energy
Department:
Energy
REPUBLIC OF SOUTH AFRICA

Development of post-2015 National Energy Efficiency Strategy, Targets, Measures and Implementation Plan

Costs and benefits of proposed policy measures

Deliverable 3 (D3)

Final Version 26th March 2016

Danish Energy Management
A part of Danish Management Group

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STRATEGIC ENVIRONMENTAL FOCUS

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Version no.	Submitted date	Purpose/ Changes	Submitted to
Rev Draft	10th February 2016	First draft for review by the Project Steering Committee	Department of Energy
Final	26th March 2016	Final draft incorporating comments from PSC and informal consultations	Department of Energy

1 INTRODUCTION

1.1 Background and purpose

As part of the process of developing the post-2015 National Energy Efficiency Strategy for South Africa, it is necessary to understand the implications of implementing policies and measures that will improve energy efficiency. A full and detailed cost benefit analysis of each individual policy measure is beyond the scope of this study, and if fact would be inappropriate at the development stage of the post-2015 National Energy Efficiency Strategy (NEES). A full analysis would be undertaken as part of the regulatory impact assessment process, which is the formal process that occurs when a decision has been made to proceed further with a particular measure and its preliminary design parameters have been decided upon.

Instead, the purpose of this document is to describe and, where possible, make approximate quantitative estimates of the likely costs and benefits associated with the implementation of packages of policy measures that have been identified in the Potential Energy Efficiency Measures report that accompanies this report. This is intended to assist in the consultative process of prioritisation as NEES development proceeds, as well as providing a foundation on which to build a more comprehensive and detailed analysis of policy measures during the implementation phase of the NEES.

1.2 Methodology

1.2.1 Taxonomy of costs and benefits

Both the costs and the benefits of policy measures may be classified according to at least three different criteria:

1.2.1.1 Private versus public / social

Private costs and benefits of an energy efficiency policy measure are those that are borne by, or accrue to, a private individual or company. Generally, this will be the entity that takes the energy saving action in response to the policy measure. The largest private benefit will almost always be the value of the energy savings themselves, while the largest private cost would generally be the capital investment necessary to realise the energy savings. Other private benefits may include improvements in product quality, improvements in working environments or reductions in maintenance costs.

Public / social costs and benefits are those that are borne by, or accrue to, wider society. Where a public body undertakes an energy saving investment in response to a policy measure, then the capital investment and the energy savings that result are likely to be the largest public cost and benefit. If the entity that takes an energy saving action in response to a policy measure is a private individual or firm, then the largest public cost would generally be the administrative cost of implementing and monitoring the policy measure.

1.2.1.2 Direct versus indirect

In every case described in this report, the direct benefit is assumed to be the amount of energy saving (relative to a business as usual baseline) that results from the policy measure under examination. The direct cost is the cost to the public purse of the policy measure, which usually takes the form of an administrative cost but may also include financial incentives provided by government.

Indirect costs and benefits may also occur. Indirect costs are those borne by players that do not participate in the policy measure itself, or which arise as a secondary consequence of the changes brought about by the policy measure. Indirect benefits (referred to here as multiple benefits[1]) are benefits other than those associated with the amount of energy saved. Only those that are specific to the policy measure under consideration are included, so benefits such as increased energy security are not considered, since these are common to all policy measures that result in a particular energy saving.

1.2.1.3 Quantifiable versus unquantifiable

These terms are self-explanatory. However, it is worth noting that many costs and benefits that are quantifiable in principle may prove to be unquantifiable in practice because the cost and effort required to obtain the necessary data may prove prohibitive.

1.2.2 Which costs, which benefits to include?

When analysing the costs and benefits of any proposed action, it is important to be clear and consistent about which costs and benefits should be considered. A private firm will generally only undertake an energy saving action if it has a positive net present value (NPV) at some test discount rate (i.e. if the present value of the private benefits accruing to the firm exceeds the present value of the private costs incurred). When assessing the costs and benefits of policy measures, the focus shifts to the public / social costs and benefits.

In fact, where a policy measure is aimed at removing a market barrier that is inhibiting a private individual or firm from undertaking an energy saving action that brings them a net benefit, it may be inappropriate to consider private costs and benefits when evaluating the policy measure. This is because there is a danger that, if private costs and benefits are taken into account, policy measures that effectively result in a large transfer payment from the public to the private sector may appear unrealistically attractive. To illustrate this, consider two alternative hypothetical policy measures:

> '**Policy Measure A**' costs R1 million of public funds, and results in firms in the industry sector implementing energy efficiency improvements that save 10 TJ of energy annually. However, the improvements undertaken are only marginally profitable from the firms' perspective, having a total NPV (at a standard discount rate) of only R2 million.
> '**Policy Measure B**' also costs R1 million of public funds, but only results in 5 TJ of savings in the industry sector. However, the improvements undertaken as a result of this policy measure are very cost-effective, and also yield significant additional multiple benefits, such that the total NPV to the firms is R5 million.

If these options are evaluated by comparing <u>all</u> costs and benefits (both private and public), Policy Measure B appears more attractive, since it has an overall NPV of R4 million (compared with only R1 million for Policy Measure A). But in terms of the energy saving stimulated per unit of public spend, Policy Measure A is better by a factor of 2.

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1 This is consistent with the preferred terminology of the International Energy Agency

Taking this argument to its extreme, it is possible to imagine a scenario where the government pays a huge sum of money to a private firm in order to incentivise it to change a single light bulb. Because this is a straight transfer payment, if we include all costs and benefits in the equation, the cost to the government and the benefit to the private firm of the incentive payment cancel each other out. The net cost is therefore simply the cost of the new light bulb, so the policy measure appears to be very cost-effective.

A more rational way to evaluate policy measures is therefore to conduct a cost-effectiveness analysis, to determine the net *public* cost per unit of energy saved regardless of whether the energy saving is made by a private or public entity. If there are any public multiple benefits, these would be offset against the public costs in order to determine the net public cost, but private multiple benefits would not be included, for the reasons outlined above. However, if the policy measure in question imposes obligatory rather than discretionary costs on private firms or individuals (e.g. the cost of an additional tax or of mandatory compliance with a regulation), these should be taken into account in assessing cost-effectiveness.

Note that there are several types of multiple benefits that are directly linked to the volume of energy saving achieved, and which are therefore common to any policy measure that aims to save energy. These do not affect the *relative* cost-effectiveness of different policy measures, and so do not need to be included in cost-effectiveness calculations. Examples include the value of greenhouse gas emission reductions, increased tax revenues from higher company profits as a result of reduced energy costs, increased energy security.

1.2.3 Synergies, rebound and free riders

Three effects (synergy, rebound and free-riders) may add to the complexity of estimating the effects of energy saving policy measures. Attempting to quantify any of these effects is beyond the scope of this report, but their existence has been noted and commented on where appropriate in the analysis in Sections 2 to 8. The effects may be briefly summarised as follows:

1.2.3.1 Synergies

The benefits of an energy efficiency policy measure cannot be quantified accurately in isolation, as they may be either magnified or diminished due to interactions with other policy measures in place. This is illustrated in Figure 1, where two barriers exist to prevent the full energy savings potential from being realised – low awareness and high first cost.

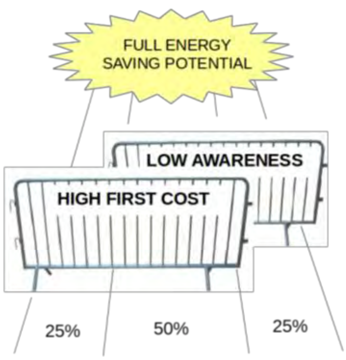

Illustration of synergies between policy measures for removing specific barriers

Policy measures that remove either barrier in isolation will only allow 25% of the potential to be realised, but by removing both simultaneously, the full potential can be achieved. Hence attempting to assess the cost-effectiveness of either policy measure in isolation makes little sense.

1.2.3.2 Free-riders

A certain amount of improvement in energy efficiency may be expected even in the absence of any policy measures. For any measure that provides an incentive to change, there are therefore likely to be some 'free-riders' who benefit from the measure even though they were going to change anyway. Note that the free-rider phenomenon may also be partial – where an incentive offered was responsible for change, but a smaller incentive would have achieved the same result.

1.2.3.3 Rebound

Improvements in energy efficiency may sometimes lead to the energy user taking the benefit in the form of an increased energy service level, rather than a reduction in energy consumption. This may be common in the residential sector where there is suppressed demand – for example, a household acquiring more efficient lighting may choose to increase the light levels around the home, resulting in little if any energy saving. From a pure cost-benefit perspective, this rebound effect makes little difference since it can be argued that the benefit of the increased lighting levels is 'worth' the same as the energy that would have been saved in the absence of rebound. However, the phenomenon adds to the difficulty in estimating the effects on energy consumption of a particular measure.

1.2.4 Data sources

It is beyond the scope of this study to attempt to generate new data. Data on population, economic growth and other demographic and macroeconomic indicators was obtained from Statistics South Africa. Other data has been obtained from a range of sources, including:

- official reports on South African energy savings initiatives
- other South Africa based studies
- official reports and studies from other countries
- academic literature
- grey literature / trade journals

All sources used are listed in the References section at the end of the report.

1.2.5 Timing of policy measure impacts

It is expected that the final post-2015 Energy Efficiency Strategy will include interim targets for 2020 and 2025, in addition to the final 2030 energy savings targets. Where possible, therefore, the estimated energy savings provided for each policy measure examined have been given for each of these interim years. However, in some cases this has not been possible due to the limited scope of this study and the paucity of solid data on which to base estimates. Where interim dates are not mentioned, the energy savings and cost estimates given are for the final year of the strategy period, 2030.

2 CROSS-SECTORAL MEASURES

2.1 Carbon tax

Although a carbon tax is not an energy efficiency measure as such, and does not form a part of the set of policy measures proposed for the post-2015 NEES, much of its impact is likely to arise from the improvements in energy efficiency that it stimulates. The existence of a carbon tax (which is likely to be in place from very early in the period that the NEES covers) is therefore an important element of the overall context within which the NEES policy measures will be implemented. It is therefore instructive to examine the likely impacts of a carbon tax on energy efficiency, and consider its cost-effectiveness at stimulating changes in efficiency in relation to other measures.

2.1.1 Description

The detailed design of a carbon tax has been developed after several years of studies and consultation, with a draft bill being published for public comment in November 2015. The tax, planned for introduction in 2016, would be set at an initial rate of R120 per tonne of CO_2 equivalent (tCO_2e), increasing by 10% each year until 2020. Initially, a range of tax-free thresholds and exemptions will be available, meaning that the actual rates paid will vary from R6-48/tCO_2e (National Treasury, 2015). The thresholds and exemptions are expected to remain in place until 2020, but may then be reduced. The actual rate paid by 2030 may therefore be as high as R176/tCO_2e (assuming no further increases to the base rate are made).

2.1.2 Estimated energy savings

As part of the process of developing the detailed design of a carbon tax, the National Treasury has carried out and commissioned a number of studies to assess its likely impact[2]. Since the main purpose of the carbon tax is to reduce greenhouse gas emissions, these studies have presented their results in terms of carbon savings rather than energy savings. However, the energy savings expected to result from a carbon tax may be inferred from these modelled carbon savings by using price elasticities of demand for different energy carriers combined with their relative prices and carbon intensities.

Table 1 below shows the price increase per GJ that a rate of R176/tCO_2e equates to, for a range of energy carriers, using standard emission factors. The table also indicates the approximate current price of each energy carrier. Price elasticities of demand for different energy carriers were obtained from the literature, using values specific to South Africa where available, but relying on estimates from other countries where necessary. These elasticities are presented in Table 2 below.

Modelling studies conducted for the National Treasury (Alton T. *et al*., 2012 and Alton T. *et al*., 2014) indicate that a carbon tax of R176/tCO_2e would lead to a CO_2 saving of about 24%. Using the data in Table 1 and Table 2 below, it can be inferred that this level of CO_2 saving equates to a reduction in final energy consumption of about 16%[3].

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2 See for example Alton T. *et al*. (2012), Lozynskyy Y. *et al*. (2014), Hood C. and Guelff C. (2013), National Treasury (2010), Alton T. *et al*. (2014).

3 Author's own calculations

Table 1 Impact on price of a carbon tax of R176/tCO_2e for a range of energy carriers

Energy carrier	Impact on price (R/GJ)	Current price (R/GJ)	% increase
Electricity	46 (= R165/MWh)	Manufacturing: 139 Mining: 174 Commercial: 222 Residential: 248 Agriculture: 292	Manufacturing: 33% Mining: 26% Commercial: 21% Residential: 19% Agriculture: 16%
Coal	17	50	34%
Diesel	13	283	4.6%
Petrol	13	334	3.9%
Natural gas	8	120	6.7%
Paraffin	13	220	5.9%
LPG	11	174	6.3%

Sources: Lozynskyy Y. *et al*. (2014), Department of Energy Annual Energy Price Reports

Table 2 Long-term price elasticity of demand for a range of energy carriers

Energy carrier	Price elasticity	Notes	Source
Electricity	-0.87	South Africa manufacturing sector only (results for other sectors not statistically significant)	Inglesi-Lotz & Blignaut (2011)
Coal	-0.28	Synthesised from several country studies not including South Africa	Coady *et al.* (2015)
Diesel	-0.20	South Africa	Boshoff (2011), Mullins & Viljoen (2012)
Petrol	-0.50	South Africa	Boshoff (2011), Mullins & Viljoen (2012)
Natural gas	-0.3	Estimated value for USA – no South Africa studies available	Coady *et al.* (2015)
Paraffin	-0.6	Estimated value for Sri Lanka – no South Africa studies available	Athukorala & Wilson (2010)
LPG	-0.4	Estimated value for Spain – no South Africa studies available	Labanderia *et al.* (2006)

However, these estimates are based on an implicit assumption that the carbon intensity of electricity generation remains constant. A more recent modelling study (Arndt *et al.*, 2016) indicates that shifts in the technology mix of power generation in response to a carbon tax mean that the reduction in energy consumption that corresponds to a particular reduction in CO_2 emissions is likely to be much smaller than these estimates suggest. The study by Arndt *et al.* shows a reduction in electricity consumption that remains less than 9% throughout the whole study period, but it is not possible from this study to determine what the overall reduction in total energy consumption would be.

The decrease in energy consumption that results from the introduction of a carbon tax does not equate to an energy *saving*, since it also includes the effects of: (i) reduced energy consumption resulting from a reduction in the overall level of economic activity, as indicated by a fall in GDP; and (ii) reduced energy consumption resulting from changes in the structure of the economy[4]. In order to estimate the true energy savings that a carbon tax leads to, it is necessary to quantify these activity-level and structural effects and subtract them from the overall change in energy consumption.

The results presented in Alton T. *et al*. (2014) suggest that a carbon tax of R176/tCO_2e would result in a reduction in GDP of about 0.45% while Arndt *et al.* (2016) indicate a somewhat smaller

4 Namely, a tendency for less carbon-intensive activities to grow in importance relative to more carbon-intensive activities.

reduction[5]. If economic structure and energy intensity remain unchanged, the percentage change in energy consumption would be approximately the same as these estimates of GDP reduction.

National Treasury models indicate the impacts of a carbon tax on GDP at the sub-sectoral level (Legote, 2012), from which it is possible to calculate the structural effect of the tax. This in turn allows an estimate to be made of the impact on energy consumption of these structural changes. The effects are very small – a reduction in energy consumption of only 0.39% for a R200/tCO_2e tax, and 0.31% for a R100/tCO_2e tax[6] can be attributed to structural effects induced by the carbon tax.

These results indicate that, although a carbon tax will lead to reductions in energy consumption through both a fall in GDP and an adjustment of economic structure, the two effects combined will amount to a change of not more than about 1%. It may therefore be concluded that the 16% fall in energy consumption described above is almost entirely due to reductions in energy intensity, and hence constitutes an energy *saving* of about 15%. As indicated, this should be regarded as an upper estimate, as it does not take account of the likely shift in the electricity generation mix.

Alton T. *et al*. (2012) use an annual GDP growth rate of 3.9% in their model[7], which would result in GDP in 2030 being about 2.15 times higher than in 2010. A business-as-usual projection would therefore give a total final energy consumption in 2030 of about 6,200PJ. The 15% reduction in energy consumption due to improvements in energy intensity stimulated by the proposed carbon tax would therefore equate to energy savings of about 930PJ.

Note that the calculations described above are intended only to give an approximate 'ball park' figure for energy savings, but do not take into account additional complexities arising from different revenue recycling options. In particular, the carbon tax design that has been developed by the National Treasury for introduction in 2016 incorporates revenue-recycling measures designed to offset the otherwise regressive distributional impact of a carbon tax. The model results presented by Alton T. *et al*. (2012) suggest that this type of progressive revenue recycling would increase the negative impact of the tax on GDP. This means that a greater proportion of the resulting reduction in energy consumption will be due to a fall in economic activity, hence a smaller proportion can be classed as genuine energy *savings*. However, this will be offset to some extent by the fact that some elements of the progressive revenue recycling option are themselves energy saving, such as funding for the 12L tax incentive scheme and additional tax relief for rooftop solar PV (National Treasury, 2015).

A further complication arises from the intention to decrease the electricity levy alongside the introduction of the carbon tax, such that the overall effect on the price of electricity will "...in the initial phase, be revenue neutral, and also neutral on the price of electricity" (National Treasury, 2015). Presumably, decreasing the electricity levy to a level of price neutrality will cancel out the overall impact of the carbon tax on electricity demand, although its effect on the demand for non-electrical energy sources would not be directly affected by a reduction in the electricity levy. The

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5 For a carbon tax of $30 per tonne, Arndt *et al.* (2016) indicate a reduction in GDP of 1.0% by 2035, while the corresponding figure in Alton T. *et al*. (2014) is a 1.2% reduction.

6 Author's own calculations

7 Note that this is substantially more conservative than the 5.4% annual growth in GDP envisaged in the National Development Plan

current basic rate of electricity levy is R0.035 per kWh[8] which, based on the emission factor for electricity generation in South Africa, is equivalent to just over R37 per tonne of CO_2. This is within the range of carbon tax levels that are expected to be levied on end-users after thresholds and exemptions have been taken into account. Hence although the carbon tax will *on average* be neutral on the price of electricity, the impact on end-users may range from positive to negative depending on the range of exemptions to which they qualify.

