



**The macroeconomic impacts of
alternative scenarios to meet Eskom's
five-year revenue requirement**

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Contents

Contents	2
List of Tables	3
List of Figures	4
Executive summary	5
1. Introduction	18
1.1 Background and context	18
1.2 Purpose of this study	20
1.3 Contributors to the study	21
1.4 Structure of the report	21
2. Exploring the alternatives available to Eskom to meet its revenue requirement	22
2.1 Introduction	22
2.2 Options to meet the revenue requirement	22
2.3 Description of Option 1: Cost-reflective tariff increases	22
2.4 Option 2: Tariff increases together with government subsidies	25
3. Overview of model and approach	28
3.1 Description of model	28
3.2 Aim of the modelling exercise	29
3.3 Description of the tariff scenarios modelled	29
4. Simulation results	35
4.1 Comparative results – impact on GDP	35
4.2 Comparative results – impact on budget-deficit and debt-to-GDP	38
4.3 Comparative results – impact on CPI inflation	40
4.4 Comparative results – impact on total employment	42
4.5 Interpreting results of model simulations post-downgrade	45
5. Key findings and conclusions	48
5.1 Key findings	48
5.2 Concluding remarks	51
Appendix 1: Review of modelling approaches and recent literature	55
Appendix 2: Introduction to CGE modelling	69
Appendix 3: UPGEM database and production structure	72
Appendix 4: Impact of downgrade on bond yields	76
Reference List	77

List of Tables

Table 1: Rating equivalence across ‘Big 3’ rating agencies – long-term foreign currency rating.....	9
Table 2: Change in South Africa and Eskom’s credit ratings from 2008 to 2017 by 3 major agencies	15
Table 3: Change in South Africa Government’s key debt metrics between 2008 and 2017	16
Table 4: Summary of scenarios modelled	30
Table 5: BAU forecast values assumed for selected exogenous macroeconomic variables (y/y%)	33
Table 6: Average impact on GDP growth over periods ‘2017 to 2021’ and ‘2022 to 2030’	37
Table 7: Average annual growth in budget deficit	39
Table 8: Average impact CPI inflation in periods ‘2017 to 2021’ and ‘2022 to 2030’	42
Table 9: Average impact CPI inflation in periods ‘2017 to 2021’ and ‘2022 to 2030’	45
Table 10: Rating equivalence across ‘Big 3’ rating agencies – long-term foreign currency rating.....	46
Table 11: Change in South Africa and Eskom’s credit ratings from 2008 to 2017 by 3 major agencies.....	52
Table 12: Change in South Africa Government’s key debt metrics between 2008 and 2017.....	53
Table 13: Three main characteristics and applications of different type of macroeconomic model.....	58
Table 14: Summary of the advantages and disadvantages of different families of macroeconomic models.....	62
Table 15: Summary of recent South African literature on the macroeconomic impacts of rising energy prices	64
Table 16: Summary of selected recent international literature on economic impacts of energy prices and/or subsidy reform.....	67

List of Figures

Figure 1: Summary of scenarios modelled	8
Figure 2: Foreign currency rating vs. interest payment burden	10
Figure 3: Impact on trend in real GDP and employment growth – 1A, 1B, 3A relative to BAU1 and BAU2	11
Figure 4: Impact on government debt-to-GDP ratio - 1A, 1B, 3A relative to BAU1 and BAU2.....	12
Figure 5: Comparing impact of various scenarios to meet Eskom’s revenue requirement on GDP.....	13
Figure 6: Trend in Average Electricity Prices realised by Eskom per kWh (1973 to 2015/16)	19
Figure 7: Macroeconomic transmission of electricity price shock	24
Figure 8: Summary of options to meet Eskom’s revenue requirement if tariff increases are inadequate ...	25
Figure 9: Macroeconomic transmission of electricity price shock together with increased government debt	27
Figure 10: Summary of scenarios modelled.....	30
Figure 11: The electricity price path assumed relative to CPI inflation (2017 to 2030)	34
Figure 12: Impact on trend in real GDP growth – 1A, 1B, 3A relative to BAU1 and BAU2	37
Figure 13: Average impact on GDP growth over periods ‘2017 to 2021’ and ‘2022 to 2030’	37
Figure 14: Cumulative impact on government’s general budget deficit - 1A, 1B, 3A relative to BAU1 and BAU2.....	38
Figure 15: Cumulative deviation in government deficit from baseline in 2021 and 2030.....	39
Figure 16: Impact on government debt-to-GDP ratio - 1A, 1B, 3A relative to BAU1 and BAU2	40
Figure 17: Impact on trend in CPI inflation – 1A, 1B, 3A relative to BAU1 and BAU2	41
Figure 18: Average impact on annual CPI inflation over periods ‘2017 to 2021’ and ‘2022 to 2030’	41
Figure 19: Impact on trend in employment growth – 1A, 1B, 3A relative to BAU1 and BAU2	44
Figure 20: Impact on total employment (jobs in millions) – 1A, 1B, 3A relative to BAU1 and BAU2	44
Figure 21: Foreign currency rating vs. interest payment burden	47
Figure 22: Impact on trend in real GDP and employment growth – 1A, 1B, 3A relative to BAU1 and BAU2.....	48
Figure 23: Impact on government debt-to-GDP ratio - 1A, 1B, 3A relative to BAU1 and BAU2	49
Figure 24: Trade-off between empirical and theoretical coherence across types of economic model	59
Figure 25: Modelling of impact of a sub-investment grade downgrade on bond yields.....	76

Executive summary

I. Background and context

In the three decades between 1978 and 2004 government allowed real (inflation-adjusted) electricity prices in South Africa to decline to artificially low levels. During this period, the real average price of electricity¹ fell by more than 40% to 30.1 c/kWh (in 2016 rands) in 2004/5 - at which point South Africa's tariffs were among the lowest in the world. (Deloitte, 2017).

In 2008, a power supply crisis that had been threatening to emerge for several years, reached a critical point and Eskom introduced nationwide loadshedding. As a result, Eskom was given the green light to embark on the massive build programme to increase power generation capacity. To enable Eskom to raise the capital it required, the National Energy Regulator of South Africa (NERSA) approved several sharp tariff increases. In the five years between 2008 and 2013, electricity prices more than doubled in real terms (inflation-adjusted) rising by a cumulative 114% while nominal prices rose by 191% over the same period (Figure 6). (Deloitte, 2017).

The sharp increases in real electricity tariffs over this period prompted a public outcry, and NERSA subsequently decided to award Eskom revenue that would limit the increase in real electricity tariffs to ~2% per year for the 5-year period from 2013. This was much lower than Eskom's requested increase of CPI plus ~10% per annum. The tariff increases that NERSA awarded Eskom over the MYPD3 period have proven to be inadequate, and Eskom's financial position has deteriorated as its annual revenue shortfall has mounted. According to Eskom (2016) the revenue shortfall that the utility faced in 2014/15 alone, was R35 billion. At the time of finalising the modelling for this report in January 2017, we noted that the ongoing deterioration in Eskom's financial position would have meaningful fiscal consequences (in the form of rising government debt and/or contingent liabilities), and that there was a significant risk that this would trigger a sub-investment downgrade (S-IG) of South Africa's sovereign credit rating. On the 3rd of April 2017, shortly after this first version of this report was finalised, Standard & Poor's downgraded South Africa's long-term foreign currency sovereign credit rating to sub-investment grade or "junk" and on the 7th of April 2017, Fitch ratings agency followed suit.

S&P noted that the downgrade reflected their view that "contingent liabilities to the state, particularly in the energy sector [i.e. government guarantees on debt issued by Eskom] are on the rise and that previous plans to improve the underlying financial position of Eskom may not be implemented in a comprehensive and timely manner." This indicates that the steady rise in government debt and contingent liabilities (guarantees of Eskom-issued debt) associated with Eskom's lower-than-required electricity tariff increases contributed meaningfully to S&P's recent decision to downgrade South Africa's credit rating on foreign currency debt to 'junk'.

¹ Average prices are calculated as the total electricity revenue realised by Eskom divided by the total kWh produced in a given period, these are then adjusted for inflation to calculate real prices and expressed in 2016 rands.

We argue in a recent analysis of the historical trends and policies in the electricity sector, Deloitte (2017), that previous assessments of the macroeconomic impacts of rising electricity prices failed to acknowledge the economic impacts of the implicit electricity subsidy Eskom requires from government when the revenue it raises via the tariff is insufficient to cover its costs. This implicit subsidy usually takes the form of an increase in debt (implicitly or explicitly guaranteed by government) or an additional equity injection from government. Government in turn has three main ways to raise the funds required to support Eskom – either by issuing more debt (borrowing) and/or by raising additional tax revenue or reducing / re-prioritising expenditure away from other government services and functions.

In its 'Reasons for decision on Eskom's MYPD3 tariff application', NERSA (2013) presented an economic impact of rising electricity tariffs on GDP, inflation, and employment under low, medium, and high tariff path scenarios. However, NERSA did not acknowledge or model the consequences of rising government / Eskom debt associated with 'low tariff path scenarios. Rather, in assessing the potential economic impact of its tariff decisions NERSA, appears to implicitly assume that if Eskom is not able to recover sufficient revenue to cover all its prudently and efficiency incurred costs, that those costs would not be incurred.

II. Aim of the study,

The aim of this study is to provide an understanding of the macroeconomic impacts of alternative scenarios to meet Eskom's five-year revenue requirement. While, like previous studies, the study should show the impacts on GDP, employment, and inflation during the five-year period, it should also demonstrate the impact on the fiscus (debt ratios and budget balance). We have also attempted to demonstrate some of the broader or longer-term economic consequences of government debt accumulation in scenarios where tariff increases generate insufficient revenue to cover Eskom's costs – this included a scenario where government debt accumulation associated with low tariff increases, triggers a sub-investment grade credit rating downgrade.

III. Key scenario assumptions, and scenarios modelled

For this modelling exercise, Eskom advised Deloitte to model the impacts associated with three alternative tariff scenarios – average annual increases over a five-year period of 8%, 13% and 19% respectively. In November 2016, when this study commenced, Eskom had not yet finalised its forthcoming tariff application nor had it decided whether it would submit a tariff application for a single-year or for a multi-year period. As such official estimates of Eskom's required revenue and sales forecasts over the next five years were not available, the scenarios are therefore hypothetical and we have made the following key assumptions:

- We assume that the upper-bound annual average increase of 19% is what Eskom requires to reach and maintain, a cost-reflective electricity tariff over the 5-year period from 2017 to 2021.
- We assume, that Eskom's total revenue requirement is the same across all tariff scenarios and that it is equivalent to the revenue that would be raised if tariffs increased at an annual average rate of 19%. For example, under the 8% tariff scenarios, Eskom experiences an annual revenue shortfall equivalent to the difference between the total revenue raised under a compounded 19% tariff increase and the

compounded 8% increase. We then have further scenarios to model how the shortfall will ultimately be recovered– e.g. by raising additional government debt (borrowing) or taxes.

