FACTORING EXTERNAL COSTS INTO POLICY AND INVESTMENT DECISION MAKING

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ABSTRACT

South Africa's addiction to fossil fuels for both electricity production and freight transport place significant external costs onto society. This paper identifies and reviews such external costs, particularly those resulting from greenhouse gases (GHGs) and air pollution. An economy-wide carbon price required to achieve the 2^{0}C target of the Paris Agreement is also identified from the literature. The aim of the paper is to provide policy and decision makers with a road map for estimating and including externalities in their decision making processes and to illustrate the significant size of fossil fuel externalities. Road freight was found to generate GHG and air pollution externalities of approximately R10.42/t.km, while rail freight only generated an estimated R0.012/t.km for GHG and air pollution related externalities. Coal-based electricity was found to have an external cost of about R0.48/kWh in terms of GHG and air polluting impacts. To achieve the 2^{0}C target, it was found that an economy-wide carbon price of R505.63/tCO_2e is required by 2020. It is important to note that external cost estimations are extremely context specific, and dependent on a number of variables. The reported figures should be used only as a guideline to begin to encourage the wider use and reporting of externalities in policy and investment decision making.

1. INTRODUCTION

The world's dependence on fossil fuels has a number of social and environmental impacts that place an external cost onto society. These include climate change, biodiversity loss, ecosystem degradation and air and water pollution, amongst others (Vivid Economics, 2016). South Africa is no exception – approximately 90% to 95% of electricity is generated from non-renewable resources, such as coal, and almost 90% of long-distance freight transport is transported by road and the combustion of liquid fuels (Thopil & Pouris, 2015; Havenga, 2015). Passenger transport in South Africa is also heavily dependent on liquid fuels (Havenga, 2015). This presents a skewed dependence on non-renewable fossil fuels and places a significant environmental externality on South African society.

External costs, or negative externalities, are negative side effects imposed onto a third party (or broader society) by the production and/or consumption of goods or services. By definition, these are not accounted for (or internalised) by those producers or consumers, and they are a cause of *market failure* in that the market price does not reflect the *true cost* of the good or service. The external costs of fossil fuels, for example, would include those associated with health impacts from air pollution and climate change, among others (Vivid Economics, 2016).

In an effort to correct market failure, so that producers and consumers make side-effects part of the decision making process, governments must encourage producers and consumers to internalise the full social cost of a particular activity. This can be achieved through regulation or market based incentives, such as a carbon tax, for example.

Current prices for coal-based electricity reflect only the private (capital investment and operating) costs of generating the electricity and is, therefore, under-priced and at risk of being over-produced. Estimating the value of external costs from coal-based electricity production is the first step towards correcting this market failure. Providing the necessary price signal will encourage more sustainable production and consumption.

Estimating the external cost must include all external impacts and damages attributed to generating electricity from coal, including coal mining; transporting coal; power plant and related infrastructure construction; coal combustion and disposal of waste products, for example (Grausz, 2011; Vivid Economics, 2016). Incorporating the external cost with the private cost of coal-based electricity will increase the price producers charge per kilowatt hour (kWh) of electricity. This will correct the market failure and encouraging a shift away from coal-fuelled to relatively lower-cost renewable energy technologies. Externality valuation is, therefore, necessary for correct pricing and better investment decision making (Havenga, 2015).

One approach for governments to incorporate an external cost of climate change across the economy is to establish a carbon price and impose it on the economy as a whole, via a carbon tax, for example. This market-based approach attempts to encourage a shift towards a more carbon efficient economy by making carbon intensive goods and services relatively more expensive (Kaufam, et al., 2016).

This paper identified external costs from the literature resulting from coal-based electricity production and road and rail freight transport activities in South Africa, with a particular focus on greenhouse gas (GHG) and air pollution externalities. In addition, an economy-wide carbon price, required to prevent average global temperatures from increasing by more than 2^0C above pre-industrial levels (referred to as the 2^0C target), was identified from the literature.

