	Flat rolled stainless steel products	3.422	412320001
		Intermediate manufactured goods	Basic iron and steel	Bars and rods of iron or steel	1.800	412400001
		Intermediate manufactured goods	Basic iron and steel	Angles, shapes, sections and similar products of iron or steel	1.096	412500001
Aluminium production	Multiple product-level weights within producer price sector	Intermediate manufactured goods	Basic precious and non-ferrous metals	Unwrought aluminium	1.408	414310001
		Intermediate manufactured goods	Basic precious and non-ferrous metals	Aluminium products	0.759	415320001
Polymers production	Multiple product-level weights within producer price sector	Intermediate manufactured goods	Plastic products	Ethylene polymers and copolymers (PET)	3.079	347100001
		Intermediate manufactured goods	Plastic products	Polyethylene	4.063	347100002
		Intermediate manufactured goods	Plastic products	Vinyl chloride polymers (PVC) and copolymers	1.102	347300001
		Intermediate manufactured goods	Plastic products	Polyurethane	0.380	347900001
		Intermediate manufactured goods	Plastic products	Plastic pipes, tubes and fittings	4.935	363200001
		Intermediate manufactured goods	Plastic products	Plastic bags	2.958	364100001
		Intermediate manufactured goods	Plastic products	Plastic containers	3.609	364900001

Carbon Budget sector	Level of concordance	Producer Price Index	PPI sector description	PPI product-level description	Product weight in producer index (index totals 100)	CPC Product Code
Pulp and paper production	No concordance for pulp production	Final manufactured goods	Paper and printed products	Newsprint	0.297	321210001
		Final manufactured goods	Paper and printed products	Paper for printing	0.450	321290001
		Final manufactured goods	Paper and printed products	Packing and wrapping paper in rolls or sheets	0.672	321320001
		Final manufactured goods	Paper and printed products	Sacks and bags of paper	0.798	321520001
		Final manufactured goods	Paper and printed products	Corrugated cardboard boxes	2.493	321530001
		Final manufactured goods	Paper and printed products	Toilet paper	0.349	321930001
		Final manufactured goods	Paper and printed products	Disposable nappies for babies	0.432	321930002
		Final manufactured goods	Paper and printed products	Plain cut paper	0.497	321990001
		Final manufactured goods	Paper and printed products	Books	1.867	322990001
		Final manufactured goods	Paper and printed products	Newspapers	0.551	323000001
		Final manufactured goods	Paper and printed products	Magazines	0.797	324100001
		Final manufactured goods	Paper and printed products	Printed stationery	0.780	326900001

A 3.4 Illustrating inflation impacts

A 3.4.1 Underlying assumptions

Given that there is limited information on firms' activities during Phase 1 Carbon Budgets, a framework for assessing the inflationary impact is demonstrated through an illustrative example. This example is based on the following assumptions:

1. The company is a chemical manufacturer, manufacturing basic organic chemicals.
2. The company operates in a highly competitive market, and all competitors face the same production costs and similar (and similarly priced) mitigation options for reducing their emissions to adhere to their carbon budgets. The company (along with all other firms in the sector) is able to pass through costs of mitigation actions.
3. Without undertaking mitigation actions, firms in the basic organic chemicals sector were expected to see output prices rise by 5%. However, mitigation actions are expected to result in output prices rising by a further 10%. Consequently, output prices for basic organic chemicals will increase by 15% as a result of activities undertaken in a specific year to reduce GHG emissions.
4. Prices for all other products in the producer inflation index increase uniformly by 5%.

These assumptions are somewhat simplifying, and real-world cases are likely to be substantially more complex. However, this example allows for the easy mechanical demonstration of how an increase in output prices could affect the economy's overall producer inflation.

A 3.4.2 Demonstration of inflation impact

Given that there is limited information on firms' activities during Phase 1 of the Carbon Budgets, a framework for assessing the inflationary impact is demonstrated through two illustrative examples.

The assumptions are somewhat simplifying, and real-world cases are likely to be substantially more complex. However, these examples allow for the easy mechanical demonstration of how an increase in output prices could affect the economy's overall producer inflation.

A 3.4.3 Illustrating the inflation impact in the coal sector

In the first example the focus is on the coal sector, where the concordance between the carbon budget sector and the producer price index appears to be relatively straightforward and there is a single product mapped to the carbon budget sector. The following information is assumed:

5. The company is a coal miner.
6. The company operates in a highly competitive market and all competitors face the same production costs, and are faced with similar (and similarly priced) mitigation options for reducing their emissions to adhere to their carbon budgets. The company, and all other firms in the sector, is able to pass through costs of mitigation actions.
7. Without undertaking mitigation actions, firms in the coal mining sector were expected to see output prices rise by 5%. However, mitigation actions are expected to result in output prices rising by a further 10%. Consequently, output prices for coal will increase by 15% as a result of activities undertaken in a specific year to reduce GHG emissions.
8. Prices for all other products in the producer inflation index increase uniformly by 5%.

Table 17 provides a summary of the price indices used to demonstrate the impact of a once-off (additional) 10% increase in coal prices due to the implementation of mitigating actions. We assume that the price increase will be implemented in January 2017. The relative price index is shown in Table 17, where prices have been indexed to 100 in January 2016. We assume that prices for all other products increase by an average of 5% between January 2016 and January 2017, while these prices increase slightly again in February 2017. We assume that all prices (including coal) increase again by 5% in January 2018.

The latter columns of Table 17 show the inflation rate based on these price increases, as well as the contribution to the inflation rate of the mitigating action. Despite higher price increases for coal products (compared to other products in the PPI bundle), price increases due to mitigating activities contribute only an additional 0.4% to the overall annual PPI inflation rate (compared to the scenario where there is no additional price increase) for mining products.

Because the price increase is assumed to be a "once-off", month-on-month inflation between February 2017 and January 2017 is 0% for coal products, and this product grouping does not contribute anything to the month-on-month inflation rate for mining goods.[28] It is also clear that because there is a "once-off" price increase due to mitigating activities, there is no additional inflation impact beyond 2017, and inflation in 2018 returns to the "normal" (pre-mitigation) rate.