Finally, it should be noted that the profile through time of the energy savings brought about by a carbon tax is likely to be complex. Although a carbon tax is likely to result in reductions in energy consumption from the beginning, in the early years these are more likely to be linked with reductions in output and structural changes, and therefore not true energy savings (although the phased nature of the planned introduction of the tax will serve to minimise these effects). As the economy adjusts through technological shifts and changes in behaviour, the impact on output is likely to diminish and the structural changes will become embedded. The efficiency improvements that will result from a carbon tax are therefore likely to build gradually through the period of the Energy Efficiency Strategy.

2.1.3 Direct cost

An important element of the direct cost of a carbon tax is the administrative cost of operating the tax. Since this policy measure would be administered by the Department for Environmental Affairs and the National Treasury, the associated costs of administration will be borne by those departments, not by the Department of Energy.

No estimates of the direct administrative cost of a carbon tax could be found in the literature, but this is likely to be very small relative to the indirect cost (i.e. the negative impact on GDP – see next section). It is widely accepted that levying environmental tax 'upstream' on the supply of fossil fuels, rather than 'downstream' at the point of use, is administratively much simpler[9]. This administrative simplicity comes at the cost of reduced precision (OECD, 2008), but the precise measurement of emissions at the point of use brings less benefit in the case of CO_2 emissions (as opposed to SO_2, NO_x and particulate emissions), because their effects are not geographically specific.

Although the earlier discussion documents produced by the National Treasury appeared to favour an upstream carbon tax, this position has changed. The tax due to be introduced in 2016 will be levied downstream on end-users of fossil fuels, which provides: (i) better visibility and transparency to consumers regarding the actual costs of carbon emissions; and (ii) a stronger incentive to invest in technologies such as carbon capture and storage.

The levying of a downstream tax also places an administrative burden on energy end-users who are required to monitor and report on their emissions. No data was available on the likely magnitude of these costs in South Africa, but data from other countries allows an approximate estimate to be made. The Australian carbon tax was estimated in a regulatory impact statement to have a total cost to firms of AUS$87.6 million (Parliament of Australia, 2015). Assuming that these costs would scale in approximate proportion to the population of the country, and applying an additional scaling factor

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8 Not including the additional R0.02 per kWh that is planned to be introduced temporarily as a tool to manage demand and alleviate electricity shortages

9 It was estimated (National Treasury, 2010) that an 'upstream' carbon tax in South Africa would require only about 86 different producers to be taxed.

to represent the higher average labour cost[10] in Australia relative to South Africa, it is estimated that the corresponding figure for South Africa would be approximately R1,600 million.

A study of firms in Sweden (Coria and Jaraité, 2015) found that the typical MRV (monitoring, reporting and verification) costs associated with the carbon tax for medium-sized firms was about €0.24 per tonne of CO_2. Again, applying scaling factors to take account of the relative country sizes and labour costs, this would be equivalent to about R720 million for South Africa. However, the Swedish carbon tax is levied on firms who supply fuel to end-users, which is further upstream in the supply chain than is planned for the South African carbon tax. Hence it should be expected that the administrative costs in South Africa would be higher than this figure.

It should also be noted that many larger entities in South Africa are already committed to monitoring and reporting on their carbon emissions through the carbon disclosure project, hence the *incremental* cost of a carbon tax is lower than might otherwise be expected. Based on these considerations, a tentative estimate for the annual administrative costs to SA firms would be around R1,200 million.

2.1.4 Indirect costs

By far the biggest indirect cost of a carbon tax derives from its expected negative impact on GDP. The UNU model (Alton T. *et al*., 2012) suggests that a carbon tax of R176/tCO_2e (equivalent to about US$12) would reduce GDP by about 0.45%. The model envisages a phased introduction of a carbon tax between 2012 and 2022, so this reduction in GDP may be assumed to occur at a gradually increasing level for each year during that period. Based on the projected GDP growth rates used in the UNU model, a 0.45% reduction in GDP would be worth R29.3 billion in 2030 (assuming a continuation through to 2030 of the 3.9% annual growth in GDP used in the UNU model).

The scenarios modelled by Arndt *et al.* (2016) allow for a shift in generation mix in response to a carbon tax, and point to a somewhat lower reduction in GDP in their basic carbon tax scenario. Where a carbon tax is combined with a removal of restrictions on the importing of electricity, their model indicates a small increase in GDP. The results presented by Arndt *et al.* (2016) do not indicate the nature of the relationship between the level of carbon tax and the impact on GDP, but assuming a simple linear relationship suggest that the 'carbon tax only' scenario would lead to a reduction in GDP of about R24.4 billion in 2030, while combining carbon tax with the unrestricted import of electricity could lead to an increase in GDP of about R12 billion by 2030.

The impact on GDP is strongly affected by the options for revenue recycling. These options are not explored by Arndt *et al.* (2016), while the UNU model indicates that the revenue recycling options that have the least negative effect on GDP also having the most adverse distributional impact. Recycling revenues purely through social transfers has a strongly progressive distributional impact, but the negative impact on GDP according to the UNU model is about 50% greater than under the base case. The design of the carbon tax due to be introduced in 2016 includes a mix of revenue recycling routes, some of which provide social benefits to lower income groups but several of which offset the burden of the carbon tax to firms by reducing their tax liability in other areas. Furthermore, many of the revenue recycling mechanisms to be included are themselves carbon-

[10] Data from the International Labour Organisation

saving. The overall impact on GDP therefore seems unlikely to significantly exceed the magnitude envisaged in the base case of the UNU model.

2.1.5 Multiple benefits

The multiple benefits that a carbon tax is able to generate are largely a function of the way in which revenues are recycled. The main multiple benefits likely to result from the revenue recycling measures that are planned following the introduction of the carbon tax in 2016 are:

- stimulus to the solar PV sector through increased tax relief for roof-top solar PV installations;
- welfare benefits for lowest income households through additional support to free basic electricity provision;
- modal shifts towards more energy efficient transport options through the provision of support to public passenger transport and rail freight

It should be noted, however, that these multiple benefits are not intrinsic features of the carbon tax itself, since the means by which revenues are recycled are not pre-determined.

2.1.6 Risk factors

The experience of Australia, where a carbon tax was repealed only two years after its introduction, indicates the potential for carbon pricing to generate political controversy. Prior to the last general election, the leader of the victorious Liberal party had styled the election a "referendum on the carbon tax"[11]. However, supporters of the carbon tax point to analysis by the Treasury that indicated the 'Direct Action' policy introduced to replace the carbon tax would cost more than twice as much to achieve the same ends[12].

Although the imminent introduction of a carbon tax in South Africa has led to some controversy, particularly in the context of electricity tariffs that have already been increasing steeply, analysis of comments received in response to public consultation revealed an overwhelming majority in favour of some form of carbon pricing, and a small majority in favour of a carbon tax (Morden and Janoska, 2014). The potential risks of introducing a carbon tax must also be viewed in contrast to the possible gains of early action in a world where countries and regions are increasingly considering the introduction of carbon pricing.

Many features of the design of the carbon tax due to be introduced in 2016 serve to mitigate the potential political and macroeconomic risks. The gradual ramping up of the tax from an initial low level provides time for end-users to respond appropriately, while several exemptions have been included to protect those firms that are most strongly exposed. There are likely to be some discussion as the mechanism is implemented, specifically relating to the possibility to offset energy supplied back to the grid, for which there appears to be no current provision.

2.2 Changes to the 12 L tax incentive

Based on preliminary feedback from stakeholders, some aspects of the current 12L tax incentive scheme mean that is does not fully meet their needs. This section therefore examines possible adjustments to 12L that would have the effect of widening its uptake.

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[11] See for example http://www.bbc.co.uk/news/world-asia-24923094 (last accessed 4 Jan. 2016)

[12] See for example http://www.theaustralian.com.au/archive/national-affairs/abbotts-direct-action-to-cost-double-that-of-labors-carbon-attack/story-fn99tjf2-1226128448888 (last accessed 4 Jan. 2016)

2.2.1 Description

The 12L scheme allows firms making energy efficiency investments to reduce their company income tax liability in the year that the investment is made by an amount proportional to the energy savings achieved. In its current form, the scheme provides an allowance of R0.95 per kWh saved which, at a company income tax rate of 28%, means that firms are effectively reducing their tax bill by R0.266 per kWh saved. The allowance was increased to its current level in early 2016 from the previous level of R0.45 / kWh, and at the same time the eligibility criteria were extended to include cogeneration projects.

The scheme has achieved a significant level of take-up in the industry and commercial sectors to date, with the rate of applications expected to grow further following the recent increase in the incentive level and the expansion of scope to include cogeneration. However, some stakeholders report aspects in which the scheme remains unattractive for them. Firstly, the M&V burden is still regarded by some as a major disincentive. Secondly, because the incentive takes the form of an allowance against profit tax liability, it cannot be accessed in years in which a loss is recorded. Thirdly, for the same reason, the scheme cannot be accessed by the Real Estate Investment Trusts (REITs) that are responsible for managing a large fraction of the country's commercial property.

Simplification and streamlining of the M&V procedures is already being considered by SANEDI, which is likely to result in the introduction of "M&V-lite" in the near future. The package of measures examined here therefore includes such a change to the 12L scheme. However, even if M&V is greatly simplified for certain types of project, the requirement will remain for all 12L projects to be independently verified by an entity accredited under SANS 50010:2011. For many projects, the cost of this is likely to remain a significant deterrent, even at the recently introduced higher incentive level. An additional measure that may therefore be considered in the medium-term is to allow larger firms that are ISO 50001-certified to self-verify 12L projects, with a fraction of projects being subject to random spot-checks and stringent penalties for intentional mis-reporting.

The inapplicability of 12L to loss-making firms could be addressed by considering minor changes to the way that allowances are claimed. Options include: (i) allowing firms that have made a loss to claim a 12L rebate against their carbon tax liability, rather than against profit tax; (ii) allowing firms to 'bank' allowances into the following tax year (or the next year in which a profit is made).

Adjustments to the way that tax allowances are claimed would also ensure that REITs are able to benefit from the incentive offered by 12L. However, when providing incentives for the retrofit of commercial buildings, care must be taken to avoid the incidence of free-riding. Extensive refurbishments of buildings are in any case required to achieve levels of specific energy consumption equivalent to the SANS 10400 XA standard, so 12L incentives should be provided only for savings that are in excess of that level. For energy savings that do not involve an extensive refurbishment, 12L incentives should be provided only if the final energy performance of the building exceeds a certain minimum level, and is certified with an energy performance certificate.

2.2.2 Estimated energy savings

Latest results on the 12L scheme (SANEDI, 2015) indicate that there have been 63 projects registered to date, having the potential to save 3,757 GWh per year. Unfortunately, additional data on these projects is not available because of confidentiality issues. The investment cost of these projects is therefore not known, nor is any information available on the extent to which the decision to invest was influenced by the availability of the 12L incentive. Without this information, estimates of the likely impact of adjusting the detailed design of 12L must be based on assumptions and approximations.

The effect of 12L incentives on the attractiveness of energy efficiency investments may be estimated by considering data from actual investments in energy efficiency made by larger industrial firms. Although recent data is available from case studies of projects implemented under the UNIDO Industrial Energy Efficiency programme (IEE) and the NBI's Private Sector Energy Efficiency initiative (PSEE), the majority of these interventions were too small for 12L to be of interest[13]. Older data relating to signatories to the Energy Efficiency Accord indicates that annual savings of 2,405GWh were realised during 2005-07 from an investment cost of R9.93 billion (Genesis Analytics, 2010). Assuming an electricity price of R500/MWh, the annual energy savings would be worth about R1.2 billion[14] which, evaluated over a 15-year project lifetime at a discount rate of 8%, gives an NPV of R320 million.

Using these investments as an example, the availability of a 12L incentive would have been worth a total of R640 million, or 6.4% of the total investment cost. Taking into account the additional M&V cost that must be borne by applicants for a 12L incentive, it can therefore be seen that if M&V costs are greater than 6.4% of total investment costs, the advantage of the 12L incentive disappears. Actual M&V costs for 12L are not known, but an indication of their likely level can be gained from Eskom's IDM programme, for which M&V costs of up to 8% are permitted by NERSA but actual levels are estimated to be closer to 3% of total costs (de la Rue du Can, 2013).

Taking the group of projects described above as an illustrative example, if a total current M&V cost of 3% is assumed, and that the introduction of simplified M&V procedures allows this to be reduced to 1%, this would represent an increased benefit of R200 million, which is sufficient to increase the NPV of the group of projects by a factor of about 1.6. If it is further assumed that the range of energy saving investment possibilities may be described in a way analogous to the well-known marginal abatement cost curve (MACC), then the effect of increasing the NPV of projects by a factor of 1.6 may be expected to lead to a similar increase in the volume of energy efficiency investments that are cost effective (see Figure 2 below)[15].

In the two years that 12L has been operating at the lower incentive level, projects resulting in total annual energy savings of about 3.76TWh have been registered. All else being equal, it may be assumed that if 12L continued at its current level for a further 5 years (i.e. until its scheduled end in 2020), additional projects resulting in total annual savings of 9.4TWh would be registered. The new incentive level, which is 2.1 times higher, may therefore be expected to lead to projects having a total annual energy savings of about 20 TWh. The effect of reducing M&V costs to the extent described above would therefore lead to an additional 12 TWh (or 42 PJ) of savings.

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13 The savings per project for these interventions were such that the amount of 12L incentive payable would be unlikely to exceed the M&V costs.

14 This represents an upper limit of the estimated value of energy savings. Energy carriers other than electricity have a lower unit cost, so energy savings of fossil fuels would have a significantly lower value.

15 Assumed that the slope of the MACC is relatively constant

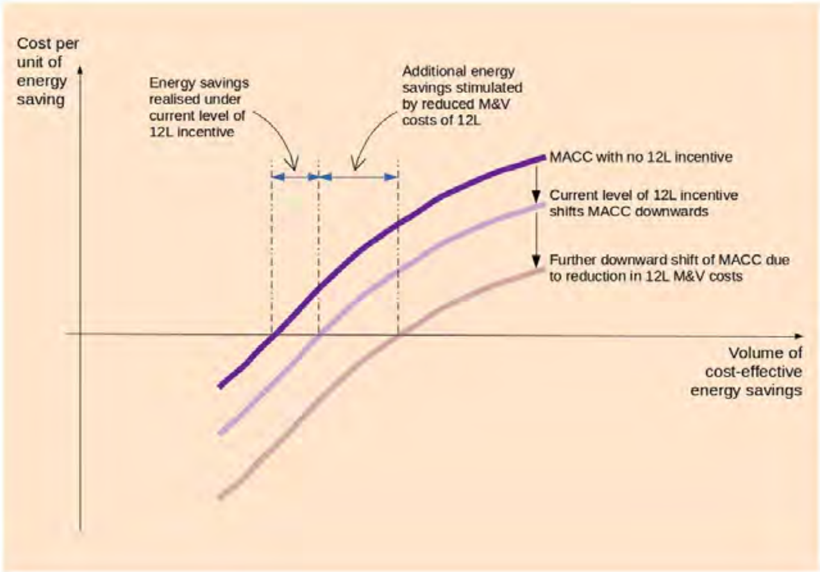

Figure 2 Estimation of the effect of reducing the M&V costs associated with 12L incentives

In reality, the effect of reducing the M&V burden is likely to be much more complex than the simple model described above. The decision making processes in firms are complex, and the reasons why decisions are made to invest or not invest are many and varied, and extend beyond the simple question of whether the investment passes some hurdle rate of return[16]. Other factors may include: the absolute magnitude of the proposed investment; the extent to which energy efficiency is seen as a core strategic priority; whether energy efficiency projects are categorised as a sub-set of maintenance operations (hence appear on the balance sheet as cost items) or as investments in productive capacity; whether the investment can be financed from internal resources rather than requiring a loan. However, despite this complexity, it remains the case that "...profitability plays an important but not decisive role in investment decision-making" (Cooremans, 2011).

2.2.3 Direct cost

Because claiming a 12L incentive is discretionary on the part of firms taking advantage of the scheme, it is not appropriate to include in this analysis the M&V costs they incur. The biggest direct cost associated with the 12L incentive scheme is therefore the forgone tax revenue equal to the amount of incentive paid, which is R0.266 per kWh saved. The measures described here to broaden the attractiveness of 12L will therefore result in additional direct costs in proportion to the increased amount of savings expected from the larger number of projects applying to receive incentives. The estimate given above of increased savings of 12 TWh therefore translates directly to an increased direct cost of R3.19 billion.

The need to conduct spot-checks of self-verifying firms would have the effect of shifting a portion of the M&V costs from the applicant firms to the public purse. Assuming the current M&V costs borne by firms amount to R0.12 per kWh, and that 20% of firms claiming 12L incentives are eligible to self-

[16] See, for example, Centre for Sustainable Energy (2012), Cooremans (2011) and Parker *et al.* (2000) for more detailed analyses of decision making processes relating to energy investments.

verify, performing random spot checks on one in ten of those would incur additional costs of about R29 million.

Minor increases in administrative costs may also be expected as a result of changing the way that allowances are claimed (e.g. banking of allowances in loss-making years, providing an alternative basis for allowances in the case of REITs). In the absence of more detailed information on the current administrative costs, it is not possible to estimate the size of these increases. However, they are expected to be very small relative to the other increases in direct costs described above.

As described in Section 1.2.2 above, it is not appropriate to include in this assessment the forgone VAT and carbon tax revenue resulting from reduced energy consumption nor the increased corporate income tax revenue resulting from higher profits of firms that have reduced their energy costs, as these changes are not unique to the measures being considered. However, it is worth noting that, at the current level of 12L incentive, the NPV of all of these changes in tax revenue is close to zero[17]. This suggests that any further increases of 12L incentives beyond the current R0.95 per kWh allowance would lead to a net lifetime cost on the public purse.