Preference was given to local externality estimates that reported external costs on a *per unit cost* basis. Where local estimates could not be verified or where there were methodological or data inadequacies, international estimates that are suitable for the South African context were considered.

The aim was to provide a road map for policy and decision makers to factor in external costs estimations into their decision making process; identify the latest external cost estimations and to illustrate two important points:

i. External costs from South Africa's dependence on fossil fuels are significant in relation to private costs, and
ii. External costs can be larger than private costs - enough to make the energy option with the lowest initial private cost become the most expensive energy option, or have the highest social cost, after accounting for external costs.

Estimating externalities is extremely context specific and, therefore, the reported figures should be **taken only as a guideline** to begin to encourage the wider use and reporting of externalities in policy and investment decision making. Actual monetary values are not generic and require significantly more research before they can be used in other policy work.

2. ROAD AND RAIL FREIGHT TRANSPORT EXTERNALITIES

A number of studies have quantified and valuated externalities from transport and logistics operations in South Africa. However, the practice is still very much in its infancy (Havenga, 2015), and few studies provide per unit cost estimations for different externality categories. Two key pieces of local literature, Swarts et al. (2012) and Jorgensen (2009), estimated externalities resulting from accidents; emissions and congestion from road and rail freight activities in South Africa, amongst others. Table 1 summarises these externality estimations, which were adjusted for inflation[1] and reported in 2018 Rand per tonne kilometre (R/t.km) prices.

Table 1: Road and rail based freight externalities in South Africa

Externality	Road freight (R/t.km)		Rail freight (R/t.km)		References
	Low	High	Low	High	
Accidents	0.08[A]	0.11[B]	0.01[B]	0.01[A]	[A] *Estimates from Swarts et al.* (2012) [B] *Estimates from Jorgensen* (2009)
Emissions	0.07[A]	0.12[B]	0.01[A]	0.03[B]	
Congestion	0.03[A]	0.05[B]	0.00	0.00	

Road freight externalities are significantly higher than those associated with rail freight, suggesting a switch to a predominantly rail based freight transport system will have significant social benefits, or at least avoid such high external costs. External costs from road accidents (R0.11/t.km) and emissions (R0.12/t.km) are the largest externalities associated with road freight (Table 1).

Swarts et al. (2012) applied a logistics model approach to quantify freight externalities in South Africa. Damage costs were used to estimate road accident externalities by adapting the methodology from a study by CSIR Transportek (DoT, 2004) to reflect freight vehicle accidents only. Road accident costs included vehicle damages, insurance, towing, fatalities, legal and medical expenses (Swarts, et al., 2012).

Due to lack of data a top-down approach was used to estimate emissions externalities from road freight transport. The newly developed method used in this study was based on the offset cost of emissions from the European Union (Van Essen, et al., 2008) and converted through purchasing power parity- (PPP) adjusted GDP per capita. Empirical data was sourced from the Freight Demand Model (FDM) for South Africa as applied in the Logistics Cost Model (Havenga, 2010) and used in tandem with vehicle data from the Road Freight Association (RFA, 2011).

A conservative approach was used to estimate congestion externalities from road freight transport and was based on national vehicle statistics. The methodology assumed that, on average, most people drive at the speed limit. The difference in average speed observed

[1] Inflation adjustments made according to South Africa's Historical CPI inflation (Stats SA, 2018).

and the speed limit are therefore attributable, under the assumptions, to congestion (Swarts et al., 2012).

Jorgensen (2009) provides a discussion paper that explains the local context well and provides expert opinion on freight externalities. The study utilised externality estimates from both local and international research thought to be applicable to and reflective of the South African case. The study utilised a value transfer approach, where external add-on cost figures were used and assumed to reflect local conditions. The paper reported external costs for accidents, emissions and congestion for two sites in South Africa: (1) the forestry traffic in the Natal Midlands, and (2) the Johannesburg – Durban N3 corridor.