Table 17 Inflation impact of mitigating action in coal sector

	PPI index	PPI Product	Product weight	Index value				Inflation		
				16-Jan	17-Jan	17-Feb	18-Jan	Annual (Jan-17 / Jan-16)	Month-on-month (Feb-17 / Jan-17)	Annual (Jan-18 / Jan-17)
No mitigating action	Coal and gas	Coal	23.40	100.00	105.00	105.00	110.25	5.00%	0.00%	5.00%
	Other products		76.60	100.00	105.00	105.50	110.25	5.00%	0.48%	5.00%
	PPI: Mining		100.00	100.00	105.00	105.38	110.25	5.00%	0.36%	5.00%

	PPI index	PPI Product	Product weight	Index value				Inflation		
				16-Jan	17-Jan	17-Feb	18-Jan	Annual (Jan-17 / Jan-16)	Month-on-month (Feb-17 / Jan-17)	Annual (Jan-18 / Jan-17)
Mitigation action results in once-off price increase in coal sector	Coal and gas	Coal	23.40	100.00	115.00	115.00	120.75	15.00%	0.00%	5.00%
	Other products		76.60	100.00	105.00	105.50	110.25	5.00%	0.48%	5.00%
	PPI: Mining		100.00	100.00	107.34	107.72	112.71	7.34%	0.36%	5.00%
	Contribution to inflation of mitigating action							2.34%	0.00%	0.00%

Source: Statistics South Africa (2016c)

A 3.4.4 Illustrating the inflation impact in the aluminium sector

A 3.4.1 The second example describes how the inflation impact could be assessed for the aluminium production sector, which may relate to more than one product within the producer price index. Similarly to the previous example, several simplifying assumptions are made, including:

1. The company operates in a highly competitive market and all competitors face the same production costs, and are faced with similar (and similarly priced) mitigation options for reducing their emissions to adhere to their carbon budgets. The company, and all other firms in the sector, is able to pass through costs of mitigation actions.
2. The company produces both aluminium products identified in the producer price index, and is able to provide information on these products. The products see different percentage increases in prices as a result of carbon mitigation actions, but these increases are once-off.
3. Prices for all other products in the producer inflation index increase uniformly by 5%.

Table 18 provides a summary of the price indices used to demonstrate the impact of a once-off (additional) increase in prices due to the implementation of mitigating actions. The overall principles remain the same as the previous example, with mitigating actions being a "once-off" shock to inflation, which is not sustained over a period. However, the key difference is that product information is required for more than one product

28 Statistics South Africa undertakes an annual review of weights used in the PPI indices. In order to ensure that product groups are comparable across different index weightings, Statistics South Africa uses a process of "chain linking". For more on the process see Statistics South Africa (2016b).

in order to effectively assess the inflation impact within the carbon budget sector, and these products could experience different price impacts from mitigating activities. In this example aluminium products see prices rise by 20%, while unwrought aluminium experiences a once-off price increase of 15%. The weighted price increase of these two products provides the price increase for the aluminium sector, and this weighted impact then carries through to overall producer prices.

Table 18 Inflation impact of mitigating action in aluminium production sector

	Carbon budget sector	Index	PPI Product	Product weight	Index value				Inflation		
					16-Jan	17-Jan	17-Feb	18-Jan	Annual (Jan-17 / Jan-16)	Month-on-month (Feb-17 / Jan-17)	Annual (Jan-18 / Jan-17)
No mitigating action	Aluminium production	Basic precious and non-ferrous metals	Unwrought aluminium	1.41	100.00	105.00	105.00	110.25	5.00%	0.00%	5.00%
		Basic precious and non-ferrous metals	Aluminium products	0.76	100.00	105.00	105.00	110.25	5.00%	0.00%	5.00%
		Basic precious and non-ferrous metals	Other products in sub-index	12.84	100.00	105.00	105.00	110.25	5.00%	0.00%	5.00%
		Other products		84.99	100.00	105.00	105.50	110.25	5.00%	0.48%	5.00%
		PPI: Intermediate manufactured goods		100.00	100.00	105.00	105.42	110.25	5.00%	0.40%	5.00%

	Carbon budget sector	Index	PPI Product	Product weight	Index value				Inflation		
					16-Jan	17-Jan	17-Feb	18-Jan	Annual (Jan-17 / Jan-16)	Month-on-month (Feb-17 / Jan-17)	Annual (Jan-18 / Jan-17)
Mitigation action results in once-off price increase in aluminium products	Aluminium production	Basic precious and non-ferrous metals	Unwrought aluminium	1.41	100.00	115.00	115.00	120.75	15.00%	0.00%	5.00%
		Basic precious and non-ferrous metals	Aluminium products	0.76	100.00	120.00	120.00	126.00	20.00%	0.00%	5.00%
		Basic precious and non-ferrous metals	Other products in sub-index	12.84	100.00	105.00	105.00	110.25	5.00%	0.00%	5.00%
		Other products		84.99	100.00	105.00	105.50	110.25	5.00%	0.48%	5.00%
		PPI: Intermediate manufactured goods		100.00	100.00	105.25	105.72	110.52	5.25%	0.40%	5.00%
		Contribution to inflation of mitigating action							0.25%	0.00%	0.00%

Source: Statistics South Africa (2016c)

As highlighted earlier, this example provides a simple illustration of how one may assess the inflationary impact of carbon mitigation activities. It is important to note that the illustration is based on several simplifying assumptions, and specifically in terms of the company's market power, ability to pass through costs and the extent to which increases in output prices will occur throughout the sector. The actual assessment of the inflationary impact of carbon mitigation activities may, in practice, require a more nuanced approach.

APPENDIX 4 ECONOMY-WIDE IMPACT MODELLING OVERVIEW

A 4.1 What is a Social Accounting Matrix?

A Social Accounting Matrix (SAM) is a table that represents interactions between commodities, activities, and agents in an economy over a given period of time. Interactions in the economic system are depicted, such as the circular flow of payments and receipts among the different elements of the system. The SAM organises information on the socioeconomic structure of an economy, highlights the flow of payments and receipts, and forms the basis for statistical models of an economy which can be used to analyse policy impacts (Bellù, 2012).

Round (2003) describes four main features of a SAM:

1. It is a square matrix. The receipt of payments and the payments made for each account are represented as rows and columns respectively. Thus for each account, there is a column and a row which explicitly shows the interconnections between different accounts and implies that corresponding row and column totals must equate.
2. It is comprehensive. All economic activities of the system are depicted in the SAM, although not all activities are necessarily given the same detail.
3. It is flexible. The user of a SAM model has a choice of the level of aggregation they would like the SAM to apply to the economic system, and which economic activities they would like to be emphasised.
4. It is social. A vital feature of a SAM is the centrality of households, as there must be some detail on the distributional implications for households for an accounting matrix to be called a SAM.