2.2.4 Indirect costs

No significant indirect costs are expected.

2.2.5 Multiple benefits

A benefit of the 12L scheme has been identified as the stimulus provided to the development of the M&V sector in South Africa. The implementation of 12L has been a significant driving force behind the development of SANS 50010, the national standard on measurement and verification of energy savings (Green Business Guide, 2014). If the proposed changes lead to a significantly increased number of applications, this will lead to further growth in the M&V market, which in turn will help the development of the market for energy performance contracting. In addition, growth in the M&V market is also likely to lead to a more competitive environment, which may result in costs being brought down. However, it is worth noting that the stimulation to the market for independent M&V professionals will be more limited if M&V-lite is implemented, and if self-verification by ISO 50001 certified firms is permitted.

2.2.6 Risk factors

The 12L scheme in its current form does not appear to have resulted in any unforeseen consequences, nor to have met any significant political opposition. As the cost of supporting 12L allowances is expected to be covered by recycling of revenues from the carbon tax, making the scheme more attractive to a wider range of stakeholders should help mitigate the potential political risks of the carbon tax.

There is a risk that reducing the average cost of M&V may increase the likelihood of free riders. Firms that were already planning on implementing energy efficiency projects but not claiming a 12L allowance because of the high cost of M&V might be more inclined to claim if this cost is reduced. In

[17] This is based on the following assumptions: R0.07 / kWh in VAT and R0.03 / kWh in carbon tax forgone because of reduced energy consumption, R0.14 / kWh increase in company income tax because of reduced energy costs, an investment lifetime of 10 years and a discount rate of 8%, as used in the Department of Energy's Integrated Resource Plan 2013 update (Department of Energy, 2013).

other words, the reduction in M&V costs may affect the decision whether to claim the 12L allowance without having any effect on the decision whether to make the investment.

A significant risk factor is associated with allowing the self-verification of projects by firms that are ISO 50001 certified. The use of random spot-checks to ensure that self-verification is not being abused will mitigate this risk to a large extent. The potential reputational loss to companies if they are found to be intentionally mis-reporting should serve as a strong deterrent.

3 INDUSTRY SECTOR

For the industry sector (manufacturing and mining), the proposed package of policy measures aims to strike an appropriate balance between enabling, incentivising and regulating to ensure that firms in the industry sector respond positively to the combined challenge of increasing electricity prices and the impending carbon tax. The effects of increasing the attractiveness of the 12L tax incentive scheme have already been considered in Section 2.2 above. The package of measure considered here is as follows:

- Minimum energy performance standards for electric motors
- Creation and promotion of a strongly branded certification for the most energy efficient products
- Incentivise enterprises to achieve ISO50001 certification
- Provision of targeted support and advice on energy efficiency
- Creation of technology/ learning hubs for energy efficiency

3.1 Description of measures

3.1.1 Minimum energy performance standards – motors but not boilers

The second element of the proposed package of measures is the introduction of minimum energy performance standards (MEPS) for electric motors, which are estimated to be responsible for about 60% of the electricity consumed in the industry sector of South Africa (Mthombeni & Sebitosi, 2008). Specifically, MEPS would apply to AC induction motors between 0.75-375kW, which are widely used throughout the industrial sector for pumps, fans, compressors, conveyors, hoists, crushing and grinding of materials and many other applications. The general consensus is that MEPS are not appropriate for motors outside of this size range: smaller motors are usually integrated into appliances, and it is more appropriate to apply MEPS to the whole appliance, while the largest motors are generally custom-designed for specific applications (IEA, 2011b).

Mandatory MEPS for electric motors is one of the International Energy Agency (IEA) core 25 policy recommendations (IEA, 2011a). Their purpose is to address the sub-optimal efficiency of motor-driven system through the failure of purchasers to employ life cycle costing when procuring equipment. The main (sometimes only) criterion applied when purchasing motors is price, but the initial price of a motor often accounts for as little as 1% of its total lifetime cost of ownership. Adoption of MEPS excludes the least efficient motors from the market and ensures that, even in the absence of energy efficiency procurement procedures, the total lifetime cost of ownership of motors is minimised.

The IEA recommends that motors conforming to the IEC[18] IE3 efficiency class should be designated as the standard efficiency motor. MEPS would exclude motors less efficient than IE3 form the market. Such a standard was adopted across the European Union at the beginning of 2015, although IE2 class motors may still be sold if they are fitted with a variable speed drive (VSD). Many of the more energy-intensive industrial firms in South Africa have already adopted the IE3 class of motor as standard for the replacement of existing motors that reach the end of life.

[18] International Electrotechnical Commission

Industrial steam boilers are also a major consumer of energy, typically accounting for about one-third of the total industry sector energy demand (Rohde *et al.*, 2014). However, introducing MEPS for this class of equipment would present significant difficulties, and is therefore not included in the policy package considered here. Because of widely heterogeneous operating conditions, the process of defining MEPS would be much more complex than for electric motors (Aydemir *et al.*, 2015). The total number of units sold annually in South Africa is probably no more than a few hundred[19], so creating and equipping a test laboratory is unlikely to be cost-effective.

Preparatory studies in the European Union indicate that their preferred route with regard to industrial steam boilers is to prescribe certain design features as mandatory (combustion controls, an economiser and a VSD on the air blower), rather than setting MEPS for the equipment as a whole (Aydemir *et al.*, 2015). Because of the clear energy savings that these features offer, they are in any case increasingly being demanded by purchasers – the EU Preparatory Study projections indicate greater than 90% penetration of all three design features in boilers sold in the EU by 2030. One possible approach in South Africa would therefore be to develop voluntary agreements with local boiler manufacturers and suppliers to adopt these design features as standard. In the short-term, raising awareness among purchasers of industrial boilers would help to create a strong demand for boilers having these features.

3.1.2 Energy endorsement labels

While MEPS serve to push the market for a particular product category towards higher efficiency by removing the worst performing models, labelling of products provides a market pull by helping purchasers to make an informed choice in favour of more efficient models. In the case of industrial equipment such as motors, integral motor-driven equipment (fans, compressors, pumps), boilers and lighting, a strongly branded endorsement label can simplify purchasing decisions by certifying that the endorsed product is among the most energy efficient in its category[20].

The most widely recognised endorsement label globally is the “Energy Star” logo, operated by the US EPA but now officially adopted in seven other countries. Generally, an Energy Star endorsement indicates that the product in question is among the top 25% of that product category in terms of energy efficiency. As the Energy Star brand has steadily become more established, it has expanded in scope to provide endorsements not only to products, but also to whole facilities – the Energy Star certified plant registry now contains details of 148 industrial facilities that have received certification recognising superior energy performance within a particular industry.

While many other countries have strongly branded energy endorsement label schemes that cover domestic appliances, relatively few have extended such schemes to cover industrial equipment (Department of Industry, 2014). Some examples are Brazil (motors, transformers, pumps), Korea (motors, heat recovery ventilators, pumps, centrifugal water chillers, transformers, multi-function switchgear systems, direct-fired absorption chiller-heaters, centrifugal blowers) and Mexico (motors, transformers, compressors). Russia is also in the process of developing a scheme, but at present this applies only to electric motors.

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19 Based on an estimate that annual sales of industrial steam boilers smaller than 50MW across the whole European Union number about 3,000 units (Gentili *et al.*, 2014).

20 Note that endorsement labels are usually designed to run alongside, rather than replace, any existing performance label system that is in place.

Endorsement labels are likely to prove particularly valuable where firms have declared a commitment to energy efficient procurement as part of a corporate energy management strategy. An energy endorsement label provides a simple indication that the item in question provides a full life-cycle cost of ownership that is among the lowest for that type of equipment. This avoids the need for the purchaser to perform complex and time-consuming calculations when choosing off-the-shelf items of energy-using equipment.

As part of the post-2015 NEES, it is proposed that exploratory studies are conducted to determine the feasibility of developing a South African energy endorsement label for certain categories of industrial equipment. Note that this could strongly complement the development of an endorsement label for household appliances (see Section 6 below), by providing a similar branding across a wide range of product types. In the longer term, the possibility of extending such a scheme to the facility level would be explored.

3.1.3 Energy management plans and promoting ISO50001 certification

Strong evidence from around the world suggests that realising the potential for energy efficiency improvements in the industrial sector is greatly facilitated when firms adopt formal plans, strategies and systems for energy management. The Department of Energy has already introduced a measure that would make the preparation and submission of Energy Management Plans mandatory for all enterprises having an annual energy consumption in excess of 180 TJ.

The policy measures considered here would complement the requirement to prepare and submit energy management plans by using a combination of awareness-raising, assistance and incentives to encourage firms to seek ISO 50001 certification. Consideration would also be given to reducing the threshold energy consumption above which energy management plans are mandatory.

Incentives for smaller firms to achieve ISO 50001 certification might include rebates against carbon tax liability to cover part of the cost of obtaining and maintaining certification. An option to consider for larger firms is to permit self-verification of 12L projects by ISO 50001 certified firms (see Section 2.2 above). The development of learning hubs as described below will also help to raise awareness of the possible benefits of ISO 50001 certification, and provide resources that may be drawn upon to assist in the certification process.

3.1.4 Awareness-raising and sharing of learning

While the most energy-intensive larger firms are likely to be very well equipped to identify and exploit energy savings opportunities, smaller firms as well as those for whom energy is only a minor component of costs may benefit from measures to improve awareness and access to impartial and high-quality information. The development of learning hubs to serve as 'one stop shops' for the provision of such information should therefore form an important part of the package of policy measures considered for the industrial sector.

One potential model is that of the Private Sector Energy Efficiency Programme (PSEE), which was very successful in providing targeted information and assistance to enterprises of all sizes. The programme, supported by UK DFID, came to an end in 2015 after providing assistance to well over 4,000 enterprises. Mechanisms used in PSEE ranged from help-desk advice, workshops and free publications aimed at small enterprises through to eight-month long subsidised consultancies aimed at large firms.

Another model is provided by the MOSH (Mining Occupational Safety and Health) Learning Hub operated by the South Africa Chamber of Mines, which serves to disseminate best practice across the industry. It achieves this by: (i) identifying a mine where some aspect of best practice is present; (ii) identifying a second mine where it can be demonstrated that the practices in the first mine are transferrable; (iii) after successful demonstration of the best practice in the second mine, staging a workshop for the whole industry; (iv) encouraging mines to join 'Communities of Practice for Adoption' to learn from each other and share experiences.

The possibility will therefore be explored of forming similarly structured Sustainable Energy Learning Hubs for each of the main industrial sub-sectors.

3.2 Estimated energy savings

The energy savings resulting from the introduction of minimum energy performance standards (MEPS) for electric motors were estimated using a simple spreadsheet model, which is described in more detail in Annex 1. The model indicated that annual energy savings amounting to about 1.4 PJ could result from this measure in the three sub-sectors covered (manufacturing, mining and water utilities). It is worth emphasising here that any estimate of the energy savings impact of introducing MEPS for electric motors will only be additive with other motors-related policy measures if those measures are evaluated using the MEPS as a baseline.

It is also important to remember that the impact of MEPS alone is likely to be small in comparison to the energy savings that may be achieved by optimising the whole system in which the motor is located. This is illustrated in Figure 3 below, where savings of 57% are achieved by optimising the whole system. Simply replacing the original motor with the more efficient model in the non-optimised system would achieve a saving of only marginally over 5%.

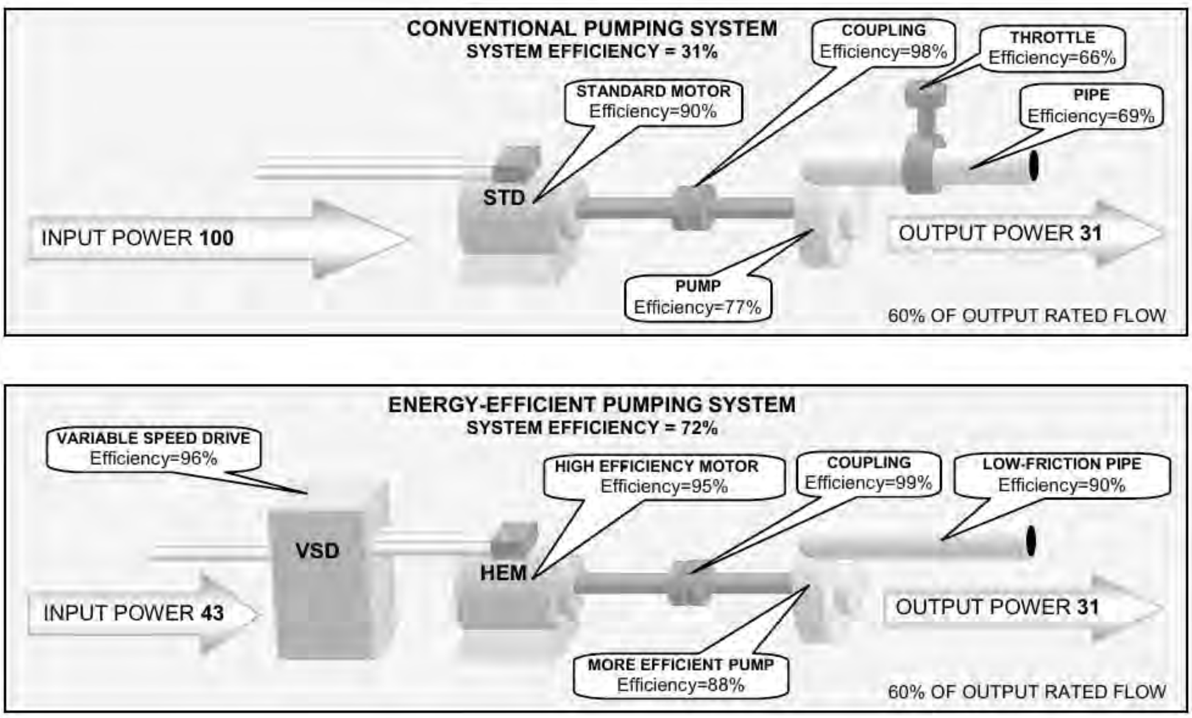

Figure 3 Illustration of the effect of system optimisation in motor-driven systems (Source: De Keulenaer *et al.*, 2004)

In fact, unless attention is paid to the optimisation of the overall system in which a motor is placed, the simple replacement of a motor with one of higher efficiency may have little or no impact on energy consumption, and in certain cases may actually result in an increase in energy losses. This is because more efficient motors generally operate at a slightly higher speed than their conventional counterparts. If this higher speed leads to greater delivery than required (for example, of a fluid being pumped) then the response of the operator of a non-optimised system might be to restrict flow using a throttle (as in the top illustration in Figure 3). This is likely to negate much of the gain achieved by using an efficient motor. The difference in speed becomes particularly important for 'cube-law' loads[21], where the use of a high-efficiency motor in a non-optimised system may actually result in a fall in system-wide energy efficiency[22].

The level of energy savings that may be expected from the introduction of an energy endorsement label for motors and motor-driven systems depends on the extent to which purchasers of the equipment in question are already motivated to consider the energy efficiency of equipment in making their decision. Very few estimates exist in the literature regarding the impacts of energy endorsement labels, and these tend to be highly speculative (see for example CLASP, 2005). In fact, it could be argued that energy endorsement labels only result in energy savings if firms employ some form of energy management strategy that leads them to consider the full life-cycle cost of ownership. Hence energy endorsement labels may be seen as complementary with the adoption of energy management plans or with ISO 50001 certification.

Several studies indicate that simply having in place an effective company-wide energy management strategy in itself leads to significant energy savings. This effect is particularly well-documented in the case of systems that are certified to ISO 50001[23]. The ISO themselves report that: "[Early adopters] report numerous early gains from implementing ISO 50001, including significant reductions in power consumption, carbon emissions and energy costs, and benefits to manufacturing plants, communities and the environment"[24].

According to a study on the impacts of ISO 50001 certification worldwide (Wulandari *et al.*, 2014), half of the recently certified enterprises reported energy savings in the range of 1-5%. A further 29% of firms reported savings of 6-10%, while 11% of firms reported savings of 11-15%. The remaining 10% of firms reported that they achieved savings of 16% or greater.

Some care must be exercised in attributing causality to an observed correlation between ISO 50001 certification and energy savings that follow. The very fact of wishing to pursue ISO 50001 indicates that the organisation in question is more likely to have higher than average awareness of the energy efficiency opportunities available. However, it would appear likely that the proposed combination of mandatory energy management plans with the provision of assistance towards ISO 50001 certification could in itself yield energy savings of the order of 5% among those firms that do not already have well-established energy management strategies in place.

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[21] These are loads where the power requirement is proportional to the cube of the speed, so that a 1% increase in speed leads to a 3% increase in power consumption. A cube-law relationship occurs when a motor is used to move a fluid, so it is most often encountered in pumps and fans.

[22] See Middelburg (2011) for a more detailed discussion.

[23] See for example http://www.bsigroup.com/en-GB/iso-50001-energy-management/case-studies/

[24] See http://www.iso.org/iso/home/news_index/news_archive/news.htm?refid=Ref1448

Information on the energy savings that resulted from the PSEE programme was not available at the time of writing, so estimates of the likely savings that could result from a continuation of a similar resource must be based on examples from other countries. Programmes to support energy audits in industry have been widely used in the EU, particularly targeted at SMEs, and are now required under the Energy End-use Efficiency and Energy Services Directive. Studies on the impacts of support schemes reveal significant savings. For example:

- Karlsson *et al.* (2012) estimate that energy savings of 20% were identified in the first 130 audits of SMEs registered under the Swedish system. It is estimated that at least 50% of the identified savings will be realised by the audited firms.
- A review of the results of similar schemes conducted by the UK Government (DECC, 2014) found that take-up rates for recommended measures ranged from 44-81%, and realised energy savings ranged from 5-10%.
- Larsen *et al.* (2006) reviewed 10 case studies of companies that had received audits under a Danish scheme, which gave realised savings of 7-20% and an average take-up rate of 64% of recommended measures.
- A study by Fleiter (2014) of an energy audits programme in Germany indicates a take-up rate of recommendations of 81%, and realised energy savings of 5%.