While Jorgensen provides a very useful basis for understanding the South African context and limitations in terms of South African studies, the paper is not peer-reviewed and the level of information on sources, methods and data do not provide a basis on which to assess the reported estimates.

While these local estimates provide a valuable starting point for local freight externality estimates, they can be improved on when taking into account the methodological and data limitations. Firstly, local freight externality estimates are low by international standards. In general, valuations of morbidity and mortality tend to be relatively lower in South Africa due to factors such as lower on average levels of income, higher levels of unemployment and shorter lifer expectancy compared to developed countries in the international literature (Hammitt & Robinson, 2011).

Accident externalities reported in Swarts et al. (2012), for example, reflect this trend and are also low in comparison to those in international studies (Demir, et al., 2015). On investigation of the source of the estimate (the Transnet Annual Report 2010) the rail freight estimate appears to be the Transnet internalised cost of accidents. Description of this cost in Transnet sustainability reports explains that this loss does not include costing for most, if not all, public fatalities for which Transnet would have no liability, such as accidents in which victims ignore signals to clear a level crossing, trespass or are involved in criminal activity. Transnet costs also exclude losses by family or friends who give up school or work to care for disabled victims of accidents. The road freight estimate also excludes amounts paid out (or anticipated to be paid out) by the Road Accident Fund, as is generally accepted practice.

Secondly, Swarts et al. (2012) combines externalities from air pollution and GHG emissions as a single estimate. This is somewhat problematic since calculations for estimating climate and health externalities must be done independently for reasons that the type and scale (in time and space) are different. For example, Swarts et al. (2012) uses an offset approach which is suitable for climate externalities but not for human health because illness and fatality impacts of harmful pollutants in one area cannot be avoided by reducing pollution in other locations, whereas climate impacts can.

The methodology in Swarts et al. (2012) can be improved by accounting for carbon dioxide equivalence of freight nitrous oxide emissions. Rail freight emissions estimates would be improved by including diesel emissions – the International Energy Agency estimates that electricity accounts for approximately two thirds and oil products for around a third of rail energy consumption in South Africa (IEA & UIC, 2012).

Therefore, to complement local estimates, freight externality costs were identified from international literature and reported in Table 2 in 2018 Rand per tonne kilometer (R/t.km) prices. This was done on the basis that sufficient information was provided to convert these estimates into local values, and to understand some of the bias introduced by using these values.

Table 2: International road and rail freight externalities applicable to South Africa

Externality	Road freight (R/t.km)		Rail freight (R/t.km)*		References
	Low	High	Low	High	
Accidents	0.02[C]	6.9[C]	0.01[C]	0.02[D]	[C] *Estimations from Korzhenevych et al.* (2014) [D] *Estimations from ECORYS* (2004)
Air pollution	0.05[C]	8.45[C]	0.01[C]	0.13[C]	
GHG emissions	0.03[D]	1.97[C]	0.04[C]	0.06[D]	
Congestion	0.29[D]	60.29[C]	0.00[D]	0.03[C]	

**Note: International rail freight figures for climate change and human health externalities reported in Table 2 are unsuitable to transfer to the local context because no country shares South Africa's unique rail energy source profile of mostly coal-fuelled electricity and a small proportion of diesel (8.5%)* (DoT, 2004).

Korzhenevych et al. (2014) employed the best practice estimation of congestion costs which was based on speed-flow relations, value of time and demand elasticities. For air pollution costs, the impact pathway (or damage cost) approach is broadly acknowledged as the preferred methodology, and the valuation of the respective health effects was based on the willingness-to-pay concept. Marginal accident costs were estimated using the risk elasticity approach and values of statistical life. Given long-term reduction targets for GHG emissions, the abatement cost approach (in contrast to the damage cost approach used for other environmental impacts) is the best practice for estimating climate cost (Korzhenevych, et al., 2014).