Eskom has indicated that based on an analysis of their financial position as at May 2017, it seems unlikely that the utility will require an annual nominal tariff increase as great as 19% to close the gap between costs (prudently and efficiently incurred) and revenue over a five-year period. There are however some upside risks to current estimates of Eskom's future revenue requirement - these include:

- **Purchase of additional renewable energy capacity** - current estimates of the revenue requirement (and therefore tariff) are based on the assumption that Eskom will not purchase any additional renewable energy capacity from IPPs (beyond that which it has already committed to). If Eskom signs additional power purchase agreements (PPAs) under the renewable energy independent power producers programme (REIPPP) the utility's average cost of electricity provision will rise further. According to data supplied to Eskom by the Department of Energy, the weighted average cost for REIPP Bid Windows 4 and 4+ will be around 83 c/kWh (in 2015 rands) inflated by annual headline CPI of 5.5% this would be 92c/kWh in 2017 rands. While accurate estimates of the LCOE (levelised cost of energy)² of Eskom's existing generation fleet are not available Joubert (2017), notes that Eskom's average fuel cost (including peaking plants and excluding IPPS) will be around 30c/kWh in 2017 and coal for its most marginal and expensive coal stations will be around 42 c/kWh in 2017. Since fuel costs typically represent 45% of the total LCOE of coal-fired plants (according to the EIA 2016). we estimate that Eskom's average LCOE for its existing coal-dominated generation fleet would be in the order of 66c/kWh (based on 30c/kWh average fuel cost). Furthermore, the LCOE measure does not reflect the additional financial costs that are ultimately associated with delivery of energy from renewable sources (these include the costs associated with higher intermittency of renewables relative to coal and higher transmission costs), so it is clear that additional renewable capacity at an LCOE of 92c/kWh will drive up Eskom's average generation costs (we estimate the LCOE is ~66c/kWh), its overall revenue requirement and therefore average tariff.
- **Lower-than-anticipated electricity demand or sales** – Analysts have revised their forecasts of South Africa's real GDP and fixed investment growth lower following the downgrade of South Africa's long-term foreign currency rating to sub-investment grade and are now generally expecting real GDP growth of between 0% and 1% y/y in 2017. Given the strong positive relationship between electricity sales and real economic activity, Eskom may face lower than expected demand which would reduce its sales and increase the average tariff it requires to cover its costs.
- **New build programme** – current estimates of the tariff required to close the revenue gap are based on anticipated capital expenditure under the approved new build programme including the completion of Medupi and Kusile and IPP capacity already procured. If, however Eskom initiates a further new build programme within the next 5 years, such as the potential nuclear build, it is likely that real tariffs

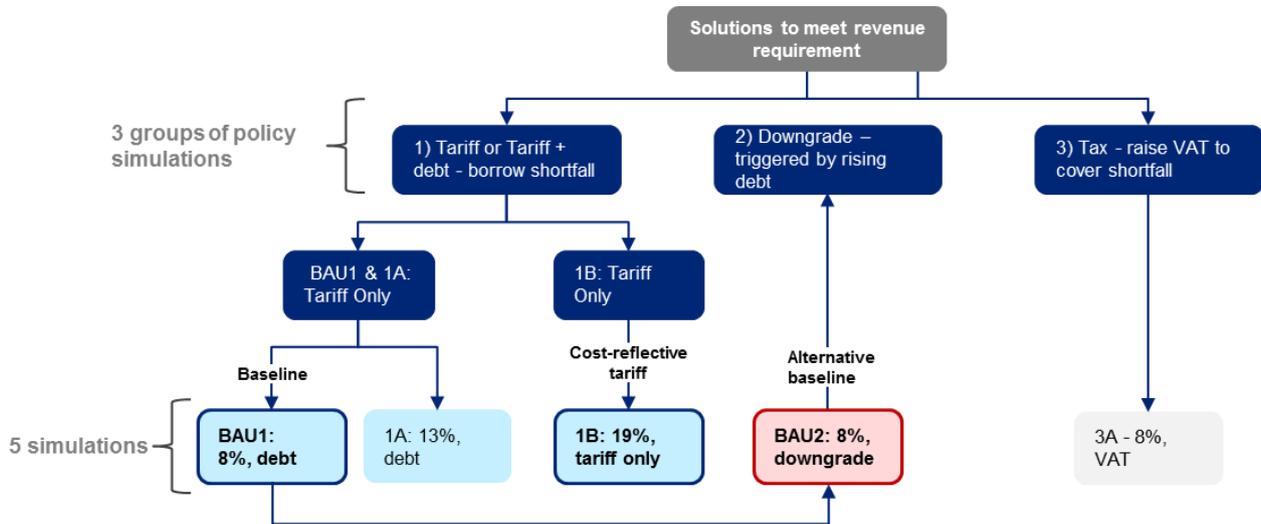
² LCOE includes fuel, capital cost and operating and maintenance costs for generation plant.

would need to rise faster than is currently anticipated to accommodate the additional costs associated with the new build programme.

Three main categories of policy simulations were modelled, each with a different set of assumptions and for three tariff path options – 8%, 13% and 19% (where applicable)³. This resulted in a total of five simulations all of which represent an alternative potential solution to meet Eskom’s total revenue requirement over a five-year period. The scenarios modelled included a ‘tariff-only’ option where electricity tariffs increase at an annual rate of 19% over five years and a baseline scenario (BAU) where tariffs increase at an average rate of 8% and the revenue shortfall is funded by raising additional government debt. Further scenarios included a 13% annual tariff increases with a debt-funded shortfall, an 8% increase with tax-hike funded shortfall and a downgrade scenario, explained further below. At the time, the modelling was undertaken (January 2017) we judged that there was also a significant risk that steadily rising government debt levels associated with the baseline tariff scenario of 8% would trigger a sub-investment grade (S-IG) credit rating downgrade⁴.

To simulate the economic impacts of this downgrade risk materialising we ran an alternative baseline simulation (BAU2) where a steadily rising debt-to-GDP ratio and deteriorating budget balance that is associated with an 8% average tariff increase triggers a S-IG credit rating downgrade. A visual summary of the five simulations modelled is provided in Figure 1.

Figure 1: Summary of scenarios modelled



³ In the interim modelling report produced by the University of Pretoria, another two groups of scenarios were considered – 1) a tax credit reducing VAT and 2) a tax credit reducing production taxes. We have decided to omit these two scenarios as the added unnecessary complexity and did not materially alter the findings. We have also re-labelled/re-coded the scenarios for the readers of the final report.

⁴ At the time of writing and finalisation of the modelling for this study, South Africa maintained an investment grade rating on both its foreign- and domestic-currency denominated debt. On the 3rd of April 2017, Standard & Poor’s downgraded South Africa’s long-term foreign currency sovereign credit rating to sub-investment grade or “junk” and on the 7th of April 2017, Fitch ratings agency followed suit. By 7th April 2017 the yields on 10-year government bonds had risen by nearly 1 percentage point or 100bps from their mid-March lows from around 8.4% to just over 9%.

IV. Interpreting results of hypothetical scenarios – particularly post-downgrade

As explained above, the tariff increases are hypothetical. In addition, the potential S-IG downgrade we modelled under the 'alternative baseline' (BAU2:8%, debt) has, in effect, already transpired. While the magnitude of the tariff increases chosen are hypothetical the scenarios still usefully illustrate the relative macroeconomic impacts of the various options available to meet Eskom's revenue requirement which include 1) Increasing the tariff alone 2) a combination of low tariff increases and raising government debt and 3) a combination of low tariff increases and tax hikes.

Furthermore, while the anticipated S-IG downgrade has already occurred, it does not mean that credit-rating downgrade risk associated with debt accumulation under a 'much lower-than-required' tariff increase is now irrelevant or even diminished. As RMB (2017) notes, countries that are downgraded to sub-investment-grade typically experience a continual negative feedback loop. Following a SI-G event, as sentiment sours and interest rates increase, the fiscal position deteriorates. As the fiscal position deteriorates, interest rates rise and economic growth slows, further credit rating downgrades within 'junk' territory are triggered. As RMB (2017) notes, "countries take seven to nine years, on average, to recoup their investment-grade rating, following a downgrade, to speculative grade".

The risk now that the SI-G event has already occurred is that government debt accumulation under 'much lower-than-required' tariff increases (e.g. 8% scenario) could (together with an ailing economy) trigger further sovereign credit rating downgrades moving South Africa lower within 'junk' territory (Table 1).

Table 1: Rating equivalence across 'Big 3' rating agencies – long-term foreign currency rating

Standard & Poor's	Fitch	Moody's	Credit Quality
Investment Grade			
AAA	AAA	Aaa	Extremely strong capacity
AA	AA	Aa	Very strong capacity
A	A	A	Strong capacity
BBB+	BBB+	Baa1	Adequate capacity to meet financial commitment unless political/economic conditions worsen
BBB	BBB	Baa2	
BBB-	BBB-	Baa3	
Sub-investment grade, junk			
BB+	BB+	Ba1	There is a risk that major ongoing uncertainties or exposure to adverse economic & business conditions will reduce government's capacity to meet its debt obligations
BB	BB	Ba2	
BB-	BB-	Ba3	
B+	B+	B1	More vulnerable to non-payment, but can currently meet obligations
B	B	B2	
B-	B-	B3	
CCC+	CCC	Caa1	Currently vulnerable to non-payment, depends on favourable external conditions to meet obligation.
CCC		Caa2	
CCC-		Caa3	
CC	CC	Ca	Default imminent, inevitable
D	DDD	C	

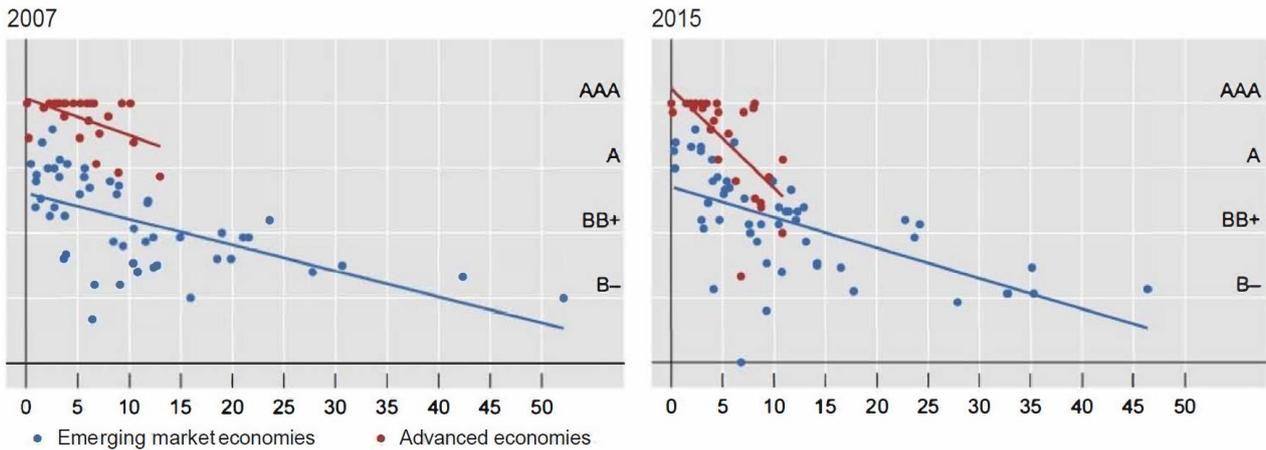
DD
D

In default, bankruptcy, administration

South Africa's long-term foreign currency ratings as at 8 April 2017.
Source: Own analysis based on EU committee report on sovereign credit ratings 2011, S&P website and others.

While there is no simple linear relationship between subsequent credit rating downgrades (post a SI-G event) and interest rates the two are inversely correlated and as downgrades occur, interest rates tend to rise. A graph presented in an analysis by the Bank of International Settlements (2015) illustrates how the proportion of total revenue that Governments spend servicing interest on debt tends to rise sharply as the foreign currency rating falls into sub-investment grade territory. As further credit rating downgrades take place governments’ find they have less and less ‘fiscal space’ or flexibility in their spending choices and are forced to focus on preserving and improving their financial position and trying to meet obligations to deliver essential services (e.g. social grants, health and education).