The likely impact on energy consumption of the provision of telephone advice and internet-based information resources is much more uncertain, and the literature contains very few impact studies. It is likely that the energy savings that can be directly attributable to the provision of such services is lower than that resulting from audits. A tentative estimate for the energy savings that may result in South Africa from the provision of energy audits, telephone advice services, targeted information and workshops is 5% of consumption within the SME sector.

3.3 Direct cost

South Africa has incorporated the internationally accepted IEC definitions for efficiency ratings of electric motors, and the associated test procedures, into its national standards system as SANS 60034-30. Given that the infrastructure for testing of electric motors is already in place, the incremental direct cost of introducing MEPS for motors is therefore relatively low. The cost to government of administering the MEPS for electric motors in Australia was estimated to be only AUS$50,000 per year (equivalent to about R0.56 million). There is no reason to believe that the equivalent cost for South Africa would be significantly different.

The introduction of an energy endorsement label for motors and motor-driven systems would incur direct costs associated with defining and adopting testing procedures for packaged systems that are not currently covered by SANS 60034-30, along with the costs of equipping a testing laboratory. Some marketing and brand-building efforts would also be required, and minor administrative costs would be incurred of a similar magnitude to those associated with the MEPS describe above.

The cost to industry of preparing and submitting mandatory energy management plans may be estimated by using available data on ISO 50001 certification as a proxy. In a survey conducted by Wulandari *et al.* (2014), almost half of the respondents estimated that the cost of obtaining certification was in the range €6,000-12,000. Another 37% reported costs of between €12,000-18,000 while 11% estimated the cost to be €18,000-30,000. The remaining 13% placed the cost of certification at greater than €30,000. With regard to the annual cost of maintaining certification, a large majority (81%) estimated this to be €6,000-12,000.

Based on available data on electricity consumption by South Africa's largest enterprises, it is estimated that no more than 200 individual enterprises would be covered if the threshold for the mandatory submission of energy management plans was reduced to 90 TJ annual consumption. Since these are the largest enterprises, it is reasonable to assume that the cost per enterprise is likely to be towards the top end of the estimates described above. This would place the total direct cost of compliance at about R107 million, with a further on-going annual cost of about R40 million.

The likely cost of operating an industry sector technology learning hub for energy efficiency may be estimated by considering the operating costs of both the PSEE programme and the National Cleaner Production Centre (NCPC), which fulfils many of the functions of the proposed learning hub. PSEE's total cost was approximately R150 million over 2.5 years, or R60 million per year. The NCPC's annual budget in 2009 stood at about R29 million, of which R19 million was for projects and R10 for running costs. Based on these figures, a tentative estimate for the annual cost of a sector learning hub would be of the order of R50 million.

3.4 Indirect costs

A number of potential indirect costs may arise from the adoption of MEPS for electric motors. The most obvious of these is an increase in the price of motors, as users are obliged to purchase a more expensive item than they might otherwise have done. The introduction of MEPS for electric motors in Australia was estimated to result in an 8% increase in the purchase price of motors (George Wilkenfeld and Associates, 2000), but this price differential is likely to be highly variable and dependent on other factors such as the price of copper[25]. Note that this estimated impact on price also included the additional compliance costs to motor suppliers, which were assumed to be passed through to buyers.

In most cases, the energy savings throughout the lifetime of the motor will more than offset the higher price[26], so there is no net cost. However, in some cases the energy savings may be insufficient to achieve this – for example, where a high-efficiency motor is being incorporated into a system that is not otherwise optimised. As explained above, the potential energy savings from using a high-efficiency motor are particularly likely to be adversely affected in cube-law loads – namely fans and pumps. These types of load would typically account for about 43% of motor energy consumption[27].

Motors with low hours of operation may also provide insufficient energy savings to offset the higher purchase price of an high-efficiency model. At average EU electricity prices, the IEA estimate that an IE3 motor becomes cost effective relative to an IE1 or IE2 model if the annual hours of operation are greater than 2,000 (IEA, 2011b). In South Africa, where electricity prices have yet to converge with cost-covering levels, this threshold is likely to be greater than 2,000 hours.

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[25] IEA (2011b) contains a more detailed discussion of the factors affecting motor prices, and observes that the price actually paid is not usually publicly disclosed. Larger purchasers rarely pay the list price for motors, and some may receive discounts of up to 70% against the list price.

[26] According to the International Energy Agency (IEA, 2011b), the purchase price of a motor typically only accounts for about 1% of its total lifetime cost.

[27] Based on estimates for the US (UNIDO, 2011) and Australia (George Wilkenfeld and Associates, 2000)

A further consideration related to the possible impact of MEPS on motor prices is the increased likelihood of users to choose to rewind rather than replace motors that have failed[28]. For motors larger than 10kW, rewinding is often chosen as a cheaper option than replacement, although given that the efficiency of a rewound motor is usually 1-5% lower than the original value, rewinding is usually considerably more expensive when evaluated over the expected lifetime of the motor. Unless adequate measures are taken to tighten the regulation of the motor rewinding industry, and to educate users as to the importance of full life-cycle costing, the impact of increased use of rewound motors must be considered an indirect cost of introducing MEPS.

The electric motors market in South Africa is estimated to be worth about US$470 million in 2014 (Lazenby, 2010), equivalent to about R7.3 billion. Assuming that 75% of this market is accounted for by motors that would be covered by MEPS (AC induction motors in the range 0.75-375kW), and that 10% of those are being used in applications where the increased purchase price would not be recouped through energy savings, the impact of an 8% increase in price would lead to a net cost to users of almost R44 million.

No other indirect costs are foreseen in connection with the other elements of the policy package.

3.5 Multiple benefits

The package of measures explored here is expected to lead to both increased productivity within the industry sector and the creation of jobs. This is particularly so if the measures are successful in bringing about a change in mind-set, towards a more holistic view focussed on whole-system optimisation, rather than a piecemeal approach to replacing individual system components.

3.6 Risk factors

No significant risk factors are foreseen with regard to the package of policy measures describe here. Although the introduction of MEPS for motors could be seen as potentially damaging to the competitive position of domestic electric motor suppliers, the risk is considered small. Firstly, a very high proportion of electric motors sold in South Africa are imported, and many of those are supplied by large international manufacturers who are already equipped to supply IE3 motors (Mthombeni and Sebitosi, 2008). Secondly, if the introduction of MEPS is announced sufficiently far in advance, it could equally act as a spur to greater innovation. A similar effect was seen among South African household appliance manufacturers, where the initial resistance to MEPS turned to enthusiasm when they had time to retool and introduce new product lines.

[28] This would only occur if the price differential relative to rewound motors increased. However, it is possible that motor rewinders would retain the price differential by increasing their own prices.

4 COMMERCIAL BUILDINGS SECTOR

The package of policy measures proposed for the Commercial Buildings sector has two main aims: to ensure that the energy efficiency of new buildings continues on a path of improvement, and to encourage the implementation of significant energy retrofits to existing buildings. The policy package considered here contains the following elements:

- Regular tightening of minimum energy performance standards for new buildings
- Mandatory energy performance certificates (EPCs) for commercial buildings
- Introducing an accreditation scheme for ESCOs
- Standards and labelling for key categories of energy-using equipment
- Tax incentives to undertake deep energy retrofits
- Creation of a sector learning hub.

4.1 Description

Energy efficiency standards for new buildings are already in place (as expressed in SANS 204 / SANS 10400XA) but the policy package considered here includes the tightening of these standards according to a pre-announced trajectory. The need for such a tightening has been recognised in the National Development Plan (NDP), which recommends “Progressively strengthen the energy-efficiency criteria set out in [SANS 204] to achieve a zero-carbon building standard by 2030”. A trajectory for tightening the efficiency standards has already being put forward (Milford, 2015), which sees an immediate introduction of a considerably more stringent maximum consumption, followed by an average 8% year-on-year strengthening. The need to act soon on two specific fronts has been identified: first, a ‘loophole’ exists in the current regulations whereby one of the three permitted routes to compliance is significantly less stringent than the other two; second, the current levels of maximum energy demand permitted are insufficiently strict such that, or some categories, a large proportion of existing buildings already meet them (Gray and Covary, 2015).

It is estimated that as many as half of South Africa’s building stock in 2030 will consist of buildings that already exist today. While improving the energy efficiency standards for new buildings is of key importance, it is also necessary to address this existing stock of buildings. The other components of the package of policy measures therefore focus on facilitating improvements to the energy performance of existing buildings.

The introduction of mandatory Energy Performance Certificates (EPCs) for commercial buildings will provide parties to a property transaction (either a sale or a lease) with the information on the likely operating costs of the building – information that is necessary in order to make an informed choice. Consideration will also be given to introducing a mandatory inspection of building air conditioning systems above a certain size threshold (similar to the requirement introduced under the European Union Energy Performance in Buildings Directive), which would help to provide prospective purchasers / tenants with a more complete picture of likely operating costs.

The demand for energy efficiency improvements in buildings may be more effectively met through mechanisms such as energy performance contracts with ESCOs (energy services companies). At present, there is no officially recognised definition of an ESCO, and no system for accreditation of firms wishing to function as ESCOs. In order to increase the confidence of the commercial buildings sector in entering into energy performance contracts, it is therefore recommended that SANAS is engaged in developing accreditation standards for ESCOs to operate in the buildings sector.

The introduction of MEPS for appliances, along with the existing labelling system, will have an impact on the sector, as many appliances covered are likely to be used widely within commercial buildings. However, several classes of equipment important to the sector are not currently covered (for example ICT equipment, instantaneous water heaters), so it is important that the current labelling regime is expanded to include these items, and that MEPS are defined. At the same time, energy endorsement labels for these categories of equipment will also be considered.

Although EPCs provide essential information about the operating costs of a building, evidence from studies in other parts of the world suggests that commercial property markets may be slow to respond to the signals provided by EPCs. As such, the relationship between energy performance and sale price / rental income may be insufficiently strong to incentivise building owners to exploit the full potential for energy efficiency improvements. Instead, the focus is limited to those energy efficiency measures that have the fastest payback periods. The IEA 25 Core Policy Recommendations include: “Implement policies to improve the energy efficiency of existing buildings with emphasis on significant improvements to building envelopes and systems during renovations” (IEA, 2011a). Facilitating these deeper energy retrofits might require the provision of additional incentives, as the high cost of retrofitting is seen as a major barrier to retrofitting by 86% of South African firms (Bernstein and Mandyck, 2013). The package of measures examined here therefore includes tax incentives to building owners to increase the financial attractiveness of investing in deep energy efficiency retrofits[29] of existing commercial buildings.

The possibility of adjusting the current 12L tax incentive scheme to better meet the needs of the commercial building sector (specifically, addressing the tax status of REITs) has been discussed in Section 2.2 above. Alternatively, tax incentives for building retrofits could take other forms, such as: (i) a partial exemption from VAT on rental income in the year following a retrofit; or (ii) a partial rebate of transfer duty on the first sale of a property following a retrofit.

Whatever form the tax incentive takes, it will be important to ensure that it is provided only for retrofits that achieve a greater energy saving than that required under SANS 10400 XA, and a significantly greater saving than could be achieved through simply exploiting the ‘low hanging fruit’. This suggests that the provision of an incentive should be limited to retrofits that achieve a minimum level of performance as certified by an EPC (for example, at least band B) as well as showing a minimum level of improvement relative to the performance before retrofit (for example, a minimum improvement of 2 EPC bands).

The final element in the proposed policy package is the creation of a sectoral technology learning hub, for the dissemination of knowledge, provision of training and sharing of experiences. Functions of the learning hub would include the development and dissemination of assessment tools for the energy performance of buildings, providing information resources and a help-desk service regarding building energy management, and providing a forum (for example, through regular workshops) for the dissemination across the sector of best practices on energy efficiency in buildings.

[29] It is worth noting that there is no universally accepted definition of the term “deep energy retrofit”, but its use here is intended to imply an integrated whole-building approach, rather than the replacement individual components with more energy efficient alternatives (see PNNL, 2011)

4.2 Estimated energy savings

Assuming that the current issues with SANS 204 / 10400 XA are addressed promptly, the energy savings that may result from progressive tightening of building standards may be estimated by projecting the rate at which new buildings are added to the current stock. If the commercial building stock increases in proportion to the expected growth in sectoral GDP, it will almost double by 2030. Using the specific energy consumption of office space as a proxy for the whole sector, and assuming an average 8% year-on-year tightening of the permitted specific energy consumption of new build (beginning from a base of 105 kWh / m^2), the average energy performance of the whole building stock is estimated to be 28% better in 2030 than in 2015. This would represent a saving of about 66 PJ relative to a business as usual projection.

The combination of mandatory EPCs for commercial buildings (possibly including inspection certificates for air conditioning systems), an accreditation scheme for ESCOs specialising in the buildings sector, and the creation of a learning hub will assist the sector in maximising the extent to which energy savings opportunities in the existing building stock are exploited. Attempting to estimate the energy savings likely to be achieved by each measure in isolation makes little sense, as the three measures are strongly complementary. Their combined effect may be estimated by considering the overall potential for energy savings within the commercial buildings sector.

Exploiting the cost-effective energy savings opportunities that exist in the current building stock will focus mainly on optimisation and retrofitting of HVAC and lighting systems. Estimates of the potential savings in these areas are made difficult by the lack of comprehensive data on current consumption patterns. Although several case studies of the achievements of the front-runners are documented, it is the less aware and proactive sections of the commercial buildings sector that policy measures must aim to target, where information on current energy use is sparse.

Estimates from Sustainable Energy Africa (van Es, 2013) suggest that 50% savings in HVAC systems and 40% savings in lighting are typically possible, but these figures must be qualified somewhat. Firstly, LED lighting is likely to become more widely available and cost-effective in coming years, so the energy savings even against a baseline where CFLs are the norm are likely to be higher than this 40% estimate. Secondly, a significant proportion of the buildings in the commercial sector either do not have building-wide HVAC systems, or have systems that are already managed efficiently. Hence the sector-wide savings available from HVAC system improvements are likely to be substantially lower than the 50% estimate.

Taking these factors into consideration, and based on an assumption that the shares of lighting and HVAC in current total consumption are 30% and 40% respectively, it is tentatively estimated that 20 PJ of savings may be expected by 2030 in the currently existing building stock. Of this, 14 PJ of savings are assumed to arise from lighting improvements. Note that this expected energy saving includes 'autonomous change', namely improvements in energy efficiency that would continue to be made even under the current policy environment. Based on preliminary consultations with key sector stakeholders, it is apparent that current increases in electricity prices are already stimulating a high level of interest in energy savings in buildings. It is therefore likely that a significant fraction of the expected savings by 2030 would occur even in the absence of additional policy measures.

Energy savings likely to result from the tightening of MEPS for appliances along with the introduction of an energy endorsement label may be estimated by considering the total consumption from such equipment. It is estimated that plug loads typically constitute one-third of the total energy consumption in commercial buildings (NREL, 2013). In the case South Africa, this currently equates to approximately 40 PJ across the commercial buildings sector, potentially rising to twice this level by 2030. A typical figure for the level of energy savings attributable to standards and labelling programmes worldwide is in the range of 10-20% (IEA, 2015). A conservative estimate for the energy savings resulting from this measure is therefore in the range of 6-9 PJ annually.

Data on the costs and benefits of energy efficiency retrofits of commercial buildings tends to be very dispersed and often takes the form of isolated case studies, and this is particularly so for 'deep' retrofits. The available data confirms the picture that very high rates of return may be obtained by exploiting the 'low-hanging fruit', but that deep retrofits are many times more expensive and may take several years longer to repay the investment costs. However, deep retrofits provide a much greater total volume of energy savings over the project lifetime, and these savings tend to be more firmly 'locked in' for the longer term.

A retrofit of Ekurhuleni Metropolitan Municipality buildings had a simple payback period of only 1.2 years (ICLEI, 2008), but over 85% of the savings were obtained from lamp replacements / re-ballasting, so this is far from being a deep retrofit. The Green Building Council of South Africa estimate that normal payback periods for retrofits are between 3-5 years, and the examples of the V&A Waterfront in Cape Town and the FirstRand building indicate that even relatively deep retrofits may have payback periods in this range (Mahlaka, 2014).

Steyn (2014) studied two building refurbishment projects in Johannesburg that included a 'green' component designed to achieve 40% energy savings. The investment cost of the 'green' portion of the work was estimated to be R660 per m^2 for the smaller building (7,762m^2) and R141 per m^2 for the larger building (16,200m^2). The work conducted on the smaller building was regarded as an 'extreme' retrofit, and the green component taken separately gave a simple payback of 8.4 years. For the larger building, the payback period of the green component was well under 1 year, but a significant fraction of the energy savings appear to have resulted from lighting upgrades.

A case study from Canberra, Australia (Australian Government, 2013) indicates a payback period of over 12 years for a deep retrofit project that achieved an energy saving of approximately 60%. A building was upgraded from an energy rating of 2-Star on the NABERS[30] scale to a post-retrofit level of 4.5-Star[31], at a cost of AUS$278 per m^2. This is equivalent to about R3,100 at the current exchange rate, but closer to R2,200 if the relative cost of labour in the two countries is taken into account. However, when the increased asset value of the building was included in the cost-benefit calculation (by discounting the increased future sale price back to its present value), the payback period fell to less than 1 year.

Other estimates put the cost of deep retrofits higher still. For example, Rocky Mountain Institute (2012) estimates that the investment cost of a deep retrofit is in the range of $270-1,600 per m^2. This is approximately equivalent to R4,000-25,000 at the current exchange rate, but closer to R2,200-13,900 if different labour costs are taken into account. These figures are also consistent with case studies analysed by the New Buildings Institute (2011), where only two out of the eleven deep retrofit projects examined had investment costs lower than $50 per m^2. Most of the case studies

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30 National Australian Built Environment Rating System

31 It is estimated using the NABERS reverse calculation tool (see http://www.nabers.gov.au/) that this corresponds to a reduction in the specific energy consumption from approximately 150 kWh/m^2 to 60 kWh/m^2.

analysed had simple payback periods calculated on the basis of energy savings alone that extended to several decades.