The range in estimated externalities in Korzhenevych et al. (2014) is due to the inclusion of different size trucks (between 7,5t and 32t), and a range of urban, suburban and rural motorways. The study uses EURO II fuel specification values for climate externality estimations and is considered to be an update and improvement on the 2008 Handbook on estimating externalities from transport (Maibach, et al., 2008).

ECORYS (2004) quantified air pollution, global warming, accidents and congestion externalities using marginal cost estimates from former Director General for Energy and Transport (DG TREN) research (UNITE, RECORDIT, REALISE) and other sources. External impacts reported in ECORYS (2004) are not restricted to the period 2007-2013, but are also valid beyond the year 2013. Therefore, the calculated impacts represent the minimum value, while the actual impacts are potentially higher.

It must be noted that international rail freight figures for climate change and human health externalities reported in Table 2 are unsuitable to transfer to the local context because no country shares South Africa's unique rail energy source profile of mostly coal-fuelled electricity and a smaller proportion of diesel (DoT, 2004; IEA & UIC, 2012).

Despite the relative differences in estimated externality values between local and international studies, their message is the same: road freight transport in South Africa generates significantly higher external costs than rail freight. This should encourage investors, policy and decision makers to begin to shift road freight onto rail.

3. ELECTRICITY EXTERNALITIES

The production of coal-based electricty generates significant externalities along its value chain, from mining through combustion and to the eventual disposal of coal waste products. While there are several studies that have estimated externalities from coal-based electricity in South Africa, few appear to report on the various catagories of externalities and/or report external costs on a *per unit* measurement basis, such as cost per kWh.

Nkambule and Blignaut (2017) report various external costs from the coal-fuel cycle of Kusile power station over its 50 year life span. The Kusile power plant presents a unique case among South Africa's coal-fired power stations in that it uses wet flue-gas desulphurisation (FGD) technology, which reduces sulphur emissions but increases water and coal demand, thereby increasing GHG emissions (Nkambule & Blignaut, 2017).

The *total value* of externalities from Kusile power plant were estimated to range between R1 449 billion to R3 279 billion, equivalent to R0.91/kWh and R2.05/kWh. Table 3 summarises the various external costs and stages of the coal fuel cycle from Kusile power plant. However, these were not reported on a per kWh basis for each of the various external impacts and, therefore, not considered for the purpose of the paper.

Table 3: Estimated external costs of Kusile Power Plant over its 50 year life span

Externality	**Units**	**High externality estimation**
GHG emissions	R billion	379.5
Human health (air pollution)		749.6
Water usage		2 142.6
Total*		3 279
Levelised externality cost of coal-based electricity	R/MWh	2 051,6

**Note: The total externality value is inclusive of other external cost not reported in the table, such as water pollution, fatalities and ecosystem loss. Source: Nkambule and Blignaut* (2017, p. 8).

From a policy perspective it is important to include and evaluate externalities associated with various stages of the coal-fuel life cycle. For example, if a policy seeks to improve water use efficiency, or reduce the impacts on human health, reporting externalities for each lifecycle stage will allow policy and decision makers to target problematic areas and achieve their goals. Nkambule and Blignaut (2017, p. 7), suggest that *coal mining* and *plant operations* consume the most water resources (36.6% and 30.7% respectively) and should, therefore, be targeted first for improving water use efficiency, for example.

Thopil and Pouris (2015) found *total* external costs of non-renewable electricity production to be between R0.09/kWh to R0.59/kWh. Thopil and Pouris (2015) provide relatively low cost estimates for mortality compared with morbidity and chronic bronchitis. This is due to a material error where they adopt a Value of Life Year (VOLY) estimate from an ExternE study and use it as a Value of Statistical Life (VSL).

Table 4 provides a summary of external cost estimates for selected impact categories from non-renewable electricity production (Thopil & Pouris, 2015, p. 505). Again, these values were not reported on a per kWh basis for each external impact and thus not considered for the purpose of the paper.