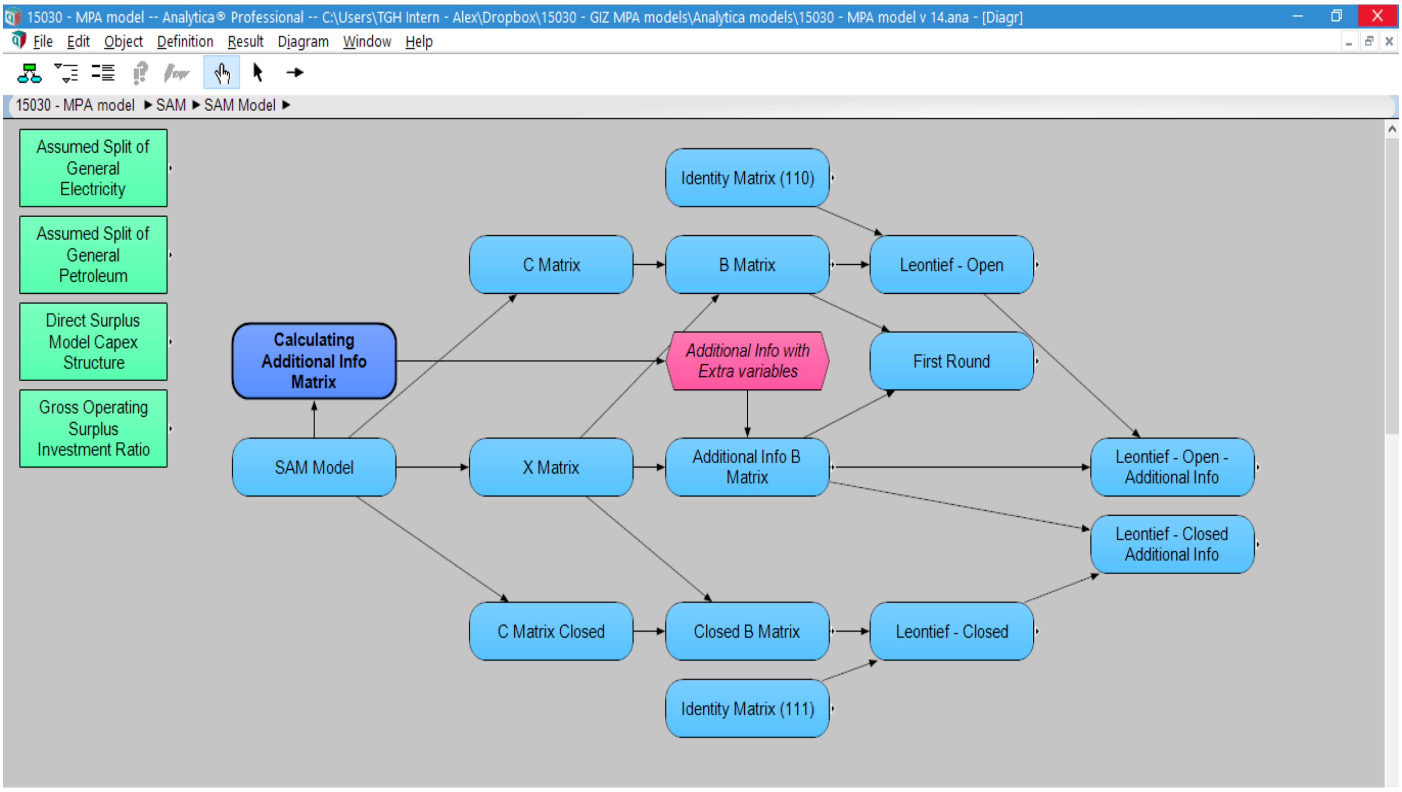
A 4.2 SAM used in this Study

The SAM that has been used for the purposes of the current study has been an amended version of the National Treasury's 2012 South African SAM (van Seventer, et al., 2016). This SAM has been amended to conform to the requirements of a square matrix by making commodities and activities map 1:1, as initially some activities produced multiple commodities and conversely some activities produced no commodities. In particular, the petroleum sector has been disaggregated (into petroleum from oil, petroleum from coal-to-liquid, petroleum from gas-to-liquid, and petroleum from biofuels), and the electricity sector has been disaggregated (into electricity from coal, electricity from nuclear, electricity from renewables, and electricity from gas). The basic SAM table, with amendments already made, is in the "SAM" module on the main module page, then inside the "SAM Model" module.

Labour and Fixed Capital Stock data were not included in the original SAM, and have been manually input into the model as a separate input also received from the National Treasury. The variable containing this data is called "Fixed Capital Stock and Labour Data" and its location is shown in Figure 4. Further amendments were made to the SAM in terms of creating the "Additional Information with Extra variables", highlighted in Figure 4. This variable determines what result rows are reported, and is calculated using existing data within the "SAM Model" and combining the data from the "Fixed Capital Stock and Labour Data" variable, as shown within the "Calculating Additional Info Matrix" module. The most important manipulations to note are the changes in the Labour results from being depicted in terms of education to being depicted in terms of skill levels, and the changes in Households from being depicted in terms of deciles to being depicted in terms of Low-, Middle- and High-income brackets. The initial categorisations and descriptions of Labour and Households are shown in Table 19.

For the purposes of the multi-criteria decision analysis and the point scoring methodology, the labour needed to be categorised into Unskilled, Semi-skilled, and Skilled employment. In order to amend the categorisations, Workers with some or no primary schooling (flab_p) were categorised as Unskilled employment; Workers who have completed grade 10 or grade 12 (flab_m + flab_s) were categorised as Semi-skilled employment; and Workers who have at least some post-secondary or higher education (flab_t) were categorised as Skilled employment. Changing the Households categorisation from deciles to income brackets used the poverty line published by Quantec of R26 697 per year for all households living in all urban areas and the population numbers for 2012 (58 847 860) (Kearney, 2016). On the basis of these numbers, we have assumed that Hhd_0 – Hhd_5 are Low-Income Households; Hhd_6 and Hhd_7 are Middle-Income Households; and Hhd_8 – Hhd_95 are High-Income Households.

Figure 4 Explanatory diagram for the location of the Fixed Capital Stock and Labour Data variable