In addition to the direct energy savings, other financial benefits of investing in energy efficiency are the improvement in the asset value of the building, and the increased rental income that may be earned. According to Fuerst and McAllister (2011a), office buildings in the US with Energy Star certification provide an average rental premium of 4-5%, and a sale price premium of 18%. In the Netherlands, office properties with EPC ratings in bands A-C were found to command rents 6.5% higher than properties with D-G ratings (Kok and Jennen, 2012), but this study did not examine the effect on sale price. However, a study in the UK found no relationship between the EPC rating of commercial buildings and either their rental or capital value (Fuerst and McAllister, 2011b). Similarly in Denmark, the impact of EPCs on the energy efficiency of existing buildings was found to be very weak, with the cost of the scheme being about 15 times greater than the value of the energy savings it stimulated[32].

It is clear from these examples that the financial benefit of energy savings is not the key motivating factor for most deep retrofits. In many cases, the substantial non-energy benefits of investing in deep retrofits (improved comfort and working conditions, prestige value of occupying the highest quality building) are sufficient to make such investments cost-effective[33], but the connection is by no means certain. This being the case, estimating the energy savings impact of providing a tax incentive to deep retrofit projects is problematic.

Using the level of the 12L incentive as a guide, and assuming that a deep retrofit would achieve an *additional* saving of 85kWh per m^2 relative to the without-incentive baseline, this would provide building owners with an incentive of R22.5 per square metre of upgraded building. Where total investment costs range from the mid-hundreds up to thousands of Rand per square metre, the effect of an incentive of this magnitude is therefore likely to be modest.

A conservative estimate is therefore made that this measure results in 1% of the total office and retail space in South Africa undergoing a deep retrofit (to a level of 105 kWh/m^2) instead of a more conventional 'shallow' upgrade (to a level of 200 kWh/m^2) each year. This represents deep retrofits to approximately 670,000m^2 annually[34], giving total annual savings of 230 TJ. Summing across the full 15-year period of the Energy Efficiency Strategy, the total energy savings would be 3.4 PJ.

4.3 Direct costs

The direct costs of successive tightenings of building energy efficiency standards are expected to be minimal, since the procedures and systems for managing building standards are already in place. Note that this is not intended to imply that the overall cost of administering the system of building standards is low, merely that there is a relatively small *incremental* cost implication associated with tightening the standards.

The direct cost of making EPCs mandatory for commercial buildings includes the cost to the building owner of having an assessment, as well as the associated administrative cost of maintaining a central

32 Danish Energy Agency, personal communication (January, 2016).

33 Bernstein and Russo (2011) report that 85% of building retrofits are funded from internal budgets. Such investments generally need to demonstrate rapid returns, with Westminster SBF (2014) reporting that the predominant criterion used by Chief Financial Officers is a payback period of under 3 years.

34 Total retail and office space is estimated to be 67 million m^2 of gross lettable area (SAPOA, 2013)

register of certificates. Based on typical costs of EPC assessments in other countries, it is estimated that this would amount to an average of about R20 per square metre in South Africa (less for larger properties, and more for smaller). The current stock of commercial plus retail space amounts to about 67 million m^2, which suggests a direct cost for current buildings of about R1.3 billion. Allowing for the expected growth in the commercial sector between now and 2030, this figure is likely to be approximately doubled, to about R2.6 billion. In comparison, the cost of maintaining a register is expected to be relatively small – in the UK for example, this is estimated to be only about £11 (R250) per building.

Creating an accreditation scheme for ESCOs will result in a direct cost to SANAS, the body responsible for administering such schemes. The total annual operating costs of SANAS are currently in the region of R80 million, but almost half of this is derived from accreditation fees and course fees. The incremental direct cost of introducing a new accreditation scheme for ESCOs is therefore unlikely to exceed about R1 million annually. This cost would be incurred ultimately by the DTI, which provides the bulk of SANAS's non-fee income.

The additional cost of extending the existing standards and labelling scheme to include new classes of equipment is expected to be in the region of R5,000 annually for each model of equipment added. It is not known at present how many different models of equipment would be covered, but an approximate total figure in the region of R1-2 million appears reasonable. For some types of equipment, new standards and test procedures may need to be defined, which would incur additional costs. Based on the tentative estimates given in the FRIDGE report (Covary and Lengoasa, 2012) on the cost of equipping testing laboratories, this cost is estimated to amount to R10-20 million annually.

The cost of setting up and operating a sectoral technology learning hub for the commercial buildings sector is likely to be somewhat lower that for the equivalent industry sector resource (see Section 3 above), since the range of different technical competencies required will be smaller. The annual cost is therefore estimated to be in the region of R20 million.

The direct cost of providing tax incentives for deep energy retrofits is the forgone tax revenue, which is assumed to be equal to the 12L incentive level of R0.266 per kWh saved, as described in Section 2.2 above. Given that tax incentives for deep retrofits are estimated to have the potential to deliver total savings of about 950 GWh over the lifetime of the NEES, this implies a direct cost of about R250 million.

4.4 Indirect costs

No significant indirect costs are anticipated from the package of policy measures described here.

4.5 Multiple benefits

The most significant multiple benefits expected from the package of policy measures proposed for the commercial sector are increased productivity among building occupants due to improved working conditions, and the creation of new employment among ESCOs and in the fields of building energy management and energy assessment / auditing.

4.6 Risk factors

If the construction industry is unable to keep pace with the rate at which building standards are tightened, there is a risk that this could lead to widespread non-compliance, and additional administrative burdens associated with enforcement. However, the setting of a planned trajectory well in advance is expected to fully mitigate this risk, and may actually be a spur to greater innovation in the area of sustainable construction.

The provision of financial incentives for deep retrofits of buildings incurs a small risk of free-riders, but this likelihood is minimised by ensuring that incentives are provided only for retrofits that meet minimum levels of improvement.

5 PUBLIC SECTOR

The public sector is somewhat anomalous in that it is distinguished primarily by its ownership, rather than by the nature of the activities that are carried out within the sector. Much of the energy consumed in the sector is related to buildings, so many of the relevant energy efficiency measures are similar to those in the commercial buildings sector. For municipal services, one of the key technologies is pumping systems for the provision of water services, which are covered by some of the measures included in the industrial sector. Finally, the operation of vehicle fleets also accounts for a large fraction of public sector energy consumption, so some of the measures described under the transport sector will have an effect on public sector energy consumption.

The policy measures described in this section are therefore limited to those that are specific to the public sector. Where a policy measure described in one of the other sector-specific sections is likely to have a significant impact in the public sector, this impact is described in this section. The policy measures specific to the public sector that are considered here are:

- Introduction of mandatory EPCs in all rented properties, and display energy certificates in all publicly accessible buildings.
- Development of energy efficiency strategies by municipalities and provincial governments
- Establishment of energy efficient procurement practices within all tiers of government
- Identification of appropriate financing solutions to support the implementation of energy savings measures in public buildings and municipal services
- Development of a public sector awareness raising campaign to facilitate “leading by example”
- Development of an energy rating scheme for municipal services

5.1 Description

The introduction of mandatory EPCs for the building stock owned by government is already in progress, but this should be extended at the earliest opportunity to include all properties occupied by public sector bodies, including those that are rented. More significantly, a requirement will be introduced for “display energy certificates” (DECs) in all public buildings. Rather than showing the ‘theoretical’ energy consumption of a building based on its construction, DECs show the actual metered consumption over a twelve-month period, as well as a comparison against previous periods. A study in the UK (Carbon Trust, 2011) revealed that the actual metered consumption may differ widely from that expected according to an EPC – in one building, it was five times higher. A DEC therefore provides more useful information to the general public than an EPC, and may be seen as a key component of the public sector’s “leading by example” to manage energy consumption.

Another aspect of leading by example is the development of energy efficiency / sustainable energy strategies by municipalities and provincial governments. While many provinces and some larger metropolitan municipalities have already developed such strategies, it is proposed to make this a requirement on all municipalities. In doing so, municipalities – which are the public bodies with which the general public have the most frequent direct contact – will be able to show demonstrable leadership in addressing the inefficient use of energy.

One key element of an effective energy efficiency strategy is to implement procurement practices that take account of the full life-cycle cost implications of purchases. Energy efficient procurement is considered of such importance that it is proposed to make it a mandatory part of public procurement. Currently, the general rule for public procurement is that 80-90% of the weighting when evaluating tenders is dependent on a combination of price, quality and functionality. In a study for the IISD[35] (Hanks *et al.*, 2008), a number of South African public officials were interviewed[36] to assess the current state of procurement practices and the prospects for sustainable procurement. Virtually all interviewees placed price as the key criterion, although some recognised that the quality criterion permitted the selection of more environmentally sustainable options that may not be the cheapest.

Procurement practices that focus on initial price, rather than lifetime cost of ownership, result in huge lost opportunities for achieving energy savings that are 'locked in' for long periods. The IISD study indicated a general willingness on the part of the interviewees to embrace sustainable procurement, but identified a number of barriers to its adoption. The most important of these were:

- the higher first cost of 'greener' options, which may not be affordable in the short term irrespective of the longer-term savings potential
- lack of awareness and expertise within public bodies – 75% of the interviewees in the IISD study identified training as an important support area for the implementation of sustainable procurement
- lack of clear guidance in current regulations. The IISD study reported that "The legislative framework in South Africa allows municipalities and provinces to pursue particular interests such as [sustainable procurement]...", but that national supply chain management regulations need to provide clear guidance on how environmental considerations fit within this framework.

This analysis suggests that, rather than simply legislating for mandatory energy efficient procurement, a number of support mechanisms need to be put in place to overcome these barriers. The most obvious of these is the provision of appropriate training to the relevant municipal officials, but support frameworks may also include: databases of pre-approved technologies, to avoid the need for cumbersome life-cycle costing calculations to be made for relatively small purchases; guidance for the use of energy service companies (ESCOs) through energy performance contracts.

Since 2002, when five metropolitan municipalities from South Africa committed to pursue green procurement at the World Conference on Sustainable Development, there has been some progress in the form of the development of green procurement policies at the municipal and provincial level. However, "...the actual implementation of such procurement practices has been slow to take off. This is due to the lack of capacity to drive the work and ineffective rollout of the process" (SEED, 2012).

Internationally, the importance of energy efficient public procurement has been recognised in Article 6 of the EU Energy Efficiency Directive (2012/27/EU)[37]. In the US, the use of full life-cycle

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[35] International Institute for Sustainable Development

[36] Twenty individuals in total, from 7 Provincial Governments and 5 Metropolitan Municipalities

[37] Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:en:PDF

costing in public procurement was initially voluntary, under the belief that it would become standard once its advantages were realised. However:

> "First-cost purchasing habits had become so ingrained in agency culture that more of a push was necessary to achieve widespread change. The voluntary nature of the requirements was identified as a potential barrier to this change." (Payne *et al.*, 2013)

As a result, energy efficient public procurement is now included in the US Federal Acquisition Regulations.

The introduction of mandatory energy efficient procurement is not the only way of realising the energy savings potential that exists within the public sector. However, given the slow progress that has been observed (both in South Africa and in the US) when the adoption of more sustainable procurement practices is voluntary, a mandatory requirement is likely to be the most effective route to the rapid and comprehensive realisation of the substantial energy savings potential.

Barriers to the implementation of larger energy efficiency investments by the public sector are well documented, and include a lack of adequate in-house technical expertise to design and develop projects, budget constraints that severely limit the number of large investment projects that may be undertaken in a given period, and an inability to finance investments through borrowing because of constraints on the permitted level of public debt. The package of measures for the public sector therefore includes the development and piloting of financing mechanisms appropriate for the public sector. Options explored are likely to include ESCO financing (for which a system for the independent accreditation of ESCOs would need to be put in place) and the "ESCO Incubator" model[38], which has been identified as a potentially important concept in mobilising finance for public sector energy efficiency investments (see IDC, 2012 for a detailed discussion of these options).

The final element of the package of policy measures for the public sector is to develop a methodology for the calculation of an energy rating for municipalities. This would provide a highly visible demonstration of the progress being made to tackle energy efficiency in the municipal sector, in keeping with the role of the public sector to lead by example. The aim would be to create a rating system against which all municipalities would be awarded a score (perhaps on a 0-100 scale) signifying their overall performance with respect to energy efficiency.

5.2 Estimated energy savings

5.2.1 Public buildings

The Department of Energy has produced an Energy and Climate Change Strategy (ECCS) for the public buildings sector in South Africa (Department of Energy, 2015), which describes a scenario for the refurbishment of the current building stock to high standards of energy efficiency. The results of the technical study that accompanied the ECCS indicate that savings by 2030 from such

[38] Sometimes referred to as a Super ESCO, the 'ESCO Incubator' is a public sector body, the main function of which is to implement large public-sector projects through energy performance contracting (EPC), using local private sector ESCOs as sub-contractors. Other key functions may include: providing loans or equity finance for smaller EPC projects, development of standardised EPC contracts, technical assistance for project development, training and accreditation of ESCOs, developing databases of approved equipment and materials. Core funding for an ESCO Incubator would be provided by government, with additional funds being leveraged from the private sector and from IFIs and international donors.

refurbishments could amount to 10 PJ annually. Although ECCS mentions the likelihood of tightening of SANS 10400 XA, it does not appear to have included the effects of such tightening in the projected energy consumption for new buildings. Based on an assumption of two step-changes that correspond to an average 8% year-on-year tightening, further savings of about 40 PJ in annual consumption are possible by 2030.

5.2.2 Municipal services

An analysis by the South African Cities Network (SACN) indicated that energy intensive municipal services (specifically, street lighting, traffic lights and water services) are typically responsible for 40-45% of the total energy consumption of municipalities (SACN, 2014). Several cities have already made progress in achieving significant energy savings in recent years. In particular, a number of street lighting / traffic light retrofits have been conducted under the Department of Energy's Municipal Energy Efficiency Demand Side Management (EEDSM) programme using an allocation of funds from the National Treasury. SALGA (2014) also describes several examples of energy efficiency improvements in the water sector, particularly the municipalities of eThekwini and City of Johannesburg.

The SACN study estimated the simple payback periods for different energy saving technologies relating to municipal services. Payback periods for lighting technologies range from 2 years (re-lamping incandescent traffic lights with LEDs) up to 10 years (re-lamping smaller street lights with high-pressure sodium lamps)[39]. In the water sector, estimated payback periods of 2.7 years can be achieved through replacing standard (IE1) motors with high-efficiency (IE2 or IE3) motors coupled with variable speed drives (VSDs). Overall, the SACN study estimated that the potential savings in water and street lighting amounted to 890 TJ annually across the 8 cities for which data was available. Since these cities account for about 35% of South Africa's total population, a simple scaling of this estimate would indicate that the total savings potential nationally would be 2.6 PJ annually.

For traffic lights, several of the cities in the SACN report have already realised the full savings potential of retrofitting with LEDs, and for several other cities no data was available. However, scaling up the baseline energy consumption figures for traffic lights according to population suggests that a savings potential of about 0.22 PJ remains across the country.

In the case of traffic lights, it is unlikely that significant savings potential will remain once all units have been upgraded to LEDs. In the case of street lighting and the water sector, larger savings than those estimated in the SACN report may be envisaged over the 15-year period of the Energy Efficiency Strategy. In particular, advances in technology and reductions in price may result in LED technology being cost-effective for all street lighting positions by 2030, and in the water sector it is likely that IE4 class motors will become cheaper and more readily available over the next 15 years.

In order to investigate the longer-term potential for energy savings from these trends, a set of simple spreadsheet models were created, based on the following assumptions:

- total demand for water services, street lighting and traffic lights increase in proportion to population

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[39] Given the long payback period for the retrofitting of the smallest lamps, it is likely that this would be cost-effective only if they are fitted with CFLs or LEDs, rather than low-pressure sodium lamps.

- equipment is replaced only at the end of its useful life (i.e. no retrofitting of working equipment was envisaged)
- for the water sector:
  - replacement of current equipment with IE3 motors and VSDs begins immediately and is spread over a 5-year span, yielding an energy saving of 20%
  - replacement of IE3 motors with IE4 motors begins after 5 years and is spread over a 5-year span, yielding an energy saving of 1.8%
  - the lifetime of equipment was assumed to be 10 years
- for street lighting:
  - replacement of mercury vapour lamps with high-pressure sodium lamps begins immediately and is completed over a two-year period, yielding a 38% energy saving
  - replacement of high-pressure sodium lamps with LEDs begins after 5 years, and is spread over a 5-year span, yielding a 22% energy saving
  - the lifetime of equipment was assumed to be 1 year for mercury vapour and high pressure sodium lamps, and 5 years for LEDs
- for traffic lights, the whole energy savings potential is assumed to be realised within the first five years.

Given that the scenario envisaged here is that energy efficient procurement is mandatory, it may appear contradictory that new technologies are assumed to take a 5-year span to reach full adoption. However, even with energy efficient procurement in place, newer technologies may not be instantly preferable to older options in all situations, as their relative price may still be dropping.

The results from the simple spreadsheet model are shown in Table 3 below. The total savings potential by 2030 is estimated to be 4.77 PJ annually, of which most comes from street lighting. The savings from water provision and wastewater treatment build slowly through time, which is a reflection of the assumption that more efficient equipment is installed only when the existing equipment has reached the end of its life. For the lighting applications, equipment lifetime is short, so the full savings potential is realised more rapidly.

Table 3 Estimated energy savings from municipal services

	Annual savings (PJ)			
Year	**Water**	**Street lighting**	**Traffic lights**	**TOTAL**
2020	0.39	2.14	0.22	**2.75**
2025	0.93	3.05	0.22	**4.20**
2030	1.48	3.07	0.22	**4.77**

5.3 Direct cost

The ECCS study on public buildings provides indicative estimates of the investment cost of the refurbishment programmes envisaged. Based on the illustrative single-building example provided, a typical refurbishment cost is expected to be about R3 per MJ of annual energy savings. This is more than ten-times the unit cost of electricity, indicating that the refurbishment programme described is likely to have a payback period extending well over ten years. This is borne out by the estimates of cumulative life-cycle cost provided in the ECCS, which show the refurbishments beginning to pay for themselves after 20-25 years. As of 2030, the net cost of the refurbishments (investment cost minus discounted value of cumulative energy savings) is estimated to stand at about R4 billion.