Table 4: Aggregated external cost estimates

Externality	High externality estimation (R million)
GHG emissions	66 651.8
Human health (air pollution)	8 770.4
Water usage	819.75
Total*	76 260.93

**Note: The total externality value is inclusive of other external cost not reported in the table, such as occupational health and nuclear externalities related to public and occupational health*. *Source: Thopil and Pouris* (2015, p. 505).

Thopil (2013), however, provided external costs estimations for various external impacts from coal-based electricty on a per kWh basis, and was thus included in the paper (Table 5). Thopil (2013) estimated a number of external costs for each coal-fired power station in South Africa individually. External costs from GHG emissions, human health impacts from air pollution, and water consumption from Thopil (2013) were aggregated, adjusted for inflation[2] and reported in 2018 Rand per kWh (R/kWh) prices in Table 5.

GHG externality estimations were based on the Impact Pathway Approach and ExternE methodology, where values were converted to Rand using PPP exchange rate for 2008. Human health externality estimations (from air pollution) were based on damage cost estimates and dose response functions for different pollutants at each coal fired power plant. The economic value of water used in Thopil (2013) was chosen from King 2002 in (De Wit & Blignaut, 2004). A value of R3/m^3 was based on a Willingness-to-pay approach (Thopil, 2013).

Table 5: Electricty externalities in South Africa

Externality	Units	Coal based electricity external cost
GHG emissions	R/kWh	0.43
Human health (air pollution)	R/kWh	0.06
Water	R/m^3	3.00

Source: Thopil (2013).

The figures reported in Table 5 were not based on a Life Cycle Anaysis and only focus on the generation stage of electricty production, emplying true external cost could be significantly larger. Thopil's (2013) analysis doesn't take into account nitrous oxides (NO_x), which are subject to regulation both as pollutants and GHGs. Only two of the 14 power stations reviewed in this analysis (Kendal and Matimba) are complient with National Minimum Emissions Standards for NO_x and thus the reported external costs can be regarded as **conservitive estimates**. For this reason, 'high estimates' of the external costs for GHG emissions, public health impacts and water usage reported in Thopil (2013, pages 109, 90 and 117 respectively) were selected for the purposes of the paper.

Human health impacts from air pollution are estimated to be as much as R0.06/kWh, while externalities from to GHG emissions are as much as R0.43c/kWh. Water consumption externalities were estimated at R3/m^3, the largest external cost from coal-based electricity in South Africa (Thopil, 2013).

[2] Inflation adjustments made according to South Africa's Historical CPI inflation (Stats SA, 2018).

Estimating externalities becomes more meaningful to policy and decision makers in the context of existing market prices. To this end, Thopil and Pouris (2015) compared external costs of electricity with 2008 consumer electricity tariffs. The average external costs (estimated within a specific context) were added to average electricity tariffs (Table 6) to obtain an average internalised electricity price. This resulted in an average tariff increase of between 30% and 181% for 2008 electricity tariff prices (Thopil & Pouris, 2015). This is equivalent to a 2018 internalised electricity tariff of between R0.43/kWh and R0.92/kWh for coal-based electricity. Note that these externality estimations differ from those reported in Table 5 due to the specific context of the study by Thopil and Pouris (2015).

Table 6: Internalisation of total average costs to average overall tariffs

Estimate	Average external cost R/kWh	Internalised average tariff R/kWh	% Increase on 2008 prices
Low	0.06	0.26	30
Central	0.13	0.33	69
High	0.35	0.55	181

Adapted from: Thopil and Pouris (2015)

The price increases observed in Table 6 are, once again, only an indication of how accounting for external costs can increase the cost of electricity. Ideally, the external costs generated by coal-fired power plants still need to be effectively integrated into the price structure of electricity. Nkambule and Blignaut (2017) suggest a conservative account of external costs from coal-derived electricity doubles to quadruples the electricity price, consequently making renewable energy options more attractive alternatives.