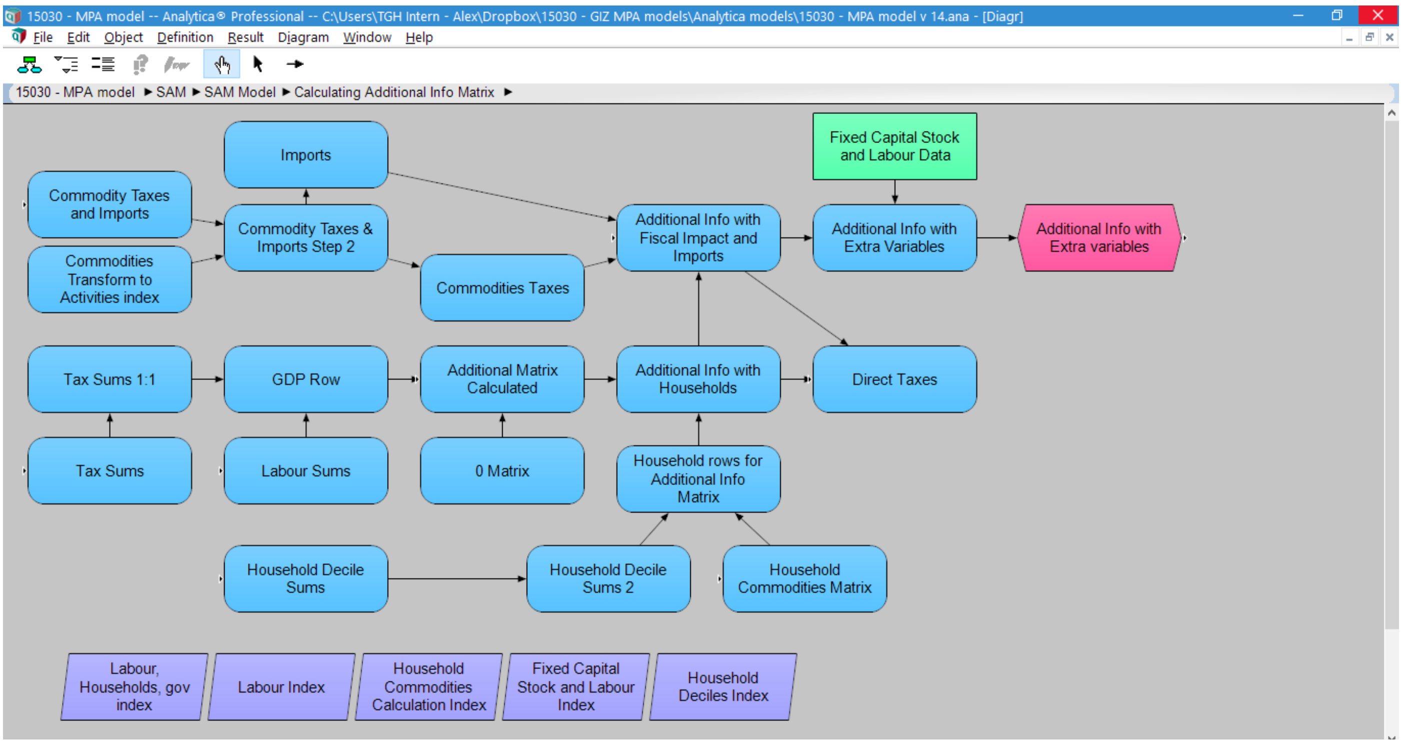


Table 19 Initial Labour and Household categories in the SAM

Categories	Description
Labour	
Flab_p	Workers with some or no primary schooling
Flab_m	Workers who have completed grade 10
Flab_s	Workers who have completed grade 12
Flab_t	Workers who have at least some post-secondary or higher education
Households	
Hhd_0	By per capita expenditure deciles; 1st decile
Hhd_1	By per capita expenditure deciles; 2nd decile
Hhd_2	By per capita expenditure deciles; 3rd decile
Hhd_3	By per capita expenditure deciles; 4th decile
Hhd_4	By per capita expenditure deciles; 5th decile
Hhd_5	By per capita expenditure deciles; 6th decile
Hhd_6	By per capita expenditure deciles; 7th decile
Hhd_7	By per capita expenditure deciles; 8th decile
Hhd_8	By per capita expenditure deciles; 9th decile
Hhd_91	By per capita expenditure deciles; 10th decile bottom 2% of this decile
Hhd_92	By per capita expenditure deciles; 10th decile next 2% of this decile
Hhd_93	By per capita expenditure deciles; 10th decile next 2% of this decile
Hhd_94	By per capita expenditure deciles; 10th decile next 2% of this decile
Hhd_95	By per capita expenditure deciles; 10th decile top 2% of this decile

Source: van Seventer, et al. (2016)

The amended SAM model has subsequently been transferred into Analytica software from Excel and automated to increase its ease of use. The objective of this transfer into Analytica has been to increase the user-friendliness of the interface, so that the impact of mitigation measures on the South African economy can be easily interpreted and mitigation measures and assumptions easily amended by DEA personnel. The operating costs, cost savings, and capital costs of various mitigation measures are fed into the model through the distinct sectors relevant to the measures, via simple input tables and check-lists. These user inputs will then automatically feed into the underlying SAM calculations and reveal easy-to-interpret results variables. The benefits of this approach are that mitigation measures can be easily amended using the interface without requiring any technical assistance in changing the underlying model

The basic underlying SAM calculations take the form of the standard Leontief Multiplier model, and the results that are reported are separated into direct, indirect, induced, and economy-wide impacts.

APPENDIX 5 PPI PRODUCT WEIGHTS USED BY STATISTICS SOUTH AFRICA

PPI Index (table)	Sector	Product	2016 Weights
Final manufactured goods	Meat and meat products	Beef carcasses	1.18
Final manufactured goods	Meat and meat products	Pork carcasses	0.21
Final manufactured goods	Meat and meat products	Lamb carcasses	0.34
Final manufactured goods	Meat and meat products	Chicken – fresh or chilled	0.22
Final manufactured goods	Meat and meat products	Frozen chicken	2.23
Final manufactured goods	Meat and meat products	Bacon	0.15
Final manufactured goods	Meat and meat products	Polony	0.15
Final manufactured goods	Meat and meat products	Meat burgers	0.12
Final manufactured goods	Meat and meat products	Viennas	0.24
Final manufactured goods	Meat and meat products	Meat pies	0.18
Final manufactured goods	Fish and fish products	Fresh and chilled fish	0.73
Final manufactured goods	Fish and fish products	Tinned fish	1.15
Final manufactured goods	Fruit and vegetables (Manufacturing)	Frozen potato fries	0.15
Final manufactured goods	Fruit and vegetables (Manufacturing)	Canned baked beans	0.15
Final manufactured goods	Fruit and vegetables (Manufacturing)	Canned vegetables	0.18
Final manufactured goods	Fruit and vegetables (Manufacturing)	Fruit juice	0.69
Final manufactured goods	Fruit and vegetables (Manufacturing)	Canned or bottled peaches	0.08
Final manufactured goods	Fruit and vegetables (Manufacturing)	Fruit concentrates	0.14
Final manufactured goods	Fruit and vegetables (Manufacturing)	Jam	0.07
Final manufactured goods	Fruit and vegetables (Manufacturing)	Raisins	0.06
Final manufactured goods	Oils and fats	Cooking oil	0.69
Final manufactured goods	Oils and fats	Margarine	0.30
Final manufactured goods	Dairy products	Fresh full-cream milk	0.51
Final manufactured goods	Dairy products	Long-life full-cream milk	0.44
Final manufactured goods	Dairy products	Cream	0.10
Final manufactured goods	Dairy products	Yoghurt	0.42
Final manufactured goods	Dairy products	Gouda	0.16
Final manufactured goods	Dairy products	Cheddar	0.24
Final manufactured goods	Dairy products	Mozzarella	0.08
Final manufactured goods	Dairy products	Ice-cream	0.22
Final manufactured goods	Dairy products	Dairy mixtures	0.09
Final manufactured goods	Grain mill products	Cake flour	0.17
Final manufactured goods	Grain mill products	White bread flour	0.21
Final manufactured goods	Grain mill products	Brown bread meal	0.11
Final manufactured goods	Grain mill products	Maize meal	0.57
Final manufactured goods	Grain mill products	Cereals	0.26
Final manufactured goods	Starches and starch products, animal feeds	Glucose and glucose syrup	0.85
Final manufactured goods	Starches and starch products, animal feeds	Dog and cat food	0.20
Final manufactured goods	Starches and starch products, animal feeds	Dairy cattle feeds	0.18
Final manufactured goods	Starches and starch products, animal feeds	Poultry feeds	0.59