The energy savings investments in municipal services are expected to pay back within a few years at most. The NPV of the energy saving measures described above ranges from R1,215 per GJ saved for the measures with the shortest payback period down to around R200 per GJ saved for the measures with payback periods of 7-8 years[40]. Considering only the energy savings that are envisaged in the first five years, these are estimated to provide an NPV in the region of R2,080 million. Since the value of the energy savings accrues to the public purse, the net direct public cost of these investments is expected to be strongly negative by 2030.

The mandatory provision of EPCs for all public buildings will also incur a cost associated with the assessment of buildings as well as with the administration of the scheme. The ECCS estimates that the total stock of public buildings in 2030 will amount to 82.5 million m^2. Based on the indicative figure of R20 per square metre used for commercial buildings (see Section 4.3 above), the total cost of obtaining EPCs will therefore be in the region of R1.65 billion.

Placing a mandatory requirement on municipalities to develop energy efficiency strategies will carry cost implications in terms of the personnel that would need to be assigned to developing and updating the strategies, as well as the training and capacity building that would be required, particularly among the smaller municipalities. Based on the likely required level of effort to develop and maintain the strategies, it is estimated that the total cost across all 278 municipalities would amount to about R11 million. With the cost of training (including associated travel, regional workshop events etc.), the total may reach twice this level, so a tentative estimate for the total direct cost is R22 million.

Implementing mandatory energy efficient procurement in the public sector will have some cost implications. In addition to the regulatory changes necessary, a range of resources in the form of a broad support framework would be required to facilitate the transition. In particular, training would need to be provided to the appropriate municipal officials, and it is likely that on-going technical assistance would also be required until the new procedures have become established.

Payne *et al.* (2013) observe that: "It is unreasonable however to expect procurement staff to perform [a full life-cycle cost] analysis when purchasing relatively inexpensive off-the-shelf products. Some mechanism for streamlining this process is necessary if life-cycle cost is to be considered for these product types." Hence in order to reduce transaction costs, a database of approved technologies may be developed to allow standard solutions to be selected for small or technically simpler procurements (in particular, street lighting). This may be complemented by the provision of simple tools to assist in the calculation of life-cycle costs. In addition, if an energy endorsement label is introduced to identify the best-performing equipment in a particular category, that will also assist in implementing energy efficient procurement for smaller items.

If mandatory energy efficient procurement forms part of a move towards broader sustainable public procurement practices, the overall cost may be considerable. For example, Hanks *et al.* (2008)

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[40] Author's own calculations based on an electricity price of R200 per GJ, a discount rate of 8% and a project lifetime of 15 years.

suggest that "...needs would best be served by a Sustainable Public Procurement National Support Unit". However, it would be inappropriate to attribute the whole of this cost to the specific NEES policy measure.

5.4 Indirect costs

No significant indirect costs are envisaged to be associated with the measures described

5.5 Multiple benefits

The multiple benefits of the package of public sector policy measures describe here are diverse and potentially very substantial. The ECCS estimates that the refurbishment efforts that are envisaged for the country's public building stock would directly create 1,600 full-time jobs. The level of effort required will also create a strong demand for ESCO services, which will have a powerful effect on growing and strengthening the ESCO sector more generally.

Among municipalities, the reduction in electricity demand resulting from the measures considered will free up constrained budgets and allow larger sums to be committed to the delivery of other (non-energy related) essential services.

The very high visibility of most public sector energy efficiency interventions will strengthen the "leading by example" message, and may act as a spur for greater energy saving efforts outside the public sector. In particular, if the public sector is able to communicate the message clearly, a more general awareness of full life-cycle costing may result in its wider adoption across all sectors.

Finally, the impact of the public sector investments will stimulate demand for energy efficient products and services, helping to transform markets. Hanks *et al.* (2008) observe that: "...when governments make a concerted effort to purchase sustainable products and services, their substantial buying power has the potential to create and drive markets".

5.6 Risk factors

No significant risk factors are envisaged in connection with the policy measures considered.

6 RESIDENTIAL SECTOR

The package of policy measures proposed for the residential sector addresses household appliances, the building envelope of dwellings and the awareness of householders with regard to energy saving opportunities. The package contains the following elements:

- Announce a 15-year trajectory for the successive tightening of minimum energy performance standards for household appliances
- Develop a strongly branded energy performance certification mark for household appliances (modelled on the 'Energy Star' brand in the USA)
- Explore the feasibility of a scrappage scheme for old, less efficient household appliances
- Announce a 15-year trajectory for the successive tightening of the energy performance component of building standards for residential buildings
- Energy performance certificates for residential buildings
- Financial incentives for the thermal improvement of existing dwellings, particularly in the rented sector
- Build on the existing awareness-raising activities targeting households and the school curriculum
- Engage municipalities in the delivery of energy efficiency measures for the residential sector
- Establish a sectoral technology hub

6.1 Description

6.1.1 Appliances

Minimum energy performance standards (MEPS) coupled with energy labels for household appliances are a well-established approach in many parts of the world to achieving significant energy savings in the residential sector. Energy labels inform appliance purchasers about performance and 'pull' the market in the direction of improved efficiency by facilitating the choice of appliances that have the lowest life-cycle cost. Meanwhile, MEPS act in a complementary manner with a 'push' towards increased efficiency by purging the market of the poorest performing appliances (Covary and du Preez, 2015).

MEPS and energy labels for appliances have been under discussion in South Africa since 1998, and a voluntary appliance labelling scheme was introduced in 2005. However, its impact and take-up were weak, resulting in the move in 2007 towards beginning development of a mandatory standards and labelling programme. The study conducted under the Department of Trade and Industry 'FRIDGE' initiative (Covary and Lengoasa, 2012) resulted in recommendations being made about the appropriate levels at which initial MEPS should be set, some of which have now been adopted.

This section therefore reviews the estimates made in the FRIDGE report on the expected energy savings impacts of MEPS, and examines the likely impacts of further tightening of standards throughout the period of the post 2015 NEES.

The current labelling system for appliances uses 'comparative labels', which provide detailed information about energy consumption, allowing the performance of different models of appliance to be compared. In many countries, it has been found that some purchasers of appliances prefer 'endorsement labels', which simply state that the endorsed model of appliance is among the most energy efficient in its category. An example of an endorsement label is the Energy Star label, which is awarded to the top performing 15-25% of appliances. An endorsement label for South Africa would be designed to run alongside the existing system of comparative labels.

To accelerate the rate at which old, inefficient appliances are removed from service, the feasibility of a scrappage scheme will also be explored. This would provide householders with a financial incentive towards the purchase price of an appliance in the highest efficiency category upon disposing of an older existing appliance. Various designs for similar schemes in other countries have been piloted, and the details of a South African scheme would be developed in consultation with key stakeholders. Given that the certified disposal of old appliances is a critical component in the functioning of such a programme, one key partner in exploring its feasibility would be eWASA (the e-Waste Association of South Africa).

6.1.2 Buildings

As with other sectors, the successive tightening of building standards between now and 2030 will impact on the residential sector. An average rate of tightening of about 8% per annum is envisaged, as proposed by Milford (2015). However, this is likely to be applied in the form of two discrete step-changes of about 33% each, rather than as a continual series of smaller changes. Announcing the expected trajectory well in advance provides the construction industry and the suppliers / manufacturers of materials time to respond appropriately by implementing new practices, developing new products and providing the necessary training.

The introduction of EPCs on a voluntary basis for residential buildings prides a mechanism whereby householders can increase the benefit they derive from energy efficiency improvements. An EPC provides evidence of a dwelling's superior energy performance (assuming that only those with the most efficient homes will apply for an EPC), which may increase the value of the home when it is next sold. In the medium to long-term, consideration will be given to making EPCs mandatory for residential buildings, as is the normal practice in the EU and elsewhere.

Lower-income households are often characterised as being caught in a three-way squeeze that locks them in a state of energy poverty: first, energy costs make up a disproportionately high portion of their total expenditure, so they are hardest hit by increasing electricity prices; second, they are more likely to live in the least energy efficient dwellings, pushing up their energy bills even further; third, their discretionary income is likely to be insufficient to be able to afford longer-term investments in improving the energy efficiency of their home. In many countries, the provision of grants to low-income households has been identified as the most direct way out of this impasse.

Options will therefore be explored for developing a programme for providing energy efficiency grants to low-income households. In line with the objectives expressed in the National Development Plan, particular emphasis will be put on accessing the rental sector, which experiences in the UK and other countries suggest is particularly challenging to target effectively.

Municipalities are well positioned to deliver energy efficiency services to the residential sector, as they have regular and direct contact with their constituents by virtue of their involvement in the delivery of a broad range of other services. The model of engaging municipalities in realising energy efficiency improvements has been proven through the DoE's EEDSM programme, in connection with municipal services. As a result of that programme, many municipalities have considerably developed their level of expertise with regard to energy efficiency, in some cases through the provision of direct training and capacity building.

A crucial difference with promoting residential energy savings is that any reduction in electricity consumption by households represents lost revenue to the municipality, in contrast to energy savings in municipal services that benefit the municipality directly. On average, South Africa's municipalities derive almost 30% of their income from electricity sales, with this figure rising to nearly half for some smaller municipalities. After taking into account the operating costs of providing power (including maintaining the distribution network and connecting new households), the net margin earned by municipalities on electricity sales averages about 8%.

In order to ensure that municipalities are fully committed to improving the energy efficiency of the homes of their constituents, they would need to be compensated for the lost revenues resulting from any electricity savings achieved. Options will therefore be explored to identify the most effective way of providing this compensation and mobilising the municipalities' involvement.

6.1.3 Awareness-raising

The current 49M awareness campaign designed and run by Eskom has achieved good results to date. An impact assessment conducted two years after its launch showed a 73% recognition rate of the campaign, and a difference of about 20 percentage points in the fraction of the population who expressed knowledge of energy saving opportunities and exhibited energy saving behaviour. Given the success of 49M, it is not the intention of the policy measures described here to reinvent or redesign the campaign, but rather to identify areas where the DoE could complement it. Possible areas to investigate are:

- working with municipalities to develop new avenues for the delivery of targeted awareness-raising to local populations
- build on the sustainable energy content of existing material for schools, developed under the Energy and Sustainability Programme established between WESSA[41] and Eskom

6.2 Estimated energy savings

6.2.1 Appliances

The FRIDGE study examined in some detail the appliance market and the likely impacts of introducing MEPS for a range of appliances. The results from that study, along with data from the household energy surveys conducted during 2012-15[42], form the basis for the estimated savings described here. The FRIDGE report estimated the energy savings that would be achieved from the initial introduction of the MEPS proposed. The policy measure examined here assumes that a trajectory is announced that leads to two successive tightenings of the MEPS thresholds in 2020 and again in 2025.

Table 4 below indicates the MEPS that have either already been introduced or were proposed in the FRIDGE report for a range of appliance types, along with the approximate reductions in specific energy consumption of the lowest performing appliances that would occur though the tightening of

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41 Wildlife and Environment Society of South Africa

42 These surveys were conducted during the development of the Department of Energy's Energy Efficiency Target Monitoring System. A total of over 5,000 households were surveyed in three separate surveys over three years.

MEPS by one and two bands. Note that these figures do not represent sector-wide energy savings, but merely the improvement in performance at the MEPS threshold.

Table 4 Current and proposed MEPS for household appliances and approximate reductions in specific energy consumption of the poorest performing appliances from successive tightening of standards

Appliance	Current (proposed) MEPS	% change by moving up to next band	% change by moving up one further band
Refrigerator	B	27% by moving to A	22% by moving to A+
Freezer	C	21% by moving to B	27% by moving to A
Dishwasher	A	11% by moving to A+	11% by moving to A++
Washing machine	A	13% by moving to A+	12% by moving to A++
Tumble dryer	C	12% by moving to B	14% by moving to A
Air conditioner	B	6% by moving to A	No bands better than A currently defined
Electric geyser	B	54% reduction in standing losses by moving to A	No bands better than A currently defined

Since ownership rates for certain types of household appliance are very low in lower-income households, the evolution of the stock of household appliances is strongly influenced by the rate at which living standards improve. The Living Standard Measure (LSM) system, developed by the South African Audience Research Foundation (SAARF), provides a convenient and widely recognised method for stratifying South African households into one of ten levels, from LSM1 to LSM10. Details of the stratification methodology may be found on the SAARF website[43], but for the purposes of this analysis it is worth noting that ownership levels of various appliances play a significant role in determining which LSM a household belongs to.

For the purpose of this analysis, the LSM strata are grouped into four bands: 'Low' (LSMs 1-3); 'Lower-mid' (LSMs 4 & 5); 'Upper-mid' (LSMs 6 & 7); 'High' (LSMs 8-10). Figure 4 below shows historical data for the percentage of South African households that fall into each of these LSM bands, along with possible future paths. The most prominent features of the graph are: (i) the rate at which the 'Low' group of LSMs has shrunk over the last 15 years, from almost 40% of households in 2000 to only about 12% today; (ii) the rapid growth of the 'Upper-mid' band, from less than 20% in 2000 to 35% today. The share of the 'Lower-mid' band has grown slowly, as there are almost as many households 'graduating' from this band into the 'Upper-mid' band as there are households joining it from the 'Low' band. The 'High' band has shown slow but gradually accelerating growth over the last 15 years.

Moving forward, the rate of change in the share of these different bands depends on the rate of economic growth as well as on how equitable that growth is. The dotted / dashed lines in Figure 4 are in no way intended to represent forecasts, and are not based on any modelled results. Rather,

43 See http://www.saarf.co.za/LSM/lsms.asp

they are intended to depict possible scenarios and to illustrate the kind of distribution that may occur in future if current trends continue.

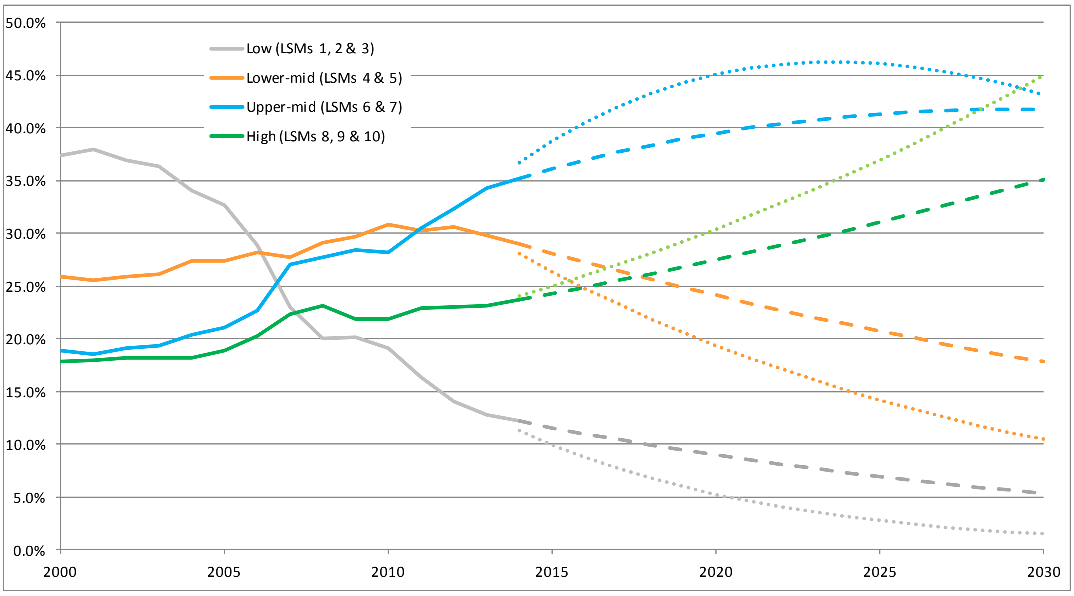

Figure 4 Distribution of households between LSM bands – actual (solid lines) and possible future progression under higher growth (dotted lines) and lower growth (dashed lines) scenarios. Source: DEM (2015)

The rates at which households progress up the LSM bands as their living standards improve has a very strong bearing on the future evolution of household energy consumption, as these improvements in living standard manifest themselves in the acquisition of a range of household appliances for the first time. Table 5 below shows the fraction of households in each LSM band that own a range of different household appliances. From this data, it is possible to see that the transition from 'Low' to 'Lower-mid' is associated with a high probability of acquiring a refrigerator for the first time. A significant number of households making the transition from 'Lower-mid' to 'Upper-mid' are likely to acquire a washing machine and (to a lesser extent) a freezer for the first time. The transition to the 'High' LSM bands is associated with the first-time acquisition of tumble dryers, dishwashers and air-conditioners, as well as a further increase in the probability of freezer ownership.

Table 5 Ownership of a range of household appliances by LSM band

LSM band	Air conditioner	Dishwasher	Washing machine	Tumble dryer	Freezer	Refrigerator
Low (LSMs 1-3)	0%	0%	0%	0%	1%	4%
Lower-mid (LSMs 4 & 5)	0%	1%	14%	0%	8%	70%
Upper-mid (LSMs 6 & 7)	4%	3%	69%	4%	23%	94%
High (LSMs 8-10)	31%	41%	96%	37%	58%	95%

Source: DEM (2015)

Particularly in the case of refrigerators, a large fraction of those purchasing appliances for the first time (as opposed to replacement purchases) are likely to be lower income households that are more strongly influenced by price and less by energy performance. Data from the early years of appliance labelling in the EU[44] indicates a clear correlation between income levels at the national level and the influence of energy labels on purchasing decisions. It would therefore be reasonable to assume that, within a given country, the lower income segments are less likely to be influenced by energy labels.