Figure 2: Foreign currency rating vs. interest payment burden



¹ Interest payments as a percentage of general government revenue.

Source: Bank of International Settlements (2015).

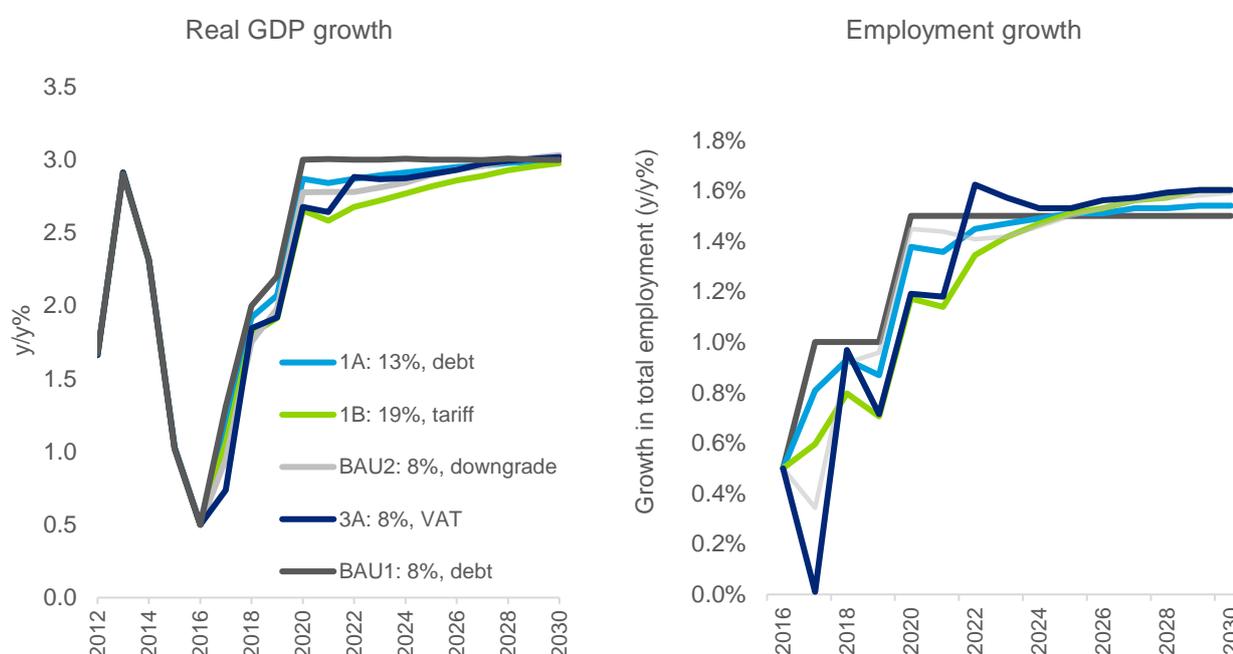
V. Approach

A brief review of the potential approaches to modelling the macroeconomic impacts of rising energy prices or energy subsidy reform that informed the approach chosen for this study is provided in Appendix 1. The model selected for the simulation of the alternative scenarios to meet Eskom’s revenue requirement is the University of Pretoria General Equilibrium Model (UPGEM) described in Bohlmann et al. (2015). UPGEM is a flexible Computable general equilibrium (CGE) model that for purposes of this study is used in standard recursive-dynamic mode.

VI. Key findings and results

The results show that an annual tariff increase of 19% is expected to have a slightly negative impact on GDP and employment growth relative to the baseline scenario (where tariffs rise by 8% a year and government borrows the shortfall). For example, under the 19% tariff scenario (1B), GDP is forecast to expand at an average rate of 2.0% y/y, which is 0.3 percentage points lower than the 2.3% y/y growth forecast in the baseline (BAU1) (Figure 3). Total employment is expected to grow at an average rate of 0.9% y/y under a 19% tariff increase compared to 1.2% y/y in BAU1 (Figure 3). This implies that under a 19% tariff increase scenario, 137000 fewer jobs will be created and sustained annually over the period 2017 to 2021, relative to BAU1. These results are consistent with those NERSA (2013) obtained when it presented the economic impact of similar tariff scenarios in its reason for decision on Eskom’s MYPD3 tariff application⁵.

Figure 3: Impact on trend in real GDP and employment growth – 1A, 1B, 3A relative to BAU1 and BAU2



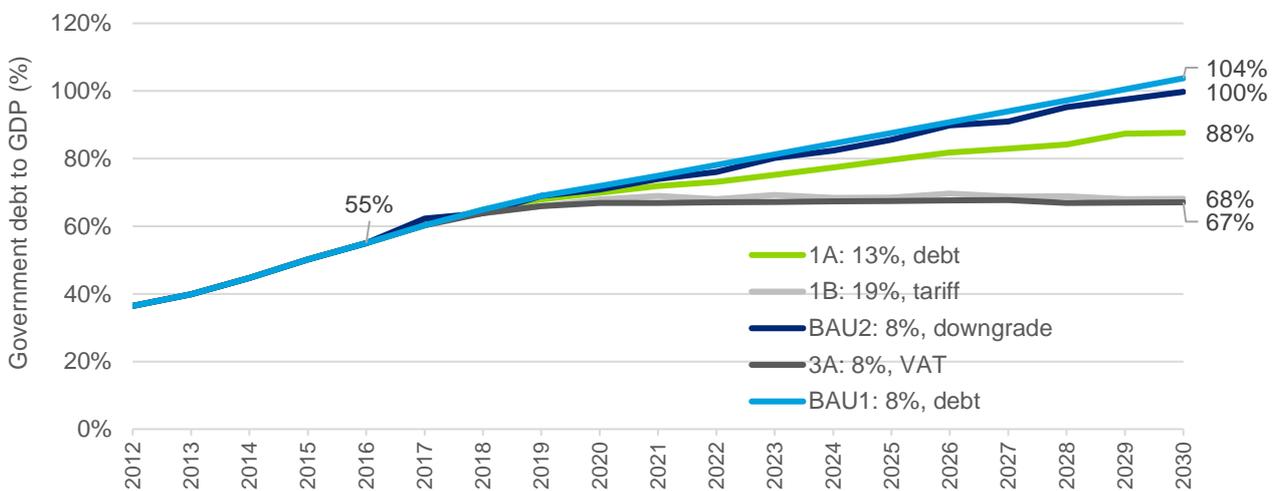
Our results however suggest that the impact of higher tariff increases on CPI inflation over the next five-year period would be more muted than what NERSA (2013) previously indicated. The simulation results suggest that scenarios with higher annual electricity price increases of 13% and 19% (1A and 1B respectively) have very little impact on CPI inflation - inflation rises in both cases by less than 0.1 percentage point, averaging 5.8% y/y in the five-year period from 2017 to 2021 and 5.5% y/y thereafter. While the low-CPI impact associated with relatively high tariff increases may seem counterintuitive, it can be attributed to the fact that higher tariff increases are expected to have a negative impact on GDP growth

⁵ NERSA noted in its economic impact study that a 16% annual tariff increase over a five-year period was expected to lower average annual GDP growth by 0.3 percentage points, reducing forecast GDP growth from 3.7% to 3.4%. NERSA also found that a series of five 16% tariff increases would compromise 652 654 jobs. We assume that NERSA was referring to the cumulative number of jobs that would be foregone over 5 years in which case our results are similar. Our results suggest that 137000 fewer jobs will be created and sustained annually under the 19% tariff scenario (1A) relative to the BAU1 over the five years to 2021. If this is expressed differently, the cumulative deviation in the total employment from baseline (BAU1) in 2021 is 685 000 jobs.

and employment. Given that GDP growth was already expected to be relatively subdued over this period (relatively to potential GDP growth of 3%), sluggish demand is likely to keep inflation in check.

We noted previously that in the economic analysis that NERSA presented in 2013, the regulator did not acknowledge the fiscal consequences of ‘lower-than-required’ tariff increases. Our results show that under the 8% tariff baseline scenario (BAU1) there is a steady and marked deterioration in government’s budget balance and that the government debt-to-GDP ratio is expected to reach 75% by 2021 and 104% by 2030 (Figure 4). By contrast under the 19% tariff scenario, the debt-to-GDP ratio stabilises at ~66% (Figure 4). Given the sharp accumulation of government debt under a ‘much-lower-than-required tariff increase’, we also noted that it was likely that BAU1: 8%, debt would trigger a sub-investment grade credit rating downgrade and as such that it would be more accurate to compare the economic impacts of a 19% tariff scenario with a scenario where an 8% tariff increase triggers a SI-G downgrade (BAU2:8%, downgrade).

Figure 4: Impact on government debt-to-GDP ratio - 1A, 1B, 3A relative to BAU1 and BAU2



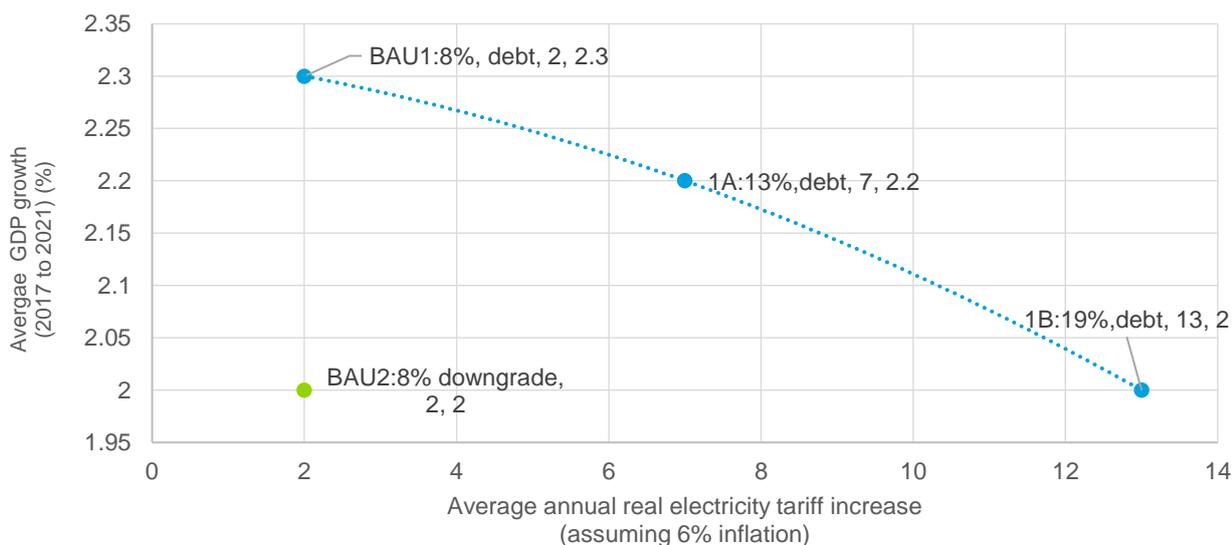
As noted earlier, the risk of a S-IG downgrade that we modelled under the ‘alternative baseline’ (BAU2:8%, debt) has in effect, already materialised. On the 3rd of April 2017, Standard & Poor’s announced the downgrade of South Africa’s long-term foreign currency sovereign credit rating to sub-investment grade.

The results of our downgrade scenario show that when the rise in government debt that is associated with a ‘much-lower-than required’ tariff increase is sufficient (together with other economic and political risk factors) to trigger a sovereign credit-rating downgrade (BAU2: 8%, debt), South African’s end up worse-off than under a 19% annual tariff increase and the negative economic impacts are likely in aggregate to be more severe⁶ for the following reasons:

⁶ The way in which the effects of a potential downgrade were modelled was conservative -we assumed that the key impact of a S-IG event would be that interest rates (or the return required on capital investment) would rise by an average of 100 basis points over the five-year period.