PPI Index (table)	Sector	Product	2016 Weights
Final manufactured goods	Bakery products	Sweet biscuits	1.43
Final manufactured goods	Bakery products	White bread	3.60
Final manufactured goods	Bakery products	Brown bread	2.59
Final manufactured goods	Sugar	Raw cane sugar	0.68
Final manufactured goods	Sugar	Refined sugar	0.76
Final manufactured goods	Other food	Peanut butter	0.03
Final manufactured goods	Other food	Nuts	0.05
Final manufactured goods	Other food	Chocolate slabs and bars	0.29
Final manufactured goods	Other food	Sweets	0.25
Final manufactured goods	Other food	Uncooked pasta	0.06
Final manufactured goods	Other food	Instant coffee	0.07
Final manufactured goods	Other food	Tea	0.05
Final manufactured goods	Other food	Chips	0.18
Final manufactured goods	Other food	Tomato sauce	0.02
Final manufactured goods	Other food	Mayonnaise	0.05
Final manufactured goods	Other food	Spices and condiments	0.13
Final manufactured goods	Other food	Non-dairy creamers	0.05
Final manufactured goods	Other food	Powdered soft drinks	0.02
Final manufactured goods	Other food	Nutritional, dietary and formulated food supplements	0.07
Final manufactured goods	Beverages	Spirits	0.46
Final manufactured goods	Beverages	White wine	0.36
Final manufactured goods	Beverages	Red wine	0.49
Final manufactured goods	Beverages	Spirit coolers	0.35
Final manufactured goods	Beverages	Beer	4.35
Final manufactured goods	Beverages	Soft drinks	1.60
Final manufactured goods	Tobacco products	Cigarettes	1.10
Final manufactured goods	Textiles	Linen	0.08
Final manufactured goods	Textiles	Loose car seat covers	0.26
Final manufactured goods	Clothing	Pantyhose and tights	0.01
Final manufactured goods	Clothing	Socks	0.02
Final manufactured goods	Clothing	Panties	0.37
Final manufactured goods	Clothing	T-shirts	0.32
Final manufactured goods	Clothing	Knitwear	0.05
Final manufactured goods	Clothing	Men's and boys' Jackets	0.73
Final manufactured goods	Clothing	Men's and boys' trousers	0.28
Final manufactured goods	Clothing	Men's and boys' shirts	0.17
Final manufactured goods	Clothing	Dresses	0.42
Final manufactured goods	Clothing	Skirts	0.21
Final manufactured goods	Clothing	Women's and girls' pants and jeans	0.20
Final manufactured goods	Clothing	Blouses	0.20
Final manufactured goods	Clothing	Bras	0.18

PPI Index (table)	Sector	Product	2016 Weights
Final manufactured goods	Footwear'	Men's and boys' footwear	0.34
Final manufactured goods	Footwear'	Women's and girls' footwear	0.12
Final manufactured goods	Paper and printed products	Newsprint	0.30
Final manufactured goods	Paper and printed products	Paper for printing	0.45
Final manufactured goods	Paper and printed products	Packing and wrapping paper in rolls or sheets	0.67
Final manufactured goods	Paper and printed products	Sacks and bags of paper	0.80
Final manufactured goods	Paper and printed products	Corrugated cardboard boxes	2.49
Final manufactured goods	Paper and printed products	Toilet paper	0.35
Final manufactured goods	Paper and printed products	Disposable nappies for babies	0.43
Final manufactured goods	Paper and printed products	Plain cut paper	0.50
Final manufactured goods	Paper and printed products	Books	1.87
Final manufactured goods	Paper and printed products	Newspapers	0.55
Final manufactured goods	Paper and printed products	Magazines	0.80
Final manufactured goods	Paper and printed products	Printed stationary	0.78
Final manufactured goods	Other wood products	Prefabricated buildings	0.33
Final manufactured goods	Petrol	Petrol	5.51
Final manufactured goods	Diesel	Diesel	3.45
Final manufactured goods	Other	Charcoal	0.08
Final manufactured goods	Other	Jet fuel	0.43
Final manufactured goods	Other	Engine oils	0.51
Final manufactured goods	Other	LPG gases	0.21
Final manufactured goods	Other	Petroleum gases or gaseous hydrocarbons	0.18
Final manufactured goods	Other	Lubricating preparations	0.09
Final manufactured goods	Other	Pre-mixed asphalt	0.11
Final manufactured goods	Other	Bituminous mixtures	0.16
Final manufactured goods	Chemical products	Radioactive elements and compounds (uranium)	0.08
Final manufactured goods	Chemical products	Organic fertilisers	0.38
Final manufactured goods	Chemical products	Mixed fertilisers	0.15
Final manufactured goods	Chemical products	Herbicide	0.34
Final manufactured goods	Chemical products	Paints	0.99

PPI Index (table)	Sector	Product	2016 Weights
Final manufactured goods	Chemical products	Provitamins, vitamins, hormones and antibiotics	1.11
Final manufactured goods	Chemical products	Antiviral and retroviral drugs	0.65
Final manufactured goods	Chemical products	Cold and 'flu preparations	0.18
Final manufactured goods	Chemical products	Anti-inflammatories	0.31
Final manufactured goods	Chemical products	Non-narcotic analgesics	0.25
Final manufactured goods	Chemical products	Expectorants	0.14
Final manufactured goods	Chemical products	Laundry bars and tablets	0.36
Final manufactured goods	Chemical products	Washing powder	0.58
Final manufactured goods	Chemical products	Lotions and creams	0.91
Final manufactured goods	Chemical products	Perfumes and deodorant	0.22
Final manufactured goods	Chemical products	Prepared explosives	1.06
Final manufactured goods	Chemical products	Water and pool treatment chemicals	0.40
Final manufactured goods	Chemical products	Synthetic fibres – polyester	0.01
Final manufactured goods	Rubber and plastic products	Tyres	1.09
Final manufactured goods	Rubber and plastic products	Motor vehicle parts and components of plastic	0.26
Final manufactured goods	Rubber and plastic products	Industrial mouldings of plastic	0.22
Final manufactured goods	Rubber and plastic products	Stationery goods of plastic	0.16
Final manufactured goods	Non-metallic mineral products	Refractory bricks and shapes	0.40
Final manufactured goods	Non-metallic mineral products	Clay bricks	0.47
Final manufactured goods	Non-metallic mineral products	Ceramic tiles	0.30
Final manufactured goods	Non-metallic mineral products	Cement	1.10
Final manufactured goods	Non-metallic mineral products	Ready-mix concrete	0.70
Final manufactured goods	Non-metallic mineral products	Roof tiles	0.16
Final manufactured goods	Non-metallic mineral products	Cement or concrete bricks	0.37
Final manufactured goods	Non-metallic mineral products	Concrete pipes	0.09
Final manufactured goods	Non-metallic mineral products	Prefabricated cement and concrete components	0.26
Final manufactured goods	Non-metallic mineral products	Abrasive tools	0.13
Final manufactured goods	Structural and fabricated metal products	Steel window frames	0.12
Final manufactured goods	Structural and fabricated metal products	Aluminium door and window frames	0.15
Final manufactured goods	Structural and fabricated metal products	Roof sheeting	1.08