The data on the distribution of households and appliance ownership levels by LSM band was used with data on population growth in a simple spreadsheet model to estimate the number of households who were likely to purchase appliances for the first time in each year. Estimates of the energy savings resulting from tightening of MEPS were then based on the assumption that it is only those who are purchasing appliances for the first time, and are therefore more likely to be price constrained, who would be affected by changes in the MEPS. It is assumed that all households acquiring appliances for the first time purchase from the lowest energy class permitted, and that a tightening of the MEPS results in a one-band increase in the performance of the appliance purchased. Figures for average usage levels and typical appliance replacement rates are the same as those used in the FRIDGE report, while estimated annual energy consumption figures for appliances were taken from Covary (2015a, 2015b, 2015c and 2015d).

The results from the simple spreadsheet model are presented in Table 6 below along with the estimated energy savings to 2020 resulting from the initial introduction of MEPS, taken from the FRIDGE report. These results indicate that the initial introduction of MEPS would save 15.5 PJ annually by 2030, which is the figure taken from the FRIDGE report. A single tightening of the MEPS thresholds would result in an additional 3.0 PJ of annual savings by 2030, giving a total of 18.5 PJ. A second tightening of the thresholds would yield a further 4.2 PJ of annual savings by 2030, giving a grand total of 22.7 PJ of savings.

Table 6 Energy savings (PJ) resulting from the initial introduction of MEPS for household appliances followed by two successive tightening of the MEPS thresholds

Year	**2020**	**2025**	**2030**
Initial introduction of MEPS	7.6	11.5	15.5
First tightening of MEPS	0	1.8	3.0
Second tightening of MEPS	0	0	4.2
TOTAL	**7.6**	**13.3**	**22.7**

The effects of tightening the MEPS thresholds are smaller than the effect of the initial introduction of MEPS for two reasons: (i) the initial introduction would have purged the market of a large number of very poorly performing appliances currently available; (ii) the spreadsheet model used is intrinsically conservative as it assumes that only those households who have not previously owned a

[44] Author's own calculations based on data from Winward *et al.* (1998) on survey results from 11 EU Member States. A regression analysis of the percentage of appliance purchasers reporting that they were 'Strongly Influenced' by an energy label versus GDP per capita at purchasing power parity gave a regression coefficient of 3.3 per '000 US$ and an r-squared of 0.60 (F-statistic = 13.7). In other words, a US$1,000 increase in GDP per capita correlated with a 3.3 percentage point increase in the reporting of a strong influence of energy labels on appliance choice.

particular appliance type are affected by MEPS. Furthermore, a large fraction of the impact of the initial introduction of MEPS as estimated in the FRIDGE report derives from the impact on the electric geyser market. Since electric geysers were not included in the spreadsheet model used here, they were not affected by the subsequent tightening of MEPS. The figures reported in Table 6 should therefore be regarded as low-end estimates of the potential savings from future tightening of MEPS.

Since the estimated energy saving impacts described above were based on the assumption that old appliances are not kept in use, the presence of a scrappage scheme would not yield additional savings. In fact, a scrappage scheme may be viewed as an additional measure to ensure that the estimated savings are actually achieved.

6.2.2 Buildings

Based on projected population growth and assumptions regarding trends in average household size, it is estimated that there will be approximately 3.6 million additional households in 2030 relative to 2015. The total stock of dwellings in 2030 is therefore likely to include about 20-25% of buildings that have been constructed since 2015. Assuming that regulations are tightened by an average of 8% year-on-year between now and 2030, it is estimated that the resulting energy savings are likely to average about 9.5 GJ per household[45]. The total saving across all new households therefore amounts to about 34 PJ.

Improvements to the stock of existing dwellings is also expected to have the potential to yield significant savings, the realisation of which is expected to be facilitated by the policy measures considered here (specifically, voluntary EPCs for residential buildings, incentives for retrofits of low-income and rented dwellings, further development and expansion of current awareness-raising, engagement of municipalities in the delivery of residential energy efficiency improvements). Given that is impossible to attribute causality between the proposed policy measures and the decision making of householders, any estimate of the energy saving impacts of the policy measures is bound to be somewhat speculative. However, if it is assumed that the measures considered result in 10% of the pre-2015 housing stock being upgraded to current SANS 204 standards, the annual energy savings would amount to 43 PJ nationally.

6.3 Direct cost

At the time that the FRIDGE study was conducted, there was no accredited testing laboratory in South Africa for SANS 941 testing of household appliances. A tentative estimate of the costs of equipping laboratories for the testing of air conditioners and refrigeration appliances was put at about R10.3 million, with the corresponding values for other appliances being significantly lower. It may be assumed that the direct costs of implications of successive tightenings of MEPS standards are insignificant. The compliance costs incurred by manufacturers in getting new models of appliance tested are assumed to be passed on through the appliance price.

The direct cost of introducing an energy endorsement label to run in parallel with the existing comparative labelling system is expected to be very small. Since the energy performance of all appliance models is already being tested, there would be no additional cost implications in this regard. The additional direct costs would therefore arise only from the development and launch of a

[45] Author's own calculations based on data in REEEP (2014).

design for the endorsement label, and awareness-raising both among appliance suppliers and targeted at households.

Few examples exist of scrappage schemes for household appliances on which to base estimates of likely costs:

- A scheme in the UK to remove from operation a large number of old, inefficient domestic gas boilers offered a rebate of £400 (over R9,000) upon trading in an old boiler with a 'G' efficiency rating. At the time the scheme was running, it was estimated that about 125,000 households would be eligible to receive this rebate, which corresponded to about 16% of the price of a new boiler.
- A pilot scrappage scheme for refrigerators and freezers in the City of Mannheim, Austria, offered a rebate of €100 against the price of an A++ appliance. To qualify for the rebate, consumers were required to produce evidence from a certified facility that the old appliance had been correctly disposed of. This programme was very expensive, costing about €0.39 per kWh of annual savings.

A precise estimate of the cost of a scrappage scheme for South Africa cannot be made until the detailed design is developed. However, the cost may be expected to greatly exceed the total sum of scrappage incentives that are paid out. Additional administrative costs may be high, as official disposal sites would be required to provide certification that appliances had been disposed of correctly. Appliance retailers would also incur the additional cost of processing scrappage certificates.

Direct costs associated with the tightening of building standards are borne by the purchasers of new dwellings (or the state, in the case of subsidised housing) as a result of the increased construction cost. No specific estimates were available of the impact on construction costs, but an indication may be obtained from the figure quoted by the Portfolio Committee on Human Settlements, which suggested a cost increase of R44,000 for a subsidised house. Using data on the rate of delivery of completed housing form the Bulletin of Statistics, this suggests the annual cost of tightening building standards may amount to about R4.4 billion. Note however that this cost will decrease as the practices leading to more energy efficient buildings become established as the norm. It should also be noted that the subsequent occupants of the dwelling benefit from the resulting energy savings. The net lifetime direct cost is therefore expected to be very low.

The use of direct subsidies to support low-income householders in implementing energy efficiency retrofits to projects carries a substantial cost implication. If it is assumed that 10% of the total retrofit savings estimated arise from subsidies, and that the energy saving measures implemented have an average payback period of five years, then the total required subsidy would amount to about R5 billion.

As discussed above, municipalities risk losing an important component of their revenue stream as a result of energy saving initiatives among their household customers. If the co-operation of municipalities is to be mobilised in the delivery of energy efficiency programmes to households, it will be necessary to compensate municipalities for this lost revenue. Typically, municipalities earn a net margin of about 8% on the power they sell (after administrative costs and the costs of managing the distribution network are factored out). This suggests that compensation[46] should be provided at the rate of at 8% of the retail value of any electricity saved. If it is assumed that 20% of the total retrofit savings described above arise as a result of municipality-led programmes, the total cost over the lifetime of the NEES would amount to about R200 million.

6.4 Indirect costs

The most significant indirect cost of tightening MEPS for appliances is likely to be the potential impact on local manufacturers, who may not be able to keep pace with too rapid a tightening of standards. The FRIDGE study reports that a lack of investment in upgrading of local manufacturing plant had led to a large fraction of locally produced appliances[47] having energy performance below the proposed MEPS levels. The report makes a tentative estimate that the cost for retooling a refrigerator manufacturing plant to produce more efficient models would exceed R100 million. A more recent study (Covary and du Preez, 2015) indicates that the long delay in implementing MEPS has provided local manufacturers with time to respond, and that the impact of the initial introduction of MEPS is therefore unlikely to be significant. Providing sufficient advance notice is given that subsequent tightening of MEPS are planned, the adverse impact may be kept to a minimum.

Another potential indirect cost is that, by removing the cheapest new appliances from the market, this may lead those who own older appliances to hold onto them for longer rather than replacing them, with consequent deterioration in performance. However, there is some evidence to suggest that this effect may be very small. Firstly, analysis presented in the FRIDGE report suggests that the relationship between energy performance and price is relatively weak, suggesting that MEPS will not necessarily have a strong upward influence of on price. Secondly, evidence from other countries (Dale and Fujita, 2008 and Galarraga *et al.*, 2011) suggests that the price elasticity of demand for appliances is relatively small, so an increase in price will have only a weak effect on the likelihood that replacement purchases will be delayed.

Removal of the cheapest new appliances from the market may also drive some first-time buyers to the second hand market, where the energy performance of available appliances may be even worse than that of the appliances that have been excluded from the market by MEPS. The likelihood of this happening would be reduced if a scrappage scheme was introduced, but this may leave some low-income households unable to afford an appliance at all. Since no data is available on the extent to which household appliances are bought second-hand, it is not possible to estimate the extent of this effect.

The tightening of building standards will have the indirect impact of reducing the rate at which subsidised housing can be delivered, because of the associated increase in average construction cost. According to the Portfolio Committee on Human Settlements, tighter regulations will increase the amount of subsidy required per dwelling from R66,000 up to R110,000[48]. Assuming the total

[46] Note that this does not imply that the direct payment of a compensation sum is envisaged. Rather, this is more likely to take the form of a fee to municipalities in payment for the services they provide with regard to the delivery of energy efficiency programmes.

[47] Note that, of the categories of appliance discussed here, it is only refrigerators, freezers and tumble dryers that are produced locally in significant numbers.

[48] See for example http://www.parliament.gov.za/live/contentpopup.php?Item_ID=5755&Category_ID=

available budget remains unchanged, this would have the effect of reducing by 40% the number of subsidised homes delivered in a given period.

No significant indirect costs are envisaged for the other components of the package of measures described here.

6.5 Multiple benefits

The combination of MEPS and an endorsement label will act as a stimulus to the local appliance industry to respond to the demands for the most modern and high-quality models, which has the potential to act as a spur for innovation.

A scrappage scheme for appliances would by necessity need to be accompanied by reliable disposal arrangements, which may result in a longer-term reduction in the unregulated disposal of household appliances.

All measures that lead to improvements in the energy efficiency of homes will result in multiple benefits with regard to comfort, health and status, particularly among low-income groups for whom energy costs are a significant burden on household budgets. Widespread retrofitting of homes contributes to an overall improvement in housing quality, which has the potential to regenerate neighbourhoods.

Finally, engaging municipalities in the delivery of energy efficiency programmes provides them with an opportunity to improve their image among constituents.

6.6 Risk factors

The potential risk of an adverse effect on local manufacturers from the introduction of MEPS appears to have receded, as the prolonged process of introducing standards has provided time for upgrading of local manufacturing capacity. Covary and du Preez (2015) report that local manufacturers would now like to see the programme begin without further delay, so further tightenings of standards seem likely to lead to greater innovation and modernisation of the industry.

Appliance retailers are reported to be poorly prepared for the onset of appliance labelling, so there is a risk factor that the introduction of a parallel energy endorsement label may lead to further confusion. To mitigate this risk, careful attention must be paid both to the appropriate timing of the launch of an endorsement label and the raising of awareness among retailers and consumers.

As with other sectors, the tightening of building standards could constitute either a risk or an opportunity depending on the response of the construction industry. If the industry responds slowly and reluctantly, there is a risk that widespread non-compliance could overwhelm municipal building control departments with the additional administrative burden of enforcement. However, a well-publicised trajectory of planned tightenings of standard could, if announced well in advance, serve to stimulate innovation.

The provision of financial incentives towards the cost of energy efficiency retrofits of existing dwellings brings the risk of free-riders. This risk may be mitigated to a large extent by providing incentives only to lower-income households, who would be less likely to make such improvements in the absence of an incentive.

Engaging municipalities in the delivery of energy efficiency improvements to households involves the risk that limited capacity may result in poor levels of delivery. This risk may be mitigated by ensuring that adequate training and capacity-building is provided to municipalities. In this regard, important lessons may be learned from the existing EEDSM programme, which requires a certain level of energy management expertise to exist in the municipal sector.

7 AGRICULTURE SECTOR

The measures proposed for the agriculture sector are:

- Explore the potential for savings in agricultural vehicle use, and develop appropriate awareness-raising material
- Development of targeted awareness-raising and training material on potential savings in motor-driven systems
- Establish the most effective means for providing financial incentives / mobilising funding
- Provide direct grants to small farmers / smallholders for all or part of the cost of interventions

7.1 Description

Relatively little research has been conducted in opportunities for energy savings in the agricultural sector, and most attention has focussed on the savings potential in electric motor-driven systems. Given that two-thirds of the energy consumed in agriculture is in the form of petroleum products, this suggests a significant savings potential in vehicles. More research is required to derive a full understanding of the patterns of fuel use, but the feasibility will be explored for targeted awareness-raising campaigns around vehicle use in the agricultural sector.

The potential for relatively large percentage energy savings through the optimisation of irrigation systems has already been identified. It is likely that similarly large savings potentials exist in other motor-driven systems (e.g. crop dryers, cooling fans for poultry sheds, compressors in cold-storage cooling systems). The provision of high-quality targeted awareness-raising material may be expected to yield significant impacts in these areas. Potential partnerships with various sector associations (e.g. AFASA, AgriSA) will be explored for the development and dissemination of such materials. In particular, the possibility will be explored for including modules on energy efficiency in the training courses run by SABI (the South African Irrigation Institute).

While the larger commercial farmers are likely to have access to bank finance, the smaller farmers and smallholders may be less well served (Oxford Business Group, 2016). Avenues for mobilising funding for energy efficiency improvements will therefore be assessed and developed. For larger projects, this might involve working with SANEDI and the National Treasury to ensure that the 12L tax incentive scheme meets the needs of the agricultural sector. A further potential source of finance is through energy performance contracts with ESCOs, financed through normal bank financing, or through Eskom's ESCO programme. The scope will be explored for providing targeted training to ESCOs wishing to enter the agricultural sector, with the possibility of introducing accreditation for specialist agricultural ESCOs at a later date. For small farmers, it is likely that the most effective way of funding energy efficiency improvements would be through direct grants. Efforts will therefore be made in partnership with DAFF to secure a National Treasury budget allocation for this purpose.

7.2 Estimated energy savings

Little detailed information is available globally on the potential for fuel savings in agricultural vehicle use. A study conducted in Colombia (Ochoa *et al.*, 2013) indicated that 44% savings in fuel consumption could be achieved through optimising ploughing and raking practices. The same study estimated that savings of 15% could be achieved simply through regular maintenance of ploughing equipment. The use of GPS guidance systems along with automated steering have been shown to give fuel savings of 12% in a study conducted in the USA (Bora *et al.*, 2012).

While the latter type of measure is clearly not likely to be relevant to the smaller farmers and smallholders, improved vehicle maintenance and better optimisation of cultivation are likely to be within the reach of all users of agricultural vehicles for traction. Energy savings of around 40% would therefore appear to be achievable through the provision of carefully designed and targeted awareness raising with regard to vehicle use. Given that petroleum products used in vehicles are estimated to account for 66% of total energy consumption in the sector, this equates to a saving of about 26 PJ annually by 2030.

Irrigation is estimated to account for about 9% of total agricultural sector energy consumption in South Africa (Department of Energy, 2012). A study by Eskom identified possible savings of 824 GJ in a sample of 12,000 centre-pivot irrigation systems. Scaling this figure up to the total area irrigated by similar systems across South Africa suggests that the total savings possible in this technology alone are 675 TJ, or over 1% of the total sector energy consumption, or well over 3% of agricultural electricity consumption.

The magnitude of the potential savings in irrigation systems is borne out by a case study from ABB, which describes 40% electricity savings from optimising a system on a farm in North West Province by installing VSDs[49]. The payback period for this investment was only seven months. Other studies suggest significant savings may be achieved by switching from high-pressure to low-pressure irrigation systems, and another case study at a grape farm in the Northern Cape illustrates the feasibility of using solar PV to power irrigation pumps.

Given that the National Development Plan envisages a 33% increase in the area of land under irrigation, the savings potential estimated by Eskom would scale to a saving of about 0.9 PJ by 2030. If the percentage savings achieved in the ABB case study are indicative of the wider potential, the savings may be significantly higher.

Other motor-driven systems used in the agricultural sector include dryers and coolers, which account for at least 3% of the total energy consumption by the sector. The efficiency of these processes can generally be improved through use of better equipment (e.g. VSDs) and proper maintenance. Reducing post-harvest food and grain losses through improved storage methods also results in energy savings, since energy would have been used in producing the lost products.

7.3 Direct cost

The main direct cost components of the package of policy measures are the cost of developing and delivering a targeted awareness-raising programme, and the provision of direct subsidies to small farmer for energy efficiency improvements.

The cost of an awareness-raising campaign depends strongly on the size and scope, and on the channels through which it is delivered. These details will not be known until the programme design

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[49] Article dated 18 March 2014 at http://www.worldpumps.com/view/37508/energy-savings-at-south-african-farm/ (last accessed 3 February 2014)

commences, but an indication of likely costs may be gained by referring to the cost estimates made by the Department of Energy for a National Energy Efficiency Awareness Campaign. This was estimated on the basis of numerous television, radio, print media and billboard advertisements, 150,000 brochures, electronic newsletters, a website and resources for schools. The total cost was estimated in 2011 to be R23 million. It is unlikely that an awareness-raising campaign for energy efficiency in the agricultural sector would require all of these elements, so a tentative estimate for its cost is R16 million.

The provision of targeted direct grants to small farmers for implementing energy efficiency improvements represents a direct cost equal to the total amount of grant funds distributed. If it is assumed that 10% of the overall saving of 1 PJ is delivered through subsidies, then a direct subsidy of R100 per GJ of saving would cost about R10 million.