4. THE 2^{0}C CARBON PRICE

There are a number of carbon price estimations required to prevent average global temperatures from exceeding 1.5^{0}C and/or 2^{0}C targets. These are often based on very complex scenario analyses, with various assumptions that ultimately influence the carbon price. These assumptions might include projected energy demand, fuel prices, mitigation targets, available technologies, policy assumptions and socio-economic conditions (Fifita, et al., 2018). Table 7 summarises the most recent global carbon prices required to achieve the two temperature targets in 2020 and 2030 (in 2018 prices).

Table 7: Global carbon prices required to achieve the 1.5^{0}C and 2^{0}C targets

Source	Target	2020 carbon price (R/tCO_2e)		2030 carbon price (R/tCO_2e)	
		low	high	low	high
IPCC 1.5^{0}C Report 2018	1.5^{0}C	826.74	33 681.89	1 395.54	56 855.48
High level commission on carbon prices 2017	2^{0}C	505.63	1 011.63	853.51	1 707.64
World Energy Outlook 2015	2^{0}C	238.15	na	1 190.74	na

Sources: IPCC 1.5ºC report 2018 (Fifita, et al., 2018)*; High level commission on carbon prices 2017* (CPLC, 2017)*; World Energy Outlook 2015* (IEA, 2015).

There are also a number of studies that attempt to quantify the social cost of carbon, which is based on the damage costs associated with climate change and are not related to the 1.5^{0}C and 2^{0}C targets. These estimates of the social cost of carbon are not included in the paper since they do not speak to a carbon price level required to achieve the 1.5^{0}C and/or 2^{0}C target (Fifita, et al., 2018).

According to the new IPCC 1.5^{0}C report, global carbon prices required to achieve the 1.5^{0}C target range between R826.74/tCO_2e and R33 681.89/tCO_2e (Fifita, et al., 2018). Such a wide range is indicative of the range of assumptions and influencing factors that impact carbon price estimations. This estimation is fundamentally different to the concepts of the social cost of carbon and a cost-benefit analysis of the carbon price. Under the cost-effective analysis modelling framework, used within the report, the carbon price reflects mitigation requirements at the margin. This provides a marginal cost of mitigation of one extra unit of emission to achieve a particular temperature target (Fifita, et al., 2018).

The carbon price varies substantially between models and scenarios within the report and increases with mitigation effort. This wide range of carbon prices depends on a number of influential variables, including methodologies, mitigation targets, projected energy demands, fuels prices, technology and policy assumptions, and socio-economic conditions. It is necessary to note that while the price of carbon is important to encourage deep mitigation required for 1.5°C consistent pathways, complementary policies are also required (Fifita, et al., 2018).

The high level commission on carbon prices 2017 (CPLC, 2017), examined carbon prices that would be consistent with achieving the temperature objectives of the Paris Agreement and suggests a 2020 price of between R505.63/tCO_2e and R1 011.63/tCO_2e is required. This included a review of multiple lines of evidence and scenarios on technology road maps, national development and mitigation pathways and global Integrated Assessment Models (IAMs). IAMs were used to produce future scenarios of technological and socio-economic development that were consistent with different global temperature goals, including both the 1.5°C and 2°C targets (CPLC, 2017).

However, because IAMs are global models, they do not have the same levels of detail as national level exercises. IAMs are also limited in their ability to capture some important aspects of economies of scale and learning and technology change that are known to be of vital importance. However, these models can investigate the timing of mitigation actions and emissions reductions, as well as interactions between sectors and countries to provide global emissions scenarios and global cost estimates (CPLC, 2017).

The World Energy Outlook 2015 report (IEA, 2015) employed the World Energy Model[3], a large-scale simulation tool designed to replicate how energy markets function, for producing energy projections. These were then used in a scenario analysis to provide long-term energy trend projections and corresponding carbon prices.