PPI Index (table)	Sector	Product	2016 Weights
Final manufactured goods	Structural and fabricated metal products	Reservoirs, tanks, vats and similar containers of iron, steel or aluminium	0.36
Final manufactured goods	Structural and fabricated metal products	Cans	1.52
Final manufactured goods	Structural and fabricated metal products	Wire	2.37
Final manufactured goods	Structural and fabricated metal products	Locks and padlocks, clasps, keys and parts thereof of base metal	0.82
Final manufactured goods	Structural and fabricated metal products	Ventilation, ducting, booths, hoods of base metal	0.50
Final manufactured goods	General- and special-purpose machinery	Engines for motor vehicles	0.10
Final manufactured goods	General- and special-purpose machinery	Hydraulic linear acting power engines and motors, and parts thereof	0.23
Final manufactured goods	General- and special-purpose machinery	Pumps	0.59
Final manufactured goods	General- and special-purpose machinery	Taps, cocks and valves	0.29
Final manufactured goods	General- and special-purpose machinery	Heating and cooling systems	0.97
Final manufactured goods	General- and special-purpose machinery	Commercial and industrial refrigerating and freezing equipment	0.29
Final manufactured goods	General- and special-purpose machinery	Filtering or purifying machinery and apparatus (except for air or engines)	0.37
Final manufactured goods	General- and special-purpose machinery	Mining, quarrying and construction machinery and parts thereof	2.66
Final manufactured goods	General- and special-purpose machinery	Munition, ammunitions and cartridges	1.47
Final manufactured goods	Household appliances and office machinery	Fridge-freezer	0.15
Final manufactured goods	Household appliances and office machinery	Geysers	0.16
Final manufactured goods	Household appliances and office machinery	Stoves and ovens	0.12
Final manufactured goods	Household appliances and office machinery	Computers	0.57
Final manufactured goods	Electrical machinery and apparatus, and subcomponents	Electric motors	0.04
Final manufactured goods	Electrical machinery and apparatus, and subcomponents	Generator sets	0.06
Final manufactured goods	Electrical machinery and apparatus, and subcomponents	Power transformers	0.14

PPI Index (table)	Sector	Product	2016 Weights
Final manufactured goods	Electrical machinery and apparatus, and subcomponents	Electricity distribution and control equipment	0.64
Final manufactured goods	Electrical machinery and apparatus, and subcomponents	Automotive wire cables	0.66
Final manufactured goods	Electrical machinery and apparatus, and subcomponents	Electrical conductors	0.16
Final manufactured goods	Electrical machinery and apparatus, and subcomponents	Batteries	0.18
Final manufactured goods	Electrical machinery and apparatus, and subcomponents	Electric lighting equipment	0.13
Final manufactured goods	Motor vehicles	Passenger vehicles	2.35
Final manufactured goods	Motor vehicles	Bakkies and vans not exceeding 3.5 tons	0.94
Final manufactured goods	Motor vehicles	Lorries, trucks and vans exceeding 3.5 tons	0.29
Final manufactured goods	Bodies for motor vehicles	Bodies for motor vehicles	0.15
Final manufactured goods	Bodies for motor vehicles	Drawbar trailers	0.37
Final manufactured goods	Bodies for motor vehicles	Tipper, tanker and trailer parts	0.12
Final manufactured goods	Parts and accessories for motor vehicles and their engines	Filters for engines	0.19
Final manufactured goods	Parts and accessories for motor vehicles and their engines	Catalytic convertors	1.26
Final manufactured goods	Parts and accessories for motor vehicles and their engines	Silencers and exhaust pipes	1.23
Final manufactured goods	Parts and accessories for motor vehicles and their engines	Complete radiators for motor vehicles	0.14
Final manufactured goods	Parts and accessories for motor vehicles and their engines	Suspension, brakes, clutch, mountings and parts	0.30
Final manufactured goods	Parts and accessories for motor vehicles and their engines	Seats for motor vehicles	0.91
Final manufactured goods	Furniture and other manufacturing	Furniture	0.01
Final manufactured goods	Furniture and other manufacturing	Mattresses	1.26
Final manufactured goods	Furniture and other manufacturing	Precious or semi-precious stones	0.26
Final manufactured goods	Furniture and other manufacturing	Gold jewellery	0.13
Final manufactured goods	Furniture and other manufacturing	Brooms and mops	0.11
Final manufactured goods	Furniture and other manufacturing	Number plates and signs	0.32
			100.00
Intermediate manufactured goods	Textiles and leather goods	Synthetic fibres	0.85
Intermediate manufactured goods	Textiles and leather goods	Woven cotton fabrics	1.55
Intermediate manufactured goods	Textiles and leather goods	Synthetic woven fabrics	2.02
Intermediate manufactured goods	Textiles and leather goods	Carpets (excluding mats and rugs)	0.94
Intermediate manufactured goods	Textiles and leather goods	Knitted or crocheted fabrics	0.30

PPI Index (table)	Sector	Product	2016 Weights
Intermediate manufactured goods	Textiles and leather goods	Tanned or dressed leather	3.73
Intermediate manufactured goods	Basic and other chemicals	Basic organic chemicals	4.25
Intermediate manufactured goods	Basic and other chemicals	Basic inorganic chemicals	3.94
Intermediate manufactured goods	Plastic products	Ethylene polymers and copolymers (PET)	3.08
Intermediate manufactured goods	Plastic products	Polyethylene	4.06
Intermediate manufactured goods	Plastic products	Vinyl chloride polymers (PVC) and copolymers	1.10
Intermediate manufactured goods	Plastic products	Polyurethane	0.38
Intermediate manufactured goods	Plastic products	Plastic pipes, tubes and fittings	4.94
Intermediate manufactured goods	Plastic products	Plastic bags	2.96
Intermediate manufactured goods	Plastic products	Plastic containers	3.61
Intermediate manufactured goods	Rubber products	Synthetic rubber	0.75
Intermediate manufactured goods	Rubber products	Unvulcanised compounded rubber	0.71
Intermediate manufactured goods	Rubber products	Conveyor belts or belting	0.75
Intermediate manufactured goods	Rubber products	Industrial rubber products	0.66
Intermediate manufactured goods	Sawmilling and wood	Untreated logs and structural timber	2.78
Intermediate manufactured goods	Sawmilling and wood	Wood in chips or particles	2.72
Intermediate manufactured goods	Sawmilling and wood	Treated logs and structural timber	2.46
Intermediate manufactured goods	Sawmilling and wood	Transmission and telephone poles	1.61
Intermediate manufactured goods	Sawmilling and wood	Boards of wood	4.12
Intermediate manufactured goods	Sawmilling and wood	Builder's carpentry of wood	6.49
Intermediate manufactured goods	Sawmilling and wood	Pallets and other load boards	0.95
Intermediate manufactured goods	Glass and glass products	Safety glass	0.71
Intermediate manufactured goods	Glass and glass products	Fibre glass	1.23
Intermediate manufactured goods	Glass and glass products	Glass containers	2.07
Intermediate manufactured goods	Basic iron and steel	Ferro-manganese	0.70
Intermediate manufactured goods	Basic iron and steel	Ferro-chromium alloy	2.06
Intermediate manufactured goods	Basic iron and steel	Flat rolled non-alloy steel products	6.74
Intermediate manufactured goods	Basic iron and steel	Flat rolled stainless steel products	3.42
Intermediate manufactured goods	Basic iron and steel	Bars and rods of iron or steel	1.80