Firstly, our results show that under the ‘BAU2:8%, downgrade’ scenario, growth in GDP and employment will slow by almost as much as they would under a 19% annual tariff increase. Simulation results (summarised in Figure 5) show that under both the downgrade scenario (BAU2: 8% downgrade) and 19% tariff scenario (1B:19%, debt) annual GDP growth will be 0.3 percentage points lower than in BAU1. Similarly, under BAU2 and total employment growth is expected to average 1.0% y/y which is an average of 0.2 percentage points lower than in BAU1, while under scenario 1B: 19%, tariff employment will increase at an average rate of 0.9% y/y or 0.3 percentage points lower than BAU1.

Figure 5: Comparing impact of various scenarios to meet Eskom’s revenue requirement on GDP



Secondly, while our results suggest that the negative impact on GDP and employment that follow a downgrade due to debt accumulation under a ‘much-lower-than-required’ tariff is almost equivalent to a 19% tariff increase, South Africans are likely to end up worse-off in aggregate under the downgrade scenario because of a simultaneous rise in debt and interest rates that doesn’t occur under the tariff only scenario. Borrowing costs (or the required return on investment) will rise by 1 percentage point (100bps) under BAU2 relative to the 19% tariff scenario (1B) and the government debt-to-GDP ratio will rise steadily reaching ~75% by 2021 and 100% by 2030 under BAU2, while under the 19% tariff scenario, the debt-to-GDP ratio stabilises at ~66%.

Finally, under any scenario (including BAU1, BAU2 and 1B) where the revenue collected via the tariff is insufficient to cover Eskom’s prudently and efficiently incurred costs, the price of electricity is being implicitly subsidised. As the World Bank (2010:22) notes: “Subsidising energy use involves providing it at a price below opportunity cost. This includes non-collection or non-payment, selling electricity at a cost that does not reflect the long-run marginal cost of supply including capital maintenance.”

The economic harm and distortions that are caused by energy subsidies, including artificially low electricity prices, is well-documented in the international literature. Some of the potential macroeconomic, environmental, and social consequences of energy subsidies, as documented by the IMF (2013) were summarised in Deloitte (2017) as follows:

- **Energy subsidies crowd-out growth-enhancing or pro-poor public spending.** Energy subsidies, while often intended to protect consumers crowd-out other priority spending (such as on social welfare, health, and education) and place an unnecessary burden on public finances. Energy subsidies (unless specifically targeted) are a poor instrument for distributing wealth relative to other types of public spending.
- **Energy subsidies discourage investment in the energy sector and can precipitate supply-crises.** Energy subsidies artificially depress the price of energy which results in lower profits for producers or outright losses. This makes it difficult for state-owned enterprises to sustainably expand production and removes the incentive for private sector investment. The result is often an underinvestment in energy capacity by both the public and private sector that results in an energy supply crisis which in turn hampers economic growth. These effects have been felt in SA.
- **Energy subsidies create harmful market distortions.** By keeping the cost of energy artificially low, they promote investment in capital-intensive and energy-intensive industries at the expense of more labour-intensive and employment generating sectors.
- **Energy subsidies stimulate demand, encourage the inefficient use of energy and unnecessary pollution.** Subsidies on the consumption of energy derived from fossil fuels leads to the wasteful consumption of energy and generate unnecessary pollution. Subsidies on fossil-fuel derived energy also reduces the incentive for firms and households to invest in alternative more sustainable forms of energy.
- **Energy subsidies have distributional impacts.** Energy subsidies tend to disproportionately benefit higher-income households who consume far more energy than lower income groups. Energy subsidies directed at large industrial consumers of energy benefit the shareholders of these firms at the expense of the average citizen.

In Deloitte (2017) goes on to give specific examples of the economic harm and distortions that can be attributed to the historic under-pricing or implicit subsidisation of electricity in South Africa these is argued include:

1. Artificially low electricity tariffs discouraged investment in the South Africa's electricity supply industry and helped to precipitate the 2008 power supply crisis. The subsidised tariffs frustrated attempts by the government to attract private investment in the early 2000s and helped to precipitate the supply crisis of 2008.
2. Subsidised electricity prices promoted investment in capital intensive industries in South Africa at the expense of more labour-absorbing sectors. Kohler (2014) who traced the 40-year change in electricity intensity across a number of countries and country groups and found that South Africa has amongst the highest electricity intensity globally.
3. Subsidised electricity prices, encourage the inefficient use of energy and contributed South Africa to becoming one of the single-largest contributors to global GHG emissions. Subsidies on the

consumption of electricity generated by Eskom which was mostly coal-based have arguably contributed South Africa becoming the 18th largest country-level contributor to global CO2 emissions⁷.

VII. Concluding remarks

It may be tempting to conclude that by limiting electricity tariff increases to 8% per annum and requiring that Eskom and/or government to borrow the revenue shortfall (and effectively implicitly subsidising the price), it is possible to minimise the negative impacts of rising electricity prices on GDP and employment growth in the short-term.

However, the results of the economy-wide impact analysis show that the fiscal and economic consequences of awarding Eskom a tariff that is much lower than what it requires (to recover its prudently and efficiently incurred costs), do eventually (and arguably have now) become evident. Our results show that when the gap between the required and actual tariff increases is large (an 8% increase awarded over five years when we assumed 19% was required) and the shortfall is covered by raising debt, there is a steady and marked deterioration in government's budget balance and debt-to-GDP ratio. For example, under the baseline 8%, debt scenario government debt-to-GDP ratio is expected to reach 75% by 2021 and 104% by 2030. By contrast under the 19% tariff scenario, where all the required revenue is raised via the tariff, the results show the debt-to-GDP ratio stabilising at ~66%.

Over the past 10-years there has been a marked deterioration in both the financial position of Eskom and the fiscal health of the South African government and this is evident from the change in debt and credit metrics summarised in Table 2 and Table 3. Since 2008, South Africa's long-term foreign-currency rating has been downgrade by 3 notches from lower-medium grade to speculative grade or 'junk' by two of the three major rating agencies. Eskom's long-term local-currency corporate bond rating has been downgraded by between 5 and 10 notches, from upper-medium grade in 2008 is now rated 'highly-speculative' by Standard and Poor's.

Table 2: Change in South Africa and Eskom's credit ratings from 2008 to 2017 by 3 major agencies

Credit metric		2008 (May-08)		2017 (Apr-17)		2017 (change in notches)	
South Africa's long-term foreign-currency rating	S&P	Lower-medium grade	BBB+ (stable)	BB+		↓	-3
	Fitch		BBB+ (positive)	Speculative	BB+	↓	-3
	Moody's		Baa1 (positive)	Lower-medium	Baa2 (negative)	↓	-1
Eskom's long-term, local currency, corporate bond rating	S&P	Upper-medium grade	A+, stable	Highly specula	B+	↓	-10
	Moody's		A1	Speculative	Ba1- (review down	↓	-7
	Fitch		A	Speculative	BB+	↓	-5

Source: Own analysis based on reports on credit history by 3 rating agencies

A summary of key debt metrics in Table 3, shows that since 2008 (when Eskom embarked on its massive capital expansion programme) the South African government's capacity to meet its debt obligations (and

⁷ Based on data from the EDGAR – emissions databased for global atmospheric research. 2015. Available online at: <http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts1990-2015&sort=des9>

to raise additional debt or issue guarantees on debt of state-owned enterprises) has become far more constrained and as such vulnerability to eventual non-payment has increased. In terms of the National Treasury broad risk management guidelines (updated in 2008) – net loan debt, provisions and contingent liabilities should not exceed 50 per cent of GDP while the broader SADC macroeconomic convergence target was to limit the metric to 60 of GDP (National Treasury, 2008). While this metric stood comfortably within these prudential limits at 34.4% GDP in 2008, in 2017 it stands at 67% of GDP – exceeding both the self-imposed risk guideline and broader SADC convergence target. Net loan debt (excluding provisions and contingent liabilities) is expected to reach 47% of GDP in 2017/18 (up from 22.6% in 2007/8). Government now spends 11.5% of its total revenue service the interest on debt (up from 8.9% in 2007/8) illustrating how the fiscal space is becoming increasingly constrained.

It is also clear that substantial support provided by government to Eskom over the past 10 years both in the form of equity and guarantees has contributed meaningfully to the deterioration in Government's overall debt metrics (and subsequent credit rating downgrades). Eskom initially received support from government in the form R6bn shareholder loan which was converted into equity in 2015 and in the form of a further R23bn equity injection completed in March 2016 (Moody's Investor Service, 2017). Government also approved R350bn worth of guarantees on Eskom's debt of which Eskom had drawn on R218bn worth by 2017/18 (the agreement is to be extend to 31 March 2023). Government guarantees of SOE debt rose from R65bn in 2008 to a total of R445bn in 2017 and 77% of this is for the electricity sector which also cover Eskom's power purchase agreements with IPPs.

Table 3: Change in South Africa Government's key debt metrics between 2008 and 2017

	2008		2017		Change (2008 to 2017)
Net loan debt as % GDP	22.6%	2008/9	47%	2017/18	up to almost 50% of GDP
Net loan debt, provisions and contingent liabilities as % GDP	34.4%	Mar-08	67%	2016/17	now over 60% of GDP
Debt service cost as % GDP	2.4%	2008/9	3.4%	2017/18	up 1 percentage point
Debt service cost as % general government revenue	8.9%	2008/9	11.5%	2017/18	up 2.6 percentage points
Government guarantees Eskom -exposure (Rbn)	26	2007/8	218	2016/17	192
Government guarantees IPPs - exposure (Rbn)	0	2007/8	126	2016/17	126
Government guarantees (Rbn)	65	2007/8	445	2016/17	381
Electricity sector as % of total govt. guarantees	40%	2007/8	77%	2016/17	37 percentage points higher

Source: Own Analysis based on data and statistical tables National Treasury's National Budget Reviews - 2007,2008, 2016 & 2017

Following the sub-investment grade downgrade of South Africa's long-term foreign currency in April 2017 and subsequent downgrade of Eskom's corporate debt by S&P to 'highly-speculative grade', neither Eskom nor the South African government will be in a position raise further debt to meet Eskom's future revenue requirement without the risk of triggering further sovereign credit rating downgrades.

In the present context, if Eskom is awarded much-lower-than-required tariff increases, it will put South Africa at greater risk of remaining within the continual negative feedback loop that countries typically experience following an SI-G event. Our analysis shows that under low tariff scenarios, Eskom's revenue shortfall grows, the fiscal position deteriorates, interest rates rise, sentiment sours, economic growth slows, further credit rating downgrades within 'junk' territory are triggered and the toxic loop repeats. As RMB (2017) notes, "countries take seven to nine years, on average, to recoup their investment-grade rating, following a downgrade, to speculative grade".

Our simulation results show that in terms of the overall economic impacts - even a sharp 19% annual tariff increase over five-years (although current information suggests a 12% annual increase may be sufficient to close the gap) would be preferable to a scenario where rapid debt accumulation associated with a much-lower-than-required '8% tariff increase triggers further credit rating downgrades.