There were three core scenarios in the report, which have different assumptions on energy-related policies and trends. These included the New Policies Scenario; the Current Policies Scenario and the 450 Scenario. One of particular interest is the 450 Scenario, which adopted an alternative approach by establishing a specified outcome of limiting the rise of global average temperatures to 2°C. Various assumptions were made to reflect the extent of policy interventions required to curb emissions and achieve the temperature

[3] A complete description of the WEM is available at *www.worldenergyoutlook.org/weomodel/.*

target. A 2020 carbon price of approximately R238.15/tCO_2e was established within the 450 Scenario.

It is justifiable that South Africa should aim for a 2020 carbon price of R505.63/tCO_2e, as suggested by the High level commission on carbon prices, 2017 report (CPLC, 2017). South Africa is a developing country and based on the fair share principal - taking into account differentiated responsibilities and respective capabilities - need not commit to higher estimates of carbon prices. In addition, given the country's poor economic growth, high unemployment, poverty and inequality, climate change policy should avoid imposing too great a shock on the economic via too high a carbon price. The carbon price, as reflected by the proposed carbon tax rate of R120/tCO_2e (RSA, 2017), however, is not nearly high enough to achieve the 2^0C target, let alone the 1.5^0C.

5. GHG AND AIR POLLUTION EXTERNAL COSTS

Table 8 provides a summary of the most recent and suitable GHG and air pollution externalities from coal-based electricity production and road and rail freight transport in South Africa. These are likely to be severe underestimations of the *total* external cost from the listed externalities, since they do not include all associated external costs from the activities in question.

Combined GHG and air pollution external costs for rail freight in South Africa are the lowest, at an approximate R0.01c/t.km. Road freight GHG and air pollution external costs are significantly higher that of rail, at R10.42/t.km. GHG and air pollution external costs from coal-based electricity are estimated to be R0.48/kWh. For South Africa to contribute meaningfully to global emissions reductions and achieve the 2^0C target of the Paris Agreement (while keeping in mind its developmental status and socio-economic challenges) a 2020 carbon price of R505.63/tCO_2e is recommended.

Table 8: Combined greenhouse gas and air pollution externalities in South Africa

Activity	Unit	External cost	Notes
Rail Freight	R/t.km	0.01*	Based on local estimations from Swarts et al (2012)
Road Freight	R/t.km	10.42	Based on international estimations from Korzhenevych et al. (2014)
Coal-based electricity	R/kWh	0.48	Based on local estimations from Thopil (2013)
Economy wide carbon price	R/tCO_2e	505.63	Carbon price required to achieve the 2^0C target of the Paris Agreement, based on High level commission on carbon prices 2017 (CPLC, 2017)

*Inaccurate estimations since Swarts et al (2012) combines air pollution and GHG externalities, which is problematic. No international estimations, however, are suitable for South Africa.

Estimating externalities is extremely context specific and, therefore, the reported figures presented in Table 8 should be **taken only as a guide** to encourage the wider use and consideration of externalities in policy and decision making in government and the private sector. Actual monetary values are not generic and require significantly more research before they can be used in the context of other policy work.

6. CONCLUSION

We continue to live in a carbon intensive world where the combustion of coal and liquid fuels places a number of external impacts on the environment and society. The cost of these externalities can be significant, with several studies suggesting they can double or quadruple the private cost of electricity, for example.

To correct the market failure that results in the over production of carbon intensive goods an efficient price signal needs to be communicated to producers and consumers. Estimating the monetary value of the external cost of fossil fuels is the first step in developing this price signal. Estimating an economy wide carbon price is an alternative means by which climate change policy can encourage a shift towards a more carbon neutral economy. Internalising external costs makes renewable sources of energy more economically attractive, for example, and will encourage policy makers and private investors to begin investing in such technologies.

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