PPI Index (table)	Sector	Product	2016 Weights
Intermediate manufactured goods	Basic iron and steel	Angles, shapes, sections and similar products of iron or steel	1.10
Intermediate manufactured goods	Basic precious and non-ferrous metals	Semi-finished products and ingots of iron and steel	1.22
Intermediate manufactured goods	Basic precious and non-ferrous metals	Unwrought or semi-manufactured gold	1.40
Intermediate manufactured goods	Basic precious and non-ferrous metals	Unwrought or semi-manufactured platinum	6.89
Intermediate manufactured goods	Basic precious and non-ferrous metals	Unwrought aluminium	1.41
Intermediate manufactured goods	Basic precious and non-ferrous metals	Aluminium products	0.76
Intermediate manufactured goods	Basic precious and non-ferrous metals	Manganese metal (electrolytic manganese)	3.33
Intermediate manufactured goods	Recycling and manufacturing n.e.c.	Metal waste and scrap	3.46
			100.00
Electricity and water	Electricity	Electricity	85.11
Electricity and water	Water	Processed water	9.64
Electricity and water	Water	Raw water	5.25
			100.00
Mining	Coal and gas	Coal	23.40
Mining	Coal and gas	Natural gas	1.76
Mining	Coal and gas	Natural gas condensate	0.81
Mining	Gold and other metal ores	Haematite	14.57
Mining	Gold and other metal ores	Gold	19.26
Mining	Non-ferrous metal ores	Chromite – less than 44% Cr_2O_3	1.81
Mining	Non-ferrous metal ores	Chromite – 44% to 48% Cr_2O_3	0.58
Mining	Non-ferrous metal ores	Metallic copper	1.06
Mining	Non-ferrous metal ores	Nickel	4.80
Mining	Non-ferrous metal ores	Platinum	15.16
Mining	Non-ferrous metal ores	Rhodium	1.58
Mining	Non-ferrous metal ores	Palladium	5.11
Mining	Non-ferrous metal ores	Metallurgical manganese	2.61
Mining	Stone quarrying, clay and diamonds	Aggregate stones	1.37
Mining	Stone quarrying, clay and diamonds	Andalusite	1.26
Mining	Stone quarrying, clay and diamonds	Phosphate concentrate	1.62
Mining	Stone quarrying, clay and diamonds	Gem diamonds	1.44
Mining	Stone quarrying, clay and diamonds	Industrial diamonds	1.82
			100.00

PPI Index (table)	Sector	Product	2016 Weights
Agriculture, forestry and fishing	Cereals and other crops	Wheat	2.52
Agriculture, forestry and fishing	Cereals and other crops	Maize	13.36
Agriculture, forestry and fishing	Cereals and other crops	Sunflower seed	1.80
Agriculture, forestry and fishing	Cereals and other crops	Sugar cane	3.26
Agriculture, forestry and fishing	Fruit and vegetables (Agriculture)	Tomatoes	1.53
Agriculture, forestry and fishing	Fruit and vegetables (Agriculture)	Onions	1.07
Agriculture, forestry and fishing	Fruit and vegetables (Agriculture)	Bananas	1.68
Agriculture, forestry and fishing	Fruit and vegetables (Agriculture)	Lemons and limes	1.36
Agriculture, forestry and fishing	Fruit and vegetables (Agriculture)	Oranges	6.46
Agriculture, forestry and fishing	Fruit and vegetables (Agriculture)	Grapes	2.21
Agriculture, forestry and fishing	Fruit and vegetables (Agriculture)	Apples	5.01
Agriculture, forestry and fishing	Fruit and vegetables (Agriculture)	Potatoes	3.97
Agriculture, forestry and fishing	Live animals	Cattle	10.75
Agriculture, forestry and fishing	Live animals	Sheep	2.52
Agriculture, forestry and fishing	Live animals	Pigs	1.98
Agriculture, forestry and fishing	Live animals	Poultry	14.72
Agriculture, forestry and fishing	Milk and eggs	Raw milk	5.99
Agriculture, forestry and fishing	Milk and eggs	Eggs	3.97
Agriculture, forestry and fishing	Other animal products	Wool	1.33
Agriculture, forestry and fishing	Forestry	Sawn and planted timber – softwood	8.60
Agriculture, forestry and fishing	Forestry	Sawn and planted timber – hardwood	1.36
Agriculture, forestry and fishing	Fishing	Hake	3.35
Agriculture, forestry and fishing	Fishing	Small pelagic (e.g. anchovies and pilchards)	0.57
Agriculture, forestry and fishing	Fishing	Rock lobster	0.30
Agriculture, forestry and fishing	Fishing	Squid	0.34
			100.00

Source: Statistics South Africa

APPENDIX 6 INTERVIEW GUIDE

SOCIO-ECONOMIC IMPACT OF PHASE 1 OF CARBON BUDGETS STUDY INTERVIEW GUIDE

This interview guide forms part of a project to assess the socioeconomic impact of Phase 1 Carbon Budgets. The project is being undertaken by DNA Economics (http://www.dnaeconomics.com) on behalf of the Department of Environmental Affairs (DEA) and is funded by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). If you have any questions regarding the project, please contact Brent Cloete (the project manager at DNA Economics) [brent.cloete@dnaeconomics.com | 012 362 0025 | 084 987 4460] or Mactavish Makwarela (DEA: Director – Climate Change: Transport Mitigation) [MAMakwarela@environment.gov.za | 012 399 9163 | 083 656 0428].

Any information provided will be treated as strictly confidential and will only be shared with the DEA. This interview guide is intended to guide an interview with a member of the project (study) team, and to allow you an opportunity to prepare for the interview. Please feel free to raise any issue that you think is relevant to this study, but that is not covered by the interview guide.

The project team thanks you for your assistance.

INTERVIEW GUIDE

1. General questions

1.1. What products do you sell (please also provide SIC codes)? What was the rand value of your output per SIC code last year? (25% market share blocks if sensitive)	
1.2. Where would you consider your main markets to be (local and international)?	
1.3. What proportion of your output (products) do you export?	
1.4. What percentage of your local markets (for each product you sell) is served by imports?	
1.5. What compliance mechanism do you expect to be linked to mandatory carbon budgets in the next phase(s)? Do you have any expectations in terms of the costs these compliance measures?	

2. Allocation Process

2.1. Please comment on the process followed to agree a carbon budget with the DEA. (i.e. please mention what you want to be done differently during the allocation of the carbon budget in the next phase; whether there were any issues/ approaches you did not agree with; what worked well; etc.) [Did you include Scope 2 emissions in your target?]	
2.2. Please expand on any issues encountered.	
2.3. Given your response above, what implications do you think each of the issues you mentioned had on the overall allocation process? (e.g. it took longer than necessary to agree on the carbon budgets because we could not find common time slots to engage with DEA, it was less costly for us to calculate our baseline because the DEA provided clear guidelines, etc.)	
2.4. How much did the allocation process cost you in terms of time and other expenses (emissions verifications/reporting/ etc.)?	

2.5. Does the carbon budget you company agreed with the DEA reflect a clear understanding of your market (or sector/sub-sector)? Please explain your answer.	
2.6. Do you have any proposals on how the carbon budget allocation process can be improved that have not been addressed during this interview?	