7.4 Indirect costs

No significant indirect costs are envisaged.

7.5 Multiple benefits

The most important multiple benefit arising from efforts to improve the energy efficiency of the agricultural sector is the direct financial gain to the rural economy. According to the Department of Agriculture, Forestry and Fisheries, farmers' costs have consistently risen faster than the value of agricultural outputs over the past three decades, by a margin of about 3% per year. Given the rate at which electricity prices have risen in recent years, energy efficiency improvements have the potential to mitigate a large part of this increase.

Statistics South Africa estimate that as many as 20% of all South African households are directly connected with agriculture, so the social benefits of shifting agriculture onto a more secure financial footing are potentially huge. Improving the energy efficiency of agriculture may be seen as part of a broader drive to modernise the sector and increase rural employment levels. According to the National Development Plan, the agricultural sector could generate nearly 1 million new jobs by 2030 if its development is managed correctly.

With regard to improvements in the efficiency of irrigation, the multiple benefits are particularly strong. Parts of South Africa continue to suffer from persistent droughts, and the Agricultural Research Council expects water scarcity to become an increasing problem in the future years. Irrigation efficiency is therefore a crucial element in the survival of the rural economy in much of the country.

7.6 Risk factors

No significant risk factors are envisaged.

8 TRANSPORT SECTOR

Improving the overall energy efficiency of the transport sector requires action in four different areas: increasing the fuel efficiency of vehicles, changing driver behaviour, reducing the demand for transport services and bringing about modal shifts. Of these four, the last two fall outside the remit of the Department of Energy, so will not be considered in detail here. In connection with the first two areas, the following package of policy measures is proposed:

- Implement minimum fuel efficiency standards for new vehicles and tyres
- Improve systems for ensuring road-worthiness of existing vehicles
- Encourage domestic car manufacturers to build more efficient vehicles
- Introduce voluntary agreements with private passenger transport companies to improve vehicle performance
- Implement a national eco-drive strategy
- Develop an accreditation scheme for energy auditors for the transport sector

8.1 Description

Because of the dominant role played by road transport in the total energy consumption of the transport sector, this will be the focus of the package of policy measures.

Since 2008, all new cars manufactured in, or imported into, South Africa have required a label specifying the fuel efficiency and CO_2 emission figures as determined in standardised tests. The first element of the package of policy measures proposed here is to complement the existing labelling scheme through the introduction of minimum fuel efficiency standards. This will ensure that the worst performing vehicles from the market. In the medium term, the possibility will be explored of extending the requirement for labelling, and minimum fuel efficiency standards, to heavy road vehicles

A significant fraction of the fuel consumption of vehicles is accounted for by the rolling resistance of its tyres. New vehicles are frequently fitted with higher performance tyres to ensure that they achieve the best possible fuel economy results when tested. However, tyres generally have a lifetime of only about two to three years, so for most of a vehicle's lifetime it will be operating with replacement tyres. The introduction of a standards and labelling scheme for tyres will ensure that the decline in energy efficiency resulting from tyre replacement is minimised.

At present, light road vehicles in South Africa are required to undergo a roadworthiness test when ownership changes, while heavy road vehicles are required to be tested annually (or every six months, in the case of buses). The emissions of vehicle are not tested as part of the roadworthiness test.[50] The package of measures examined here includes a proposal to introduce emissions testing as part of the roadworthiness test, and consider introducing a requirement for light road vehicles to be tested annually. Although not specifically a fuel efficiency test, emissions being tested for (carbon monoxide, hydrocarbons and particulates) provide a strong indication of whether the performance of vehicle is satisfactory. A regular emissions test would ensure that vehicles whose fuel efficiency had fallen well below design levels are identified and removed from service.

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[50] Although legislation was published for public comment in 2012 that would introduce bi-annual testing of light road vehicles, the requirement for regular testing has not yet been introduced.

The existence of a standards and labelling scheme for new vehicles should in itself act as a strong motivating influence on local vehicle manufacturers to improve the efficiency of the vehicles offered. To accelerate this trend, the possibility will be explored of entering into voluntary agreements with manufacturers to introduce a range of energy efficient technologies as standard into locally made vehicles at the earliest opportunity. Examples of such technologies include tyre pressure monitoring systems, in-car feedback instruments and engine start-stop systems.

To complement the policy measures aimed at influencing the efficiency of the vehicle stock, three further measures will address the efficiency of use. First, voluntary agreements will be sought with private passenger transport companies to improve vehicle performance. Cost-effective steps that transport companies may take to improve performance include driver training and the adoption of a vehicle fleet energy efficiency strategy.

Second, a national eco-drive strategy will be developed and implemented. The details of the strategy will be defined during the development phase, but it is likely to include incorporating energy-efficient driving into the curriculum of driving schools. The possibility will also be explored of incorporating elements of eco-driving into the awareness-raising materials produced under the 49M brand.

Third, the feasibility will be investigated of developing an accreditation scheme for energy auditors for the transport sector. The creation of a network of accredited specialist transport energy auditors would facilitate the management of fleet performance among companies and public sector bodies with significant vehicle fleets.

8.2 Estimated energy savings

In an unpublished 2015 study conducted for the Department of Transport, it is tentatively estimated that the potential for savings of about 24% exists from improvements in vehicle efficiency in road vehicles. However, it is not clear whether this relates only to savings resulting from improvements to the efficiency of new vehicles, or whether there is also an implication of an accelerated rate of removal of older, poorly performing vehicles from the roads.

The IEA estimates that there is potential for the fuel economy of new vehicles to be improved cost-effectively by 50% by 2030 (IEA, 2010). It is realistic to expect that, with regular roadworthiness that include an emissions test, the bulk of the road vehicles in use today will have been scrapped by 2030. If the potential improvement in fuel economy envisaged by the IEA is realised, this implies that the average fuel efficiency of the vehicle stock in 2030 will be some 25% better than today's *new* cars.

In this regard, the estimations made by the Department of Transport appear somewhat conservative. Nevertheless, using this conservative estimate of the potential improvement in the fuel efficiency of the vehicle stock, and based on expected growth rates in vehicle numbers, the total annual energy savings resulting from higher fuel efficiency standards in new cars is estimated to be about 100 PJ by 2030.

The combination of policy measures aimed at improving the energy efficiency of the existing vehicle stock may be expected to yield the following savings:

- ***Voluntary agreements with private passenger transport companies***. Data is sparse on the savings that may be obtained through implementing best operational and maintenance practices in passenger transport vehicle fleets. Available estimates range from 5-6% (ESMAP, 2011) to greater than 10% (TfL, 2011).

- ***Eco-driving***. Results from the UK Drive Smarter campaign[51] indicate 15% savings on the day of training, and long-term sustained savings of 1-6%. An IEA study on the potential for energy savings in transport (IEA, 2010) suggests that longer term savings from eco-driving training may be higher: "Immediately after eco-driving training, average fuel economy improvements of between 5% and 15% were recorded for cars, buses and trucks. Over the medium term, fuel savings of around 5% were sustained where there was no support beyond the initial training or around 10% where further feedback was available."

8.3 Direct cost

Since 2008, all new cars have to carry a label indicating their average fuel consumption and CO_2 emissions, so the incremental cost of introducing minimum standards is expected to be minor. With regard to tyre standards and labels, ISO 28580 is not yet incorporated into SANS, so this would carry some cost implications. In particular, there is no appropriate testing laboratory for tyre rolling resistance at present, which constitutes a direct cost of introducing this measure.

Roadworthiness testing centres already exist, but are presumably not currently equipped to undertake emissions tests. If roadworthiness testing is moved to a regular annual requirement, this would result in a significant increase in the required throughput of testing centres, and it is likely that additional centres would need to be created to handle the additional volume. It may be assumed that, in the long run, these costs would be passed through to vehicle owners in the form of test fees.

8.4 Indirect costs

A potential indirect cost of the introduction of stricter fuel efficiency standards, and of the adoption of additional energy savings features in cars, is that this will lead to an increase in the average cost of new vehicles. This might in turn provide a disincentive to replace older vehicles, or increase the number of second hand vehicles on the road. However, the introduction of emissions tests in regular roadworthiness tests would help to reduce the likelihood of this occurring.

8.5 Multiple benefits

The main multiple benefits expected from the package of policy measures describe here include: quieter cars, due to reductions in tyre noise; improved road safety, as a result of more frequent roadworthiness testing; reduced urban air pollution from reductions in the average fuel consumption of vehicles and, in particular, removal from the roads of the most polluting vehicles.

8.6 Risk factors

No significant risk factors are envisaged.

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[51] See http://www.energysavingtrust.org.uk/domestic/drive-smarter

9 ENERGY PRODUCTION AND DISTRIBUTION

The measures proposed for the energy sector are:

- Developing an enabling framework for cogeneration and trigeneration
- Introducing energy efficiency obligations on generators and distributors of electricity
- Expansion of internal efficiency programmes for producers

9.1 Description

Procurements for IPPs using cogeneration launched by Eskom in the mid-2000s were unsuccessful, with only about 400 MW of industrial capacity being brought in through short-term power purchase contracts. Co-generation is not currently incentivised, specifically as the Carbon Tax does not take into consideration electricity fed back into the grid. The feasibility will therefore be explored of extending the eligibility of REIPPP to include industrial cogeneration (subject to minimum efficiency thresholds) and the generation from industrial waste heat recovery. This will also entail developing a methodology for determining the eligibility criteria for cogeneration / waste heat recovery plants.

An effective approach method that has been used internationally (particularly in Denmark and the UK) to initiate significant energy efficiency savings has been to place energy efficiency obligations on all players in the electricity supply chain (generation, transmission and distribution). This requires specific savings to be achieved by the utility companies, while allowing them autonomy to establish how best to achieve those savings. The funds necessary to cover the costs of the savings measures and lost revenues are typically raised through a levy on the tariff. A similar system will be considered for implementation in South Africa, which would place an obligation on Eskom as well as all IPPs above a certain size threshold and on municipalities who are involved in the distribution of power.

In addition to placing an energy efficiency obligation on all participants in the electricity supply chain, a further policy measure to be considered is to set mandatory targets on all generators for the achievement of efficiency savings within 'internal' operations (i.e. any operations not directly involved in the generation of power, such as buildings and vehicle fleets). Eskom has already made significant progress in this respect, through its Internal Energy Efficiency programme, but as more IPPs begin to emerge it is essential that all meet the same high standards of internal energy efficiency. This will ensure that the power generation sector is seen to be "leading by example".

9.2 Estimated energy savings

The Department of Energy Integrated Energy Plan (2012) and Integrated Resource Plan (2010-30) jointly define the anticipated energy mix with a view to informing policy to address future energy service needs efficiently and in the most socially beneficial manner. It is likely that coal will continue to be a significant factor[52], but the IEP does build in improvements in coal technologies. The overall thermal efficiencies of the power plant can be improved from the current average of 33% to roughly 38% by the year 2030 with the inclusion of super critical boiler higher efficiency coal power plants and IGCC type power plants. Retirement of older, inefficient power plants (particularly return-to-

[52] Note however that recent modelling studies on the impact of a carbon tax indicate that the share of coal in power generation would fall to below 75% by 2035 (Arndt, 2016)

service plants) has to be implemented once the two new coal-fired power plants (Medupi and Kusile) are completed. These efficiency improvements represent an annual energy saving of about 300 PJ.

It has been estimated that the potential exists for at least 900 MW_e of industrial cogeneration capacity in South Africa (EE, 2009), which would generate about 20 PJ annually as base-load plant. Arcelor Mittal already have over 30 MW_e of cogeneration plant installed in the steel industry, and estimate that the potential exists to expand this to over 100 MW_e. Mondi have about 95 MW_e of cogeneration capacity using biomass waste.

Biomass waste (bagasse, timber and sawmill waste and waste from the pulp and paper industry) represents one of the largest potential sources of power from cogeneration. The total volume of such material was estimated in 2004 to represent a total resource of about 46 PJ (Petri, 2014). However, the actual yield of electricity from this resource if fully utilised in cogeneration plant would be considerably less, and it is not clear from the figures reported whether this included resources that were already being exploited. Other estimates put the potential power generation from bagasse at about 400 MW, with a possibility to increase this to 2,000 MW within 20-30 years, at an investment cost of about R10/W[53].

Significant potential also exists to generate power from waste heat recovery in various industries. This is already being exploited by various players particularly in the metals industry. For example, Samancor have a 30MW plant at the Tubatse ferrochrome smelter, while AngloPlatinum are producing 3.8MW of power from waste heat recovery at their Rustenburg smelter. The potential for generating power from waste heat recovery in the cement industry has been estimated at 55-100 MW (IIP, 2014), which would represent about 2 PJ annually if operated as base-load plant.

By international comparisons, the overall losses in South Africa’s electricity transmission and distribution system are at an acceptable level, at about 9%. However, this figure masks some very high losses in the low voltage distribution networks operated by municipalities. It is estimated that 18% of electricity that is bought from Eskom by municipalities is lost, with some municipalities reporting losses (both technical and non-technical) of 30-40% and the City of Johannesburg estimating its losses to be 22%.

Based on data provided by Eskom, about 22 TWh were lost during 2013 in distribution and transmission. Eskom has initiated the Energy Losses Management Programme (ELP) with activities being undertaken to reduce theft and tampering and feeder losses. Based on these efforts, distribution feeder losses decreased by an average of 13% between 2013 and 2014. However, it is likely that significant losses remain in the low-voltage distribution systems. Achieving a reduction in overall losses of one percentage point would represent a saving of about 9 PJ. Given that it is likely that municipalities are incurring significant losses, addressing these would remove a large burden from municipal budgets, enabling them to allocate more resources to the delivery of other essential services.

9.3 Direct and indirect costs

Costs could not be estimated at the time of writing due to unavailability of necessary data.

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[53] Engineering News, Sep. 1, 2006 (http://www.engineeringnews.co.za/article/sa-urged-to-take-seriously-cogeneration-opportunities-2006-09-04)

9.4 Multiple benefits

The most significant multiple benefits are the freeing up of municipal finances to allow more to be spent on delivering other vital services, and the greater political acceptability of future tariff increases if Eskom and other entities involved in the generation and distribution of power are seen to be striving to eliminate waste.

9.5 Risk factors

No significant risk factors are envisaged.

ANNEX 1 – Simple spreadsheet model for estimating the effects of MEPS for electric motors

A simple spreadsheet model was created to estimate the likely effects of introducing MEPS for electric motors. To simplify the calculations, only the 'motor-intensive' sectors were considered, which are defined here as manufacturing, mining and water utilities. The starting point for the simple model was the estimate by the IEA that electric motors in these sectors accounted for 78 TWh in 2006 (IEA, 2011b). The assumptions on which the simple model are based were as follows:

- Total consumption of motors in the motor-intensive sectors is proportional to the GDP of those sectors
- Overall annual economic growth is projected at 3.9%, which is the value used in the modelling of the carbon tax (see Section 2 above) and a more conservative estimate than that used in the National Development Plan
- The share of GDP accounted for by the motor-intensive sectors will continue the trend observed between 2006-2012
- The average motor lifetime is 20 years, so that 5% of the current stock of motors are replaced within the following year
- The effect on efficiency of excluding sub-IE3 motors is estimated based on the assumptions that:
    - the market share by motor size mirrors the distribution of motors in use reported by Mthombeni (2008);
    - the sub-IE3 motors that would be purchased in the absence of MEPS are split 70:30 between IE2 and IE1;
    - efficiency levels are based on 2-pole motors
- The fraction of new motors affected by MEPS begins at 50% of all new motors and falls linearly to zero over a ten-year period. This reflects the likely 'autonomous change' in the efficiency of motors through time even in the absence of MEPS
- MEPS are introduced from 2020

The results of the simple spreadsheet model are shown in Table 7 below. The GDP of the motor-intensive sectors rises slightly until 2025, then falls to R61.7 billion by 2030. It is this figure that determines the total consumption of motors in use in these sectors, which rises from 79 TWh in 2015 to a maximum of 84 TWh before falling back by 2030. The consumption of new motors added annually falls steadily from 4.8 GWh in 2015 to 3.6 GWh in 2030.

The overall effect of introducing MEPS according to this model is a total energy saving of about 382 GWh, or 1.38 PJ. This figure rises to 1.99 PJ if the higher GDP growth rate of 5.4% is used since, under this scenario, the consumption by motors in the motor-intensive sectors continues to grow substantially throughout the whole time period shown. The timing of these energy savings within the 15-year period of the Energy Efficiency Strategy depends on when MEPS are launched. In the simple model depicted above, MEPS are implemented from 2020, and the energy savings that result occur throughout the remaining period to 2030, but at a declining level due to the assumption that a certain level of autonomous improvement in efficiency change would be taking place even in the absence of MEPS.

Table 7 Results of simple spreadsheet model of effects of MEPS

	GDP (billion const. 2010 R)			Consumption (TWh)			
YEAR	Total	Share in motor-intensive sectors	Motor-intensive sectors	Motors in motor-intensive sectors	New motors purchased in motor-intensive sectors	Fraction of new motors affected by MEPS	Energy saving as a result of MEPS (GWh)
2015	286	0.21	58.8	79	4.8	0	0
2016	297	0.20	59.4	80	4.8	0	0
2017	309	0.19	60.0	81	4.8	0	0
2018	321	0.19	60.5	81	4.8	0	0
2019	333	0.18	61.0	82	4.7	0	0
2020	346	0.18	61.5	82	4.7	0.5	99.6
2021	360	0.17	61.8	83	4.6	0.45	90.3
2022	374	0.17	62.2	83	4.6	0.4	80.7
2023	388	0.16	62.4	84	4.5	0.35	70.8
2024	403	0.16	62.6	84	4.4	0.3	60.7
2025	419	0.15	62.7	84	4.3	0.25	50.4
2026	435	0.14	62.7	84	4.2	0.2	40.1
2027	452	0.14	62.6	84	4.1	0.15	29.8
2028	470	0.13	62.4	84	3.9	0.1	19.6
2029	488	0.13	62.1	83	3.8	0.05	9.6
2030	507	0.12	61.7	83	3.6	0	0.0
TOTAL							**382.1**

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