While our results suggest that negative impact on GDP and employment that follow a downgrade due to debt accumulation under a 'much-lower-than-required' tariff is almost equivalent to a 19% tariff increase, South Africans are likely to end up worse-off in aggregate under the 'low-tariff downgrade scenario' because of a simultaneous rise in debt and interest rates triggered by a downgrade. In addition, in the low-tariff scenarios, the price of electricity remains implicitly subsidised, and outlined in detail in Deloitte (2017), energy price subsidies are associated with a wide-range of market distortions and economic harm. The following examples are discussed in Deloitte (2017), electricity price subsidies: discouraged private sector investment in the South African electricity supply industry and helped to precipitate the 2008 power supply crisis; have promoted investment in capital intensive industries at the expense of more labour-absorbing ones; and have encouraged the inefficient use of power leading to avoidable pollution.

In conclusion, it would be ill-advised for the regulator to continue to limit Eskom's tariff increases to 8% per year. It would also be incorrect given the current context and results of this analysis to assume that this will limit the negative impact on GDP and employment, even in the short-term. Our recommendation is that tariff increases should at least be sufficient to transition Eskom towards a more cost-reflective electricity tariff (prudently and efficiently incurred) over the next 5 years. This will reduce of the risk of South Africa being trapped for a prolonged period in the continual negative feedback loop that countries typically experience following an SI-G rating downgrade.

Eskom has indicated that based on an analysis of their financial position as at May 2017, it seems unlikely that the utility will require an annual nominal tariff increase as great as 19% to close the gap between costs (prudently and efficiently incurred) and revenue over a five-year period. Eskom and its key stakeholders should also take care to ensure that the upside risks to forecasts of the tariff required to meet its revenue requirement over the next five years are carefully managed – these include obligations to purchase additional renewable energy capacity, risk of lower-than-anticipated electricity demand or sales and additional capital expenditure and associated costs that will be incurred if Eskom and the Department of Energy deems it prudent and necessary embark on a new build programme within the next five years.

1. Introduction

1.1 Background and context

In the late 1970s and early 1980s Eskom embarked on a massive capacity expansion programme. Real electricity prices rose sharply so that Eskom was in a financial position to raise the capital required to fund the new build. However, the sharply rising electricity tariffs sparked a public outcry and a commission appointed to investigate the situation, found that Eskom had substantially over-invested in capacity. In the three decades between 1978 and 2008 government allowed real (inflation-adjusted) electricity prices in South Africa to decline to artificially low levels. Between 1978 and 2004 the real average price of electricity⁸ fell by more than 40% reaching a low of 30.1 c/kWh (in 2016 rands) in 2004/5. By 2004/5 electricity prices in South Africa, and particularly those faced by industrial consumers were among the lowest in the world. (Deloitte, 2017).

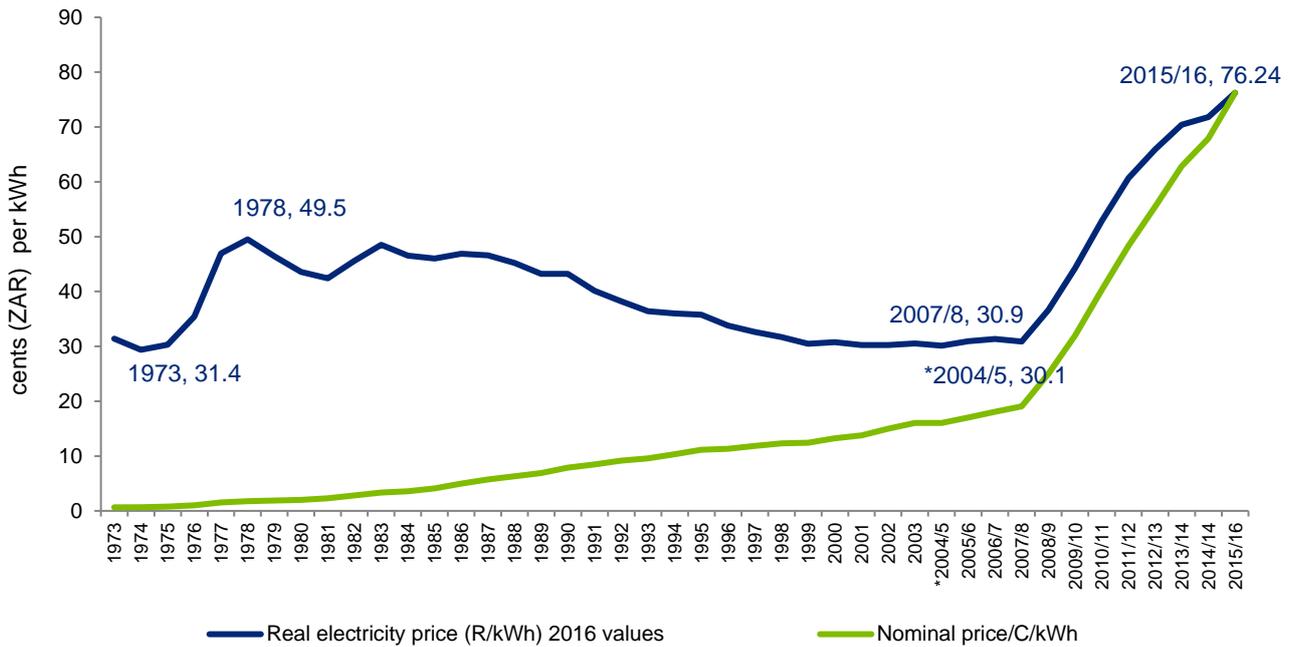
From 2008, the trend in prices took a dramatic turn when the power supply crisis that had been threatening for several years, reached a critical point and Eskom introduced loadshedding. As a result, Eskom was given the green light embark on the massive build programme to increase power generation capacity. But at this point, since electricity tariffs were at long-term-lows, Eskom had neither the cash reserves nor the future potential revenue steam to cover the cost of the new build. To enable Eskom to begin raising the capital it required, the National Energy Regulator of South Africa (NERSA) approved several sharp increases in annual tariffs and in the 5 years between 2008 and 2013, electricity prices more than doubled in real terms (inflation-adjusted) rising by a cumulative 114% while nominal prices rose by 191% over the same period (Figure 6). (Deloitte, 2017).

The sharp increases in real electricity tariffs over this period prompted a public outcry, and NERSA subsequently decided to limit the increase in real electricity tariff to ~2% per year for the 5-year period from 2013. This was much lower than Eskom's requested increase of CPI plus ~10% per annum and as such, NERSA disallowed a substantial proportion of Eskom's budgeted costs across almost all operating cost categories – "in assessing Eskom's MYPD 3 Revenue Application the Energy Regulator disallowed over R100 billion over 5 years" (Eskom, 2016).

In an overview of electricity consumption and pricing in South Africa (Deloitte, 2017), we noted that in the context of the need for higher electricity tariffs, NERSA inevitably has to balance the concerns of the public and with the requirement that it award Eskom a tariff that ensures that it raise sufficient revenue to deliver on its new build and IPP procurement programmes, while remaining financially sustainable. But as we argued in Deloitte (2017), it appears that the decision by NERSA to disallow Eskom more than R100 billion of the revenue it applied for over the MYPD3 period was influenced by concern about the negative economic impact that sharp tariff increases would have on the economy.

⁸ Average prices are calculated as the total electricity revenue realised by Eskom divided by the total kWh produced in a given period, these are then adjusted for inflation to calculate real prices and expressed in 2016 rands.

Figure 6: Trend in Average Electricity Prices realised by Eskom per kWh (1973 to 2015/16)



Source: Deloitte Analysis, Eskom data and 2011 annual report

Note: In 2004/5 Eskom change financial year from calendar year (year-ending 31 December) to year-ending 31 March

The tariff increases NERSA awarded Eskom over the MYPD3 period have proved to be inadequate and Eskom’s revenue shortfall has mounted. According to Eskom (2016) the revenue shortfall that the utility faced in 2014/15 alone, was R35 billion (assuming that Eskom will not be able to recover some of this shortfall via a future RCA application). In November 2016, Standard and Poor’s (S&P) downgraded Eskom’s long-term corporate credit rating one notch further into sub-investment grade territory to 'BB' with a negative outlook noting concerns that “Eskom's capital structure and free cash flow remain at unsustainable levels, even if its liquidity position and operating performance should show some improvement during the current fiscal year” (Linder, 2016).

At the time of finalising the modelling for this report in January 2017, we noted that the ongoing deterioration in Eskom’s financial position would have meaningful fiscal consequences (in the form of rising government debt and/or contingent liabilities), and that there was a significant risk that this would trigger a sub-investment downgrade (S-IG) of South Africa’s sovereign credit rating. On the 3rd of April 2017, shortly after this first version of this report was finalised, Standard & Poor’s downgraded South Africa’s long-term foreign currency sovereign credit rating to sub-investment grade or “junk” and on the 7th of April 2017, Fitch ratings agency followed suit.

S&P noted that the downgrade reflected their view that “contingent liabilities to the state, particularly in the energy sector [i.e. government guarantees on debt issued by Eskom] are on the rise and that previous plans to improve the underlying financial position of Eskom may not be implemented in a comprehensive and timely manner.” This indicates that the steady rise in government debt and contingent liabilities (guarantees of Eskom-issued debt) associated with Eskom’s lower-than-required electricity tariff increases

contributed meaningfully to S&P's recent decision to downgrade South Africa's credit rating on foreign currency debt to 'junk'.

We argue in a recent analysis of the historical trends and policies in the electricity sector, Deloitte (2017), that previous assessments of the macroeconomic impacts of rising electricity prices failed to acknowledge the economic impacts of the implicit electricity subsidy Eskom requires from government when the revenue it raises via the tariff is insufficient to cover its costs. This implicit subsidy usually takes the form of an increase in debt (implicitly or explicitly guaranteed by government) or an additional equity injection from government. Government in turn has three main ways to raise the funds required to support Eskom – either by issuing more debt (borrowing) and/or by raising additional tax revenue or reducing / re-prioritising expenditure away from other government services and functions.

In its 'Reasons for decision on Eskom's MYPD3 tariff application', NERSA (2013) presented an economic impact of rising electricity tariffs on GDP, inflation, and employment under low, medium, and high tariff path scenarios. However, NERSA did not acknowledge or model the consequences of rising government / Eskom debt associated with 'low tariff path scenarios. Rather, in assessing the potential economic impact of its tariff decisions NERSA, appears to implicitly assume that if Eskom is not able to recover sufficient revenue to cover all its prudently and efficiency incurred costs, that those costs would not be incurred.

1.2 Purpose of this study

This report was commissioned by Eskom as part of its preparation for its fourth Multi-Year Price Determination (MYPD4) tariff application. The overall purpose of this study is to assess the economy-wide effects macroeconomic impacts of different scenarios to meet Eskom's revenue five-year revenue requirement (e.g. by increasing tariffs and/or raising debt or taxes): The study provides in-depth analysis on the impact of various electricity tariff and funding scenarios on the budget position of Eskom and the general government.

The specific objectives of the study were to:

- Discuss and outline schematically, the transmission of an electricity price increase through the economy and explain potential trade-offs under two scenarios – 1) full tariff increase awarded to Eskom 2) Partial increase with equity/guarantees required to cover revenue shortfall.
- Discuss briefly the potential financing options available to Eskom should it not receive sufficient revenues to cover its costs via the approved tariffs over the next 5 years and the likely fiscal consequences.
- Review any publicly available studies conducted on the impact of rising electricity prices in South Africa since the previous review conducted by Deloitte on behalf of Eskom in 2012, in order to understand modelling approach, scope of study, limitation and results.
- Explore the potential approaches to modelling the macroeconomic impacts of alternative scenarios to meet Eskom's revenue requirement over five years, noting the key advantages and drawbacks of each of the main approaches.

- Model the macroeconomic impacts of alternative scenarios to meet Eskom's revenue requirement over the next 5 years and report on the relative impact of each scenario on key macro variables including GDP, CPI, household income, budget balance, Government debt etc. The tariff scenarios to be modelled would be determined by Eskom.
- Discuss the modelling results and comment on the trade-offs apparent in the economic impact across all scenarios.

1.3 Contributors to the study

This study was led by Deloitte, the main contributors to the study were Kay Walsh, an economist at Nova Economics and Dr Heinrich Bohlmann and Professor Jan Van Heerden from the University of Pretoria who were responsible for the CGE modelling.

1.4 Structure of the report

This report is structured around six sections:

1. **Executive summary** - provides a summary of the background and context, purpose of the study, the study approach and key findings and conclusions.
2. **Introduction** - provides an introduction to the project, the background and context, the main objectives of the study, key contributors to the report and a summary of the structure of the report.
3. **Exploring the alternatives available to Eskom to meet its revenue requirement** – identifies and explores the alternatives available to Eskom to raise sufficient revenue to cover its costs over the five-year period from 2017 and provides a schematic illustration of the likely impact of alternative scenarios.
4. **Overview of model and approach** – provides a description of model for used for the simulation of macroeconomic impacts and a non-technical overview of the CGE methodology. Provides a description of the key scenario assumptions, the scenarios considered and those modelled.
5. **Simulation results** – provides a comparative analysis of all the main simulation results.
6. **Key findings** – summarises the key findings and main conclusions of the report.

Appendix 1: Review of modelling approaches and recent literature – explores the potential approaches to modelling the macroeconomic impacts of rising energy prices or energy subsidy reform and provides brief review of the most recent literature on the macroeconomic impacts of rising energy prices in South Africa.

Appendix 2: Introduction to CGE modelling.

Appendix 3: UPGEM database and production structure.

Appendix 4: Impact of a downgrade on bond yields.

2. Exploring the alternatives available to Eskom to meet its revenue requirement

2.1 Introduction

The purpose of this chapter is to identify and explore the alternatives available to Eskom to raise sufficient revenue to cover its costs over the five-year period from 2017. We have also provided a schematic illustration of the likely impact of alternative scenarios to meet Eskom's revenue on the economy when tariffs are 1) tariff increases are sufficient to cover Eskom's costs and 2) when tariff increases are inadequate and the shortfall must be covered by debt/equity.

2.2 Options to meet the revenue requirement

In our view, the alternatives at Eskom's disposal essentially fall into one of two main categories:

1. **Option 1 – Tariff only, cost-reflective increases:** The annual average tariff increase awarded to Eskom over a five-year period result in a tariff that is cost-reflective – in other words the amount of revenue raised via the tariff will be sufficient to cover Eskom's costs. More specifically, the costs associated with the efficient delivery of electricity supply at an acceptable level of service quality (including adequate provision for future capital maintenance).
2. **Option 2 –Tariff increases together with government subsidies:** The annual average tariff increase awarded to Eskom over a five-year period is insufficient to cover Eskom's costs and results in an annual revenue shortfall. To cover the shortfall, Eskom raises debt (which is either explicitly or implicitly guaranteed by government) and/or receives a further direct equity injection from government. Because government is ultimately responsible for financing the utility's revenue shortfall, electricity prices remain implicitly subsidised.

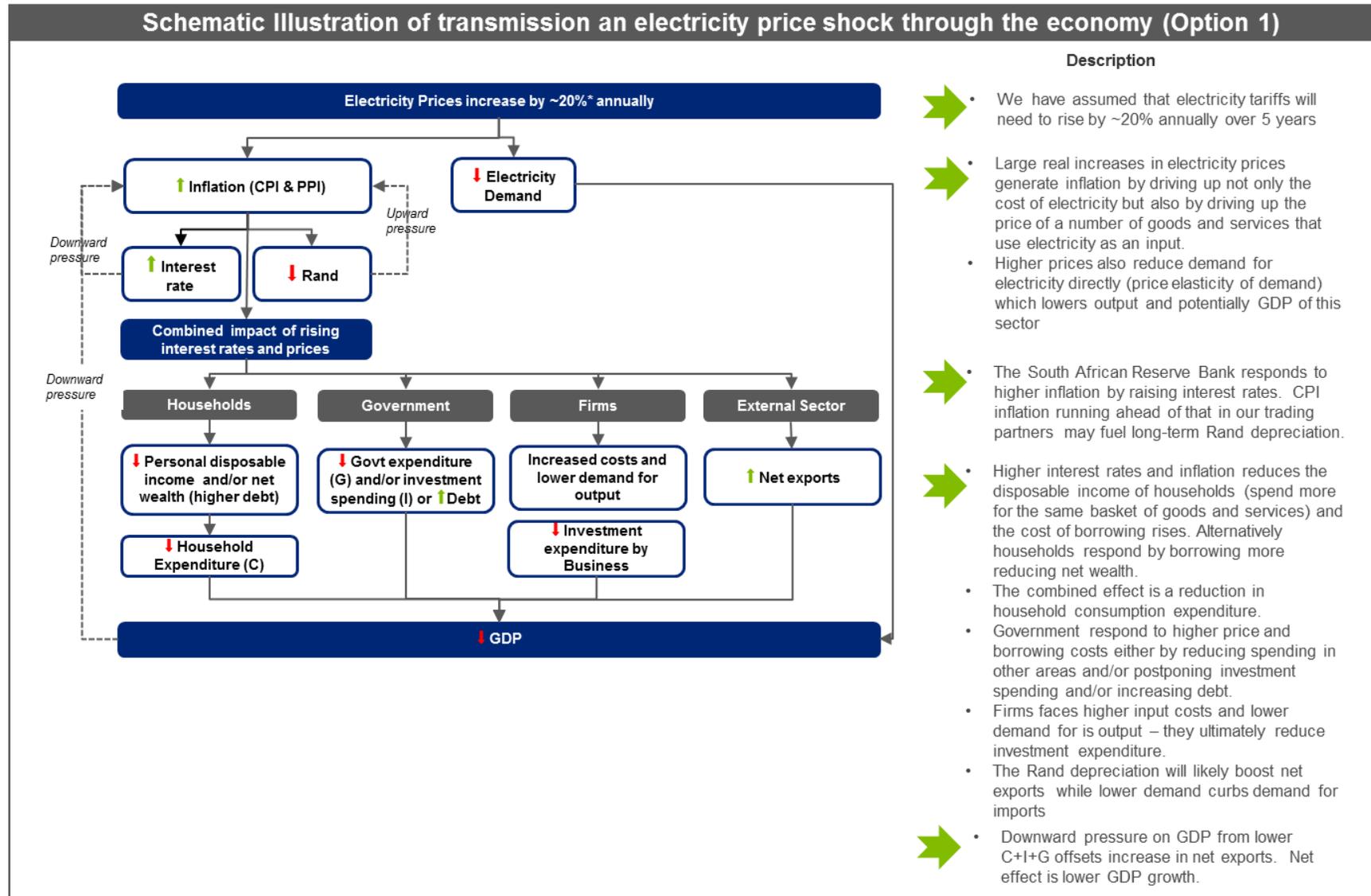
2.3 Description of Option 1: Cost-reflective tariff increases

The first option is that Eskom is awarded annual average tariff increase that generates revenues sufficient to cover all the utility's costs (including an allowance for future capital maintenance). In other words, all the revenue that Eskom requires to remain financially sustainable will be raised through the tariff. In terms of the regulatory methodology NERSA applies, allowable revenue should be equal to the cost of efficient service provision at an acceptable level of service quality. The allowed revenue should also include adequate return on investment and incentives for the utility to operate and expand its network and asset base in a socially optimal manner (Gunatilake, Perera, & Carangal-San Jose, 2008).

At the time of writing, Eskom had not yet finalised its MYPD4 tariff application and the magnitude of the tariff increases that would be required to meet Eskom's revenue requirement over a five-year period were not known. We assumed that annual tariff increase required will be in the region of ~20% per year for 5 years.

In Figure 7 we provide a diagram illustrating how an electricity price shock is transmitted through the macroeconomy. The interactions in an economy-wide macroeconomic model are a lot more complex than this schematic suggests –this simplification is for illustrative purposes.

Figure 7: Macroeconomic transmission of electricity price shock



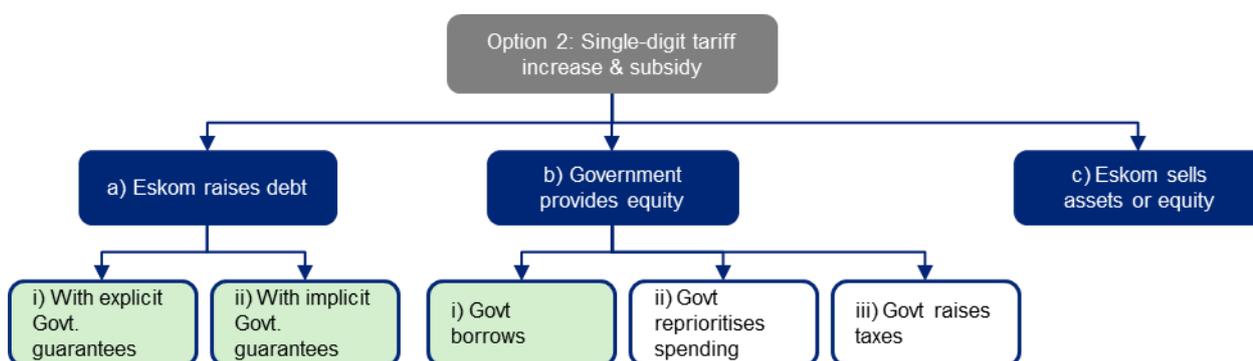
2.4 Option 2: Tariff increases together with government subsidies

In this scenario, we assume that the national electricity regulator of South Africa (NERSA), continues to award Eskom single-digit tariff increases for the five-year period from 2017 to 2021. An annual tariff increase which is 2 or 3 percentage points above CPI inflation will be insufficient to meet Eskom’s revenue requirement over a five-year period. As a result, electricity tariffs move further away from cost-reflective levels and Eskom’s annual revenue shortfall continues to widen.

If Eskom is only awarded a single-digit tariff increases but requires ~20% it will face mounting annual revenue shortfalls (this could be in the order of R30bn to R40bn annually over 5 years). This shortfall will need to be funded and the sub-options are summarised as follows and in Figure 8:

- 2a (i): Eskom borrows and draws on existing approved sovereign guarantees or is issued new guarantees.
- 2a (ii): Eskom borrows without guarantees but investors understand it its debt is implicitly guaranteed by Government.
- 2b (i): Government provides Eskom with a further equity injection and borrows to raise the funds.
- 2b (ii): Government provides Eskom with a further equity injection but reduces spending drastically in other areas to raise the funds.
- 2b (iii): Government provides Eskom with a further equity injection but immediately raises taxes to raise the funds (probably PIT and/or CIT or special levy as VAT is too regressive).
- 2c: A Stake of Eskom is sold to a private sector investor or Eskom sells existing generation or non-core assets.

Figure 8: Summary of options to meet Eskom’s revenue requirement if tariff increases are inadequate



The most likely option in our view is that either Eskom or Government raises additional debt to cover the shortfall as in sub-options 2 a(i), 2a(ii) or 2b(i). Eskom’s long-term credit rating was downgraded by S&P to sub-investment grade in 2015 and was further downgraded into ‘junk’ territory in November 2016. Given Eskom’s poor credit rating, the utility is unlikely to be able to raise further debt on its own balance sheet without drawing further on the R350bn worth of guarantees government made available. Any debt

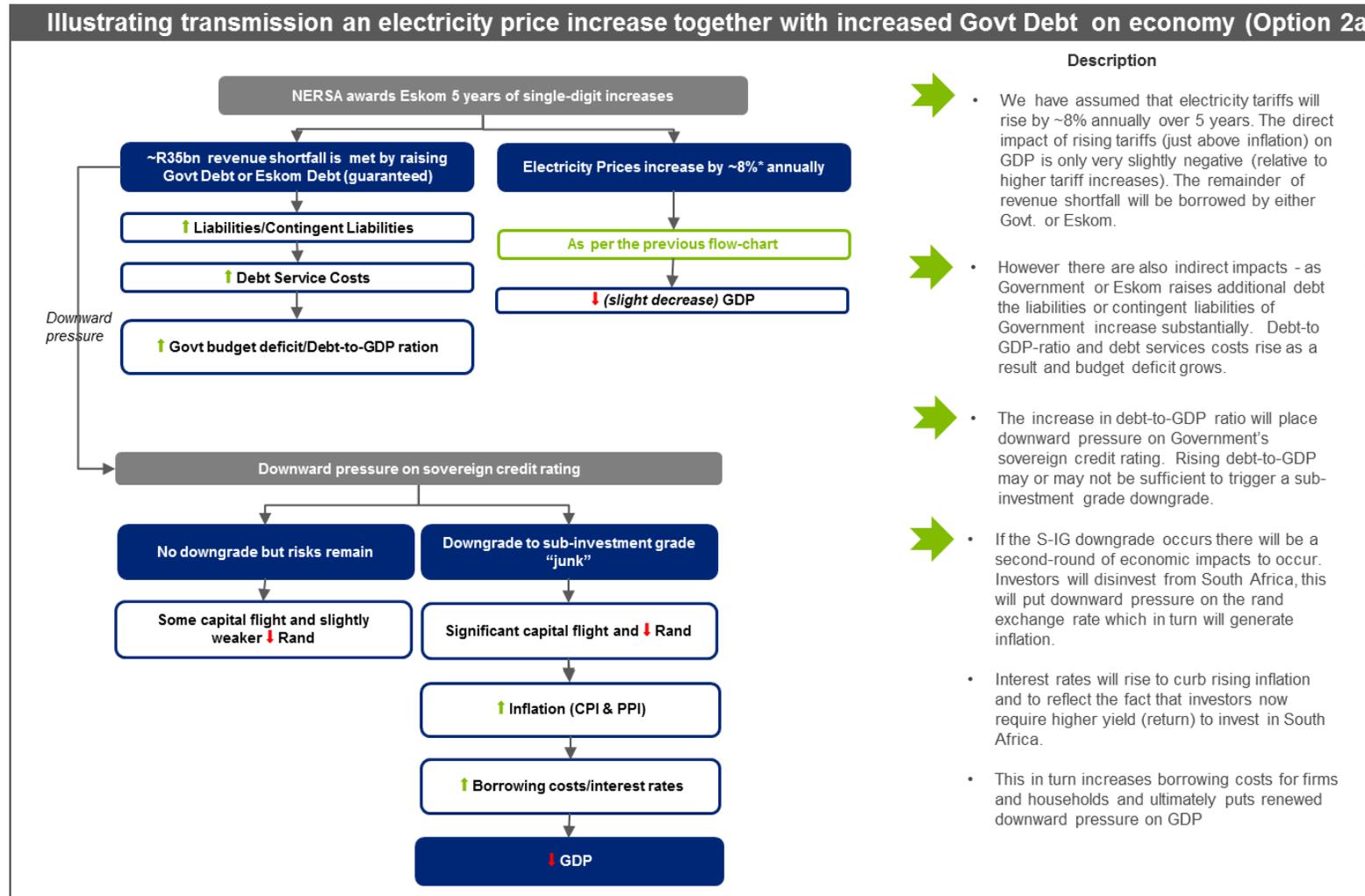
the utility raises that is guaranteed by government becomes a contingent liability on government's balance sheet so in macroeconomic terms there is little difference between sub-options 2a(i), 2a(ii) or 2b(i). This means that a single simulation where government raises debt on behalf of Eskom to meet its revenue shortfall is sufficient to consider the economic impact associated with these sub-options.

In sub-option 2b(ii), government could theoretically reprioritise spending, cutting expenditure in other areas (e.g. health, education, public safety etc.) to provide Eskom with an additional equity injection. However, since Eskom's expected annual revenue shortfall under an 8% annual tariff increases would be substantial – we estimate it would be in the order of R30bn to R40bn - this is not a feasible option, it would amount to reprioritising roughly 4% of total annual government expenditure. This is particularly unlikely given that government has struggled to balance its budget since it last achieved a surplus in 2006 and has reported a budget deficit for the ten consecutive years since.

While government could raise general taxes (sub-option 2b(iii)) such as VAT, CIT or PIT to fund Eskom, this is far less efficient than funding Eskom via its own tariff (user-pays) and will potentially have negative distributional impacts. Option 2c is the least feasible option, since it is very unlikely in our view that private investors would find an equity stake in Eskom (as a whole) an attractive proposition, given that the utility is in a weak financial position and currently generates zero return-on-equity. While Eskom and the National Treasury considered the possibility of selling some Eskom's ageing generation assets or non-core assets (such as property) to meet the utility's growing funding shortfall in 2014, it proved unattractive. Since tariffs remain below cost-reflective levels and its future tariff path is uncertain, Eskom's assets would currently be under-valued, the sale of under-valued assets could compromise Eskom's viability in future.

In Figure 9 we provide a diagram illustrating the potential transmission of higher electricity prices together with increased government debt through the macroeconomy (Sub-options 2a or 2b(i)). The interactions in an economy (and in macroeconomic models) are more complex than this schematic suggests – this simplification is for illustrative purposes.

Figure 9: Macroeconomic transmission of electricity price shock together with increased government debt



3. Overview of model and approach

3.1 Description of model

The model used for the simulation of the tariff scenarios, which are described in the following section, is the University of Pretoria General Equilibrium Model (UPGEM) described in Bohlmann et al. (2015). A comprehensive review of potential approaches to modelling the macroeconomic impacts of rising energy prices or energy subsidy reform which informed our approach and choice of model is provided in Appendix 1. Appendix 1 also includes a brief of recent local and international literature on the macroeconomic impacts of rising energy prices in South Africa.

UPGEM is a flexible CGE model that can be run in either comparative-static or recursive-dynamic mode. For the purposes of this report, the standard recursive-dynamic version of UPGEM, like that used in Bohlmann et al. (2015) was used. The ability of CGE models, such as UPGEM, to recognise the many inter-linkages in the real economy, and account for price-induced behaviour and resource constraints in determining both the direct and indirect effects of an external shock on the economy over time, has made it one of the preferred methodologies for practical policy analysis around the world. As noted in Appendix 1, CGE models have frequently been used both locally and internationally to examine the impact of rising energy prices and the removal of energy subsidies.

In a dynamic CGE analysis, the impacts of an exogenous shock such as a rise in electricity tariffs are assessed by computing the differences between a scenario in which the shock has occurred – the policy simulation – and a counterfactual scenario in which the shock under examination did not occur – the baseline scenario. The results are then reported as percentage change deviations over time between the 'baseline' simulation run and the 'policy' simulation run.

One of the key steps in CGE modelling is the choice of the modelling closures. This is the choice of which variables will be made exogenous (values will be forecast independently of the model) and which will be determined endogenously (will be determined within the model by other variables in the system and the prescribed relationships between them). In the baseline, we exogenise those variables for which reliable forecast information exists, which typically includes macroeconomic variables, such as the components of GDP, population growth and various price indices forecast by various macroeconomic specialists. In the policy runs, all the naturally endogenous variables are set as endogenous, because we are interested in the impact of the policy change on them. In this study, the standard baseline forecast and policy closures appropriate for UPGEM, as described in Dixon & Rimmer (2002: 262-274) have been applied. Any changes to the standard closures (made to facilitate the various modelling scenarios in this report) are described later in this section.

A more detailed but non-technical overview of the CGE methodology, including the description of a stylized miniature model, BOTE-M in has been provided in the Appendices. Readers unfamiliar with the CGE

methodology are encouraged to first read the Appendices before attempting to work through the simulation scenarios and results.

3.2 Aim of the modelling exercise

The overall aim of this modelling exercise is to assess and compare the macroeconomic effects of various options that are available to meet Eskom's revenue requirement over the 5-year period from 2017 to 2021. It is envisaged that the simulations and modelling evidence produced in this report will enable decision and policy-makers to assess the trade-offs between the potential fiscal and economic consequences of alternative options to meet Eskom's 5-year revenue requirement.

3.3 Description of the tariff scenarios modelled

3.3.1 Scenarios modelled

For this modelling exercise, Eskom advised Deloitte to model the impacts associated with three alternative tariff scenarios – average annual increases over a five-year period of 8%, 13% and 19% respectively. In November 2016, when this study commenced, Eskom had not yet finalised its forthcoming tariff application nor had it decided whether it would submit a tariff application for a single-year or for a multi-year period. As such official estimates of Eskom's required revenue and sales forecasts over the next five years were not available, the scenarios are therefore hypothetical and we have made the following key assumptions:

- We assume that the upper-bound annual average increase of 19% is what Eskom requires to reach and maintain, a cost-reflective electricity tariff over the 5-year period from 2017 to 2021.
- We assume, that Eskom's total revenue requirement is the same across all tariff scenarios and that it is equivalent to the revenue that would be raised if tariffs increased at an annual average rate of 19%. For example, under the 8% tariff scenarios, Eskom experiences an annual revenue shortfall equivalent to the difference between the total revenue raised under a compounded 19% tariff increase and the compounded 8% increase. We then have further scenarios to model how the shortfall will ultimately be recovered– e.g. by raising additional government debt (borrowing) or taxes.

Three main categories of policy simulations were modelled, each with a different set of assumptions and for three tariff path options – 8%, 13% and 19% (where applicable)⁹. This resulted in a total of five simulations all of which represent an alternative potential solution to meet Eskom's total revenue requirement over a five-year period. The scenarios modelled included a 'tariff-only' option where electricity tariffs increase at an annual rate of 19% over five years and a baseline scenario (BAU) where tariffs increase at an average rate of 8% and the revenue shortfall is funded by raising additional government debt. Further scenarios included a 13% annual tariff increases with a debt-funded shortfall, an 8% increase with tax-hike funded shortfall and a downgrade scenario, explained further below. At the time, the modelling was undertaken (January 2017) we judged that there was also a significant risk that steadily

⁹ In the interim modelling report produced by the University of Pretoria, another two groups of scenarios were considered – 1) a tax credit reducing VAT and 2) a tax credit reducing production taxes. We have decided to omit these two scenarios as the added unnecessary complexity and did not materially alter the findings. We have also re-labelled/re-coded the scenarios for the readers of the final report.

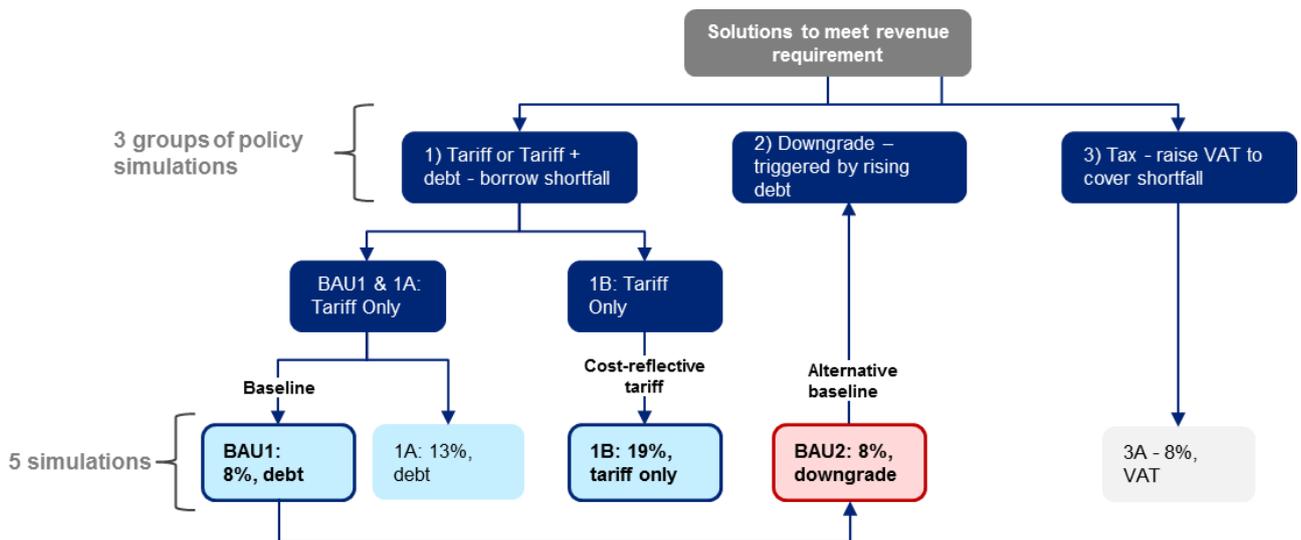
rising government debt levels associated with the baseline tariff scenario of 8% would trigger a sub-investment grade (S-IG) credit rating downgrade¹⁰.

To simulate the economic impacts of this downgrade risk materialising we ran an alternative baseline simulation (BAU2) where a steadily rising debt-to-GDP ratio and deteriorating budget balance that is associated with an 8% average tariff increase triggers a S-IG credit rating downgrade. A visual summary of the five simulations modelled is provided in Figure 10.

Table 4: Summary of scenarios modelled

		Average annual tariff increase		
		8%	13%	19%
Solution to meet revenue requirement				
1	Debt - borrow shortfall	BAU1: 8%, debt	1A: 13%, debt	n/a
	Tariff only	n/a	n/a	1B: 19%, tariff only
2	Downgrade - rising debt triggers downgrade	BAU2: 8%, downgrade	n/a	n/a
3	Tax - raise VAT to cover shortfall	3A: 8%, VAT	n/a	n/a

Figure 10: Summary of scenarios modelled



3.3.2 Factors that will influence revenue and tariff required over next 5 years

Eskom has indicated that based on an analysis of their financial position as at May 2017, it seems unlikely that the utility will require an annual nominal tariff increase as great as 19% to close the gap between

¹⁰ At the time of writing and finalisation of the modelling for this study, South Africa maintained an investment grade rating on both its foreign- and domestic-currency denominated debt. On the 3rd of April 2017, Standard & Poor’s downgraded South Africa’s long-term foreign currency sovereign credit rating to sub-investment grade or “junk” and on the 7th of April 2017, Fitch ratings agency followed suit. By 7th April 2017 the yields on 10-year government bonds had risen by nearly 1 percentage point or 100bps from their mid-March lows from around 8.4% to just over 9%.

costs (prudently and efficiently incurred) and revenue over a five-year period. There are however some upside risks to current estimates of Eskom's future revenue requirement - these include:

- Purchase of additional renewable energy capacity** - current estimates of the revenue requirement (and therefore tariff) are based on the assumption that Eskom will not purchase any additional renewable energy capacity from IPPs (beyond that which is has already committed to). If Eskom signs additional power purchase agreements (PPAs) under the renewable energy independent power producers programme (REIPPP) the utility's average cost of electricity provision will rise further. According to data supplied to Eskom by the Department of Energy, the weighted average cost for REIPP Bid Windows 4 and 4+ will be around 83 c/kWh (in 2015 rands) inflated by annual headline CPI of 5.5% this would be 92c/kWh in 2017 rands. While accurate estimates of the LCOE (levelised cost of energy)¹¹ of Eskom's existing generation fleet are not available Joubert (2017), notes that Eskom's average fuel cost (including peaking plants and excluding IPPS) will be around 30c/kWh in 2017 and coal for its most marginal and expensive coals stations will be around 42 c/kWh in 2017. Since fuel costs typically represent 45% of the total LCOE of coal-fired plants (according to the EIA 2016). we estimate that Eskom's average LCOE for its existing coal-dominated generation fleet would be in the order of 66c/kWh (based on 30c/kWh average fuel cost). Furthermore, the LCOE measure does not reflect the additional financial costs that are ultimately associated with delivery of energy from renewable sources (these include the costs associated with higher intermittency of renewables relative to coal and higher transmission costs), so it is clear that additional renewable capacity at an LCOE of 92c/kWh will drive up Eskom's average generation costs (we estimate the LCOE is ~66c/kWh), its overall revenue requirement and therefore average tariff.
- Lower-than-anticipated electricity demand or sales** – Analysts have revised their forecasts of South Africa's real GDP and fixed investment growth lower following the downgrade of South Africa's long-term foreign currency rating to sub-investment grade and are now generally expecting real GDP growth of between 0% and 1% y/y in 2017. Given the strong positive relationship between electricity sales and real economic activity, Eskom may face lower than expected demand which would reduce its sales and increase the average tariff it requires to cover its costs.
- New build programme** – current estimates of the tariff required to close the revenue gap are based on anticipated capital expenditure under the approved new build programme including the completion of Medupi and Kusile and IPP capacity already procured. If, however Eskom initiates a further new build programme within the next 5 years, such as the potential nuclear build, it is likely that real tariffs would need to rise faster than is currently anticipated to accommodate the additional costs associated with the new build programme.

3.3.2.1 General description of the three categories of policy simulation

The three categories of policy simulation are described generally as follows:

¹¹ LCOE includes fuel, capital cost and operating and maintenance costs for generation plant.

1. **Tariff only or Tariff and Debt simulations:** For this category of simulations we assume that Eskom will raise its total revenue either entirely via an increase in the electricity tariff (19% av. Annual increase) or partially via the tariff (8%, 13%). In the case of the partial tariff increases, we assume government raises debt to cover the revenue shortfall (in reality, Eskom might raise debt on its own balance sheet but this would either be explicitly or implicitly guaranteed by the government). At the one extreme, this category includes the 'business-as-usual (BAU) or baseline simulation which is an 8% average annual tariff increase accompanied by a relatively large increase in government borrowing to meet the shortfall. At the other extreme we have the 'tariff only' or cost-reflective tariff scenario, where the tariff increase of 19% per annum is sufficient on its own to meet Eskom's revenue requirement.
2. **Downgrade simulation:** This category simulates the risk that the sharply rising government debt/GDP ratios that are associated with the baseline scenario (BAU1 - 8%, debt) would trigger a sub-investment grade downgrade of South Africa's sovereign credit rating. The simulation is effectively an alternative baseline.
3. **Tax - raise VAT to cover shortfall:** In this simulation, we consider the impact of Government immediately raises taxes (to avoid increasing its debt and the risk of a downgrade) to meet Eskom's revenue shortfall under an 8% tariff scenario. While government is more likely to raise personal and corporate income taxes than VAT to fund Eskom than VAT, the model specification made it far more difficult to 'increase' PIT/CIT in this instance. We believe however that the aggregate impact on the economy would be similar regardless of which tax instrument is used, only the distributional impacts would differ markedly.

3.3.2.2 Additional category of policy simulations modelled but not included

A fourth category of policy simulations which we describe as 'tax credit' scenarios were also modelled to consider ways of funding Eskom's revenue through alternative tax instruments. We chose not to present the results of these additional six tax simulations in this summary report as the net impact is very similar to the results of our other tax scenario - 3A:8% VAT. As we discuss below, raising taxes emerges as the least attractive option to meet Eskom's revenue requirement so it is not worthwhile in our view to spend time considering alternative tax instruments within this category. In the 'tax credit' set of simulations, government's budget deficit and expenditure are held constant at the worst level (associated with 8% tariff increase) and we simulate by how much government could then reduce corporate and personal income tax if electricity tariffs were instead raised by 13% and 19% respectively. While somewhat less intuitive, this is an alternative way of considering what the relative economy-wide impacts are of allowing Eskom's revenue shortfall to be funded by raising tax via different tax instruments (Specifically VAT vs PIT&CIT vs production taxes). While the results are not reported here they can be made available (in raw format) on request.

3.3.2.3 Detailed description of each of the five model simulations

The setup and assumptions for each of the seven individual model simulations outlined above is described in more detail below. This includes a description of any changes to standard model closures that were required to conduct these simulations:

Tariff only or 'Tariff and Debt' simulations

- BAU1: 8%, debt** - This is the business-as-usual (BAU) or baseline scenario in which electricity tariffs rise at an average rate of 8% y/y over the five-year simulation period. For this scenario future values of GDP, CPI, Investment, and electricity prices are forecast independently of the model based on a combination of historical data and short-term forecast data. We assume GDP accelerates from 1.3% in 2017 to 3% average annual growth from 2020. We assume CPI slows from 6.1% in 2017 to long-term average of 5.5% a year (Table 5). Government's budget deficit is determined endogenously. We assume that increased debt associated with the rising budget deficit that occurs in this scenario has no further economic effects, including on borrowing costs. However, rising debt/GDP ratios are often associated with lower credit ratings and increased borrowing costs, or alternatively, higher required gross rates of return for investors. Such a potential event is modelled separately in the alternative baseline or downgrade scenario - BAU2: 8%, downgrade.

Table 5: BAU forecast values assumed for selected exogenous macroeconomic variables (y/y%)

Variable	2012	2013	2014	2015	2016	2017	2018	2019	2020-30
Real GDP	2.2	2.3	1.6	1.3	0.5	1.3	2.0	2.2	3.0
GFCF (Investment)	3.6	7.0	1.5	2.5	-2.8	1.1	2.6	3.1	4.5
Consumer Prices	5.7	5.8	6.1	4.6	6.4	6.1	5.9	5.7	5.5
Electricity Prices	16.0	8.0	8.0	8.0	9.4	8.0	8.0	8.0	8.0

- 1A: 13%, debt.** In this scenario electricity prices are exogenously set to increase by 13% in nominal terms (5 percentage points above the baseline) from 2017-2021. The price increase is imposed via a specific tax on electricity in order for the additional revenue generated by the state-owned electricity sector to affect the budget deficit and subsequent debt position. Government expenditure is exogenous and set to remain on its BAU baseline path.
- 1B:** Same as scenario 1A but with electricity prices set to increase by 19% in nominal terms (11 percentage points above the baseline) from 2017-2021.

Downgrade simulation

- BAU2: 8%, downgrade** - Policy scenario in which the required gross rate of return for investors (which represents borrowing costs) increases by 1 percentage point to reflect a riskier investment environment in the wake of a credit ratings downgrade. Previous work by Deloitte to model the impact of sub-investment grade downgrade suggested that interest rates would rise and remain between 1 and 1.5 percentage points higher for at least 2 years following an S-IG event (see Appendix 4). This

simulation serves as a proxy for a scenario in which the funding gap and subsequent financial loss incurred by the state-owned electricity sector (Eskom) affects the deficit position of the country as a whole, leading to a credit ratings downgrade. As such, BAU can be viewed as alternative bask line should this event occur.