3. Administration of carbon budgets

3.1. Is your company required to report its GHG emissions in terms of the National Greenhouse Gas Emission Reporting Regulations?	
3.2. Is your company required to prepare and submit a Pollution Prevention Plan in terms of the National Pollution Prevention Plans Regulations?	
3.3. Has the requirement to develop Pollution Prevention Plans created (or will it create) any additional GHG emissions reporting requirements for your company? How costly is it to comply with these requirements?	
3.4. Have you placed (or will you be placing) any new systems in place to be able to complete annual Pollution Prevention Plans? If so, how costly was it (or will) it be) to put these systems in place?	
3.5. Are you planning to put any new systems in place to report in terms of your progress in remaining within your carbon budget? If so, how will it cost your company to put these systems in place?	
3.6. Do you foresee any additional reporting or process requirements as a result of the next (mandatory) phase of carbon budgets?	
3.7. Do you have any proposals on how the administration of carbon budgets can be improved during the next phase?	

4 Adherence to carbon budgets

4.1. Do you think your company can realistically remain within your carbon budget without undertaking any intentional mitigation action?	
4.2. Do you think your company can realistically remain within your carbon budget without undertaking any mitigation action you were not planning before you agreed on your carbon budget?	
4.3. Will your company be aiming to remain within your carbon budget (i.e. do you see any reputation or other risks to not complying with your carbon budget)?	
4.4. If you answered YES to Question 4.3, how firm is your company's commitment to remaining within your carbon budget (i.e. what policies, procedures or guidance have been created to ensure you remain within the carbon budget)?	
4.5. Does this commitment include sticking to the mitigation actions and timing outlined (or to be outlined) in your Pollution Prevention Plan, or does your company reserve the right to vary activities based on economic conditions?	
4.6. Is your company likely to have a different approach to any of Question 4.3, Question 4.4 or Question 4.5 during the next (mandatory) phase of carbon budgets?	

5. Mitigation Actions due to Carbon Budgets

5.1. Do you plan to implement any mitigation action(s) directly as a result of the Phase 1 Carbon Budgets (i.e. are you planning on undertaking mitigation actions you would not have undertaken in the absence of the carbon budgets, or would only have undertaken later)? (YES / NO)

5.2. If you have answered YES to Question 5.1, please complete the information below for all the mitigation actions your company would not have undertaken in the absence of carbon budgets. [Please provide information in a separate spreadsheet if more than 4 mitigation actions are relevant.]

	Mitigation actions that will be implemented directly as a result of Phase 1 of Carbon Budgets			
Name of mitigation action:	**1)**	**2)**	**3)**	**4)**
Description:				
Source of emissions impacted?				
Which products are impacted? [Please provide SIC code if not already provided in response to Question 1.1.]				
Annual expected emission reduction as a % of company's total reduction in GHG emissions as a result of intentional mitigation action.				
Impact of mitigation action on Electricity cost (expressed in Rand or percentage of total electricity cost).				
Impact of mitigation action on fuel demand– (expressed in Rand or percentage of total fuel cost).Please provide your answer per type of fuel: • Coal • Biomass • Wood or wood products • Coke and refined petroleum products • Gas or steam • Other – please specify				
Impact on other inputs. (Expressed in Rand or percentage of total cost for each type of input).				
Any other increases or savings in operational costs not already captured.				
Expected implementation date.				
Most likely year when option will be fully implemented.				
Has the expected implementation date of this mitigation action changed as a result of the carbon budgets?				
Labour requirements of mitigation action (Rand value).				
Skill level of required labour.	Unskilled %:,semi-skilled %:, skilled%:	Unskilled %:,semi-skilled %:, skilled%:	Unskilled %:,semi-skilled %:, skilled%:	Unskilled %:,semi-skilled %:, skilled%:
Number of jobs expected to be created as a result on implementation of the mitigation actions.	Unskilled %:,semi-skilled %:, skilled%:	Unskilled %:,semi-skilled %:, skilled%:	Unskilled %:,semi-skilled %:, skilled%:	Unskilled %:,semi-skilled %:, skilled%:

	Mitigation actions that will be implemented directly as a result of Phase 1 of Carbon Budgets			
Name of mitigation action:	**1)**	**2)**	**3)**	**4)**
Description:				
Source of emissions impacted?				
Number of jobs expected to be lost as a result on implementation of the mitigation actions.	Unskilled %:,semi-skilled %:, skilled%:	Unskilled %:,semi-skilled %:, skilled%:	Unskilled %:,semi-skilled %:, skilled%:	Unskilled %:,semi-skilled %:, skilled%:
Location of mitigation action.				
Capital cost of investment – please indicate in what years (roughly) the capital expenditure will happen.				
How will the mitigation action be financed?				
Impact on fixed cost per annum.				
Impact on variable cost (per Rand of output).				
If impact on variable cost is not per Rand of output, please specify unit in this row.				
How much do you expect the sales price of the products your company sells to increase as a result of this mitigation action?				
Impact of mitigation action on the efficiency of you production process – expressed as a percentage. (Please mention if it is improvement or reduction)				
Probability that mitigation action will be implemented (0%–100%).				

5.3. Is your company planning on undertaking any mitigation actions not mentioned in the table above to meet its carbon budget (i.e. changing output levels or product mix, changing investment plans, moving production activities, etc.? If so, please explain.	
5.4. Has the carbon budgets had any impact on mitigation action at your company not captured by the two blocks above (i.e. prioritised mitigation actions that impact emissions covered by the carbon budget relative to mitigation actions that reduce Scope 2 emissions, for example, or changed the order in which mitigation actions are to be implemented?)	

6. Additional information on impact of mitigation actions

6.1. Do you expect an impact on your company's competitiveness in domestic or foreign markets by the current phase of carbon budgets? What about the next (mandatory) phase?	
6.2. Do you anticipate any of your suppliers taking part in Phase 1 Carbon Budgets, do you foresee any impact on the price of goods/services you procure from these suppliers (please specify inputs and the percentage increase in price you expect)?	

6.3. Do you foresee any other increases in your company's costs due to other companies participating in Phase 1 Carbon Budgets (i.e. energy/inputs)? If so, how?	
6.4. Do you foresee any of your answers to Questions 6.1, 6.2 or 6.3 to change when the carbon budgets move into the next (mandatory) phase?	

7. Additional Considerations

7.1. Do you anticipate any benefits from adhering to Phase 1 Carbon Budgets (i.e. reputation; share price; lending conditions)? If so, what are the benefits?	
7.2. How do you expect Carbon Budgets to affect your sector or the economy more broadly? Please consider both the current (voluntary) and future (mandatory) phases.	
7.3. Will carbon budgets affect your company's decisions to invest in/expand your current operations? How do you expect Carbon Budgets to affect your sector or the economy more broadly? Please consider both the current (voluntary) and future (mandatory) phases.	
7.4. Will carbon budgets affect your company's decisions to invest in new activities or sectors where your company is not currently operating? How do you expect Carbon Budgets to affect your sector or the economy more broadly? Please consider both the current (voluntary) and future (mandatory) phases.	
7.5. How should new entrants into your sector be dealt with under the current and future phases of carbon budgets?	
7.6. Do you have any other concerns or opinions on carbon budgets that have not been addressed?	
7.7. Do you have any suggestions regarding social or economic issues that need to be addressed before the next carbon budgeting phase?	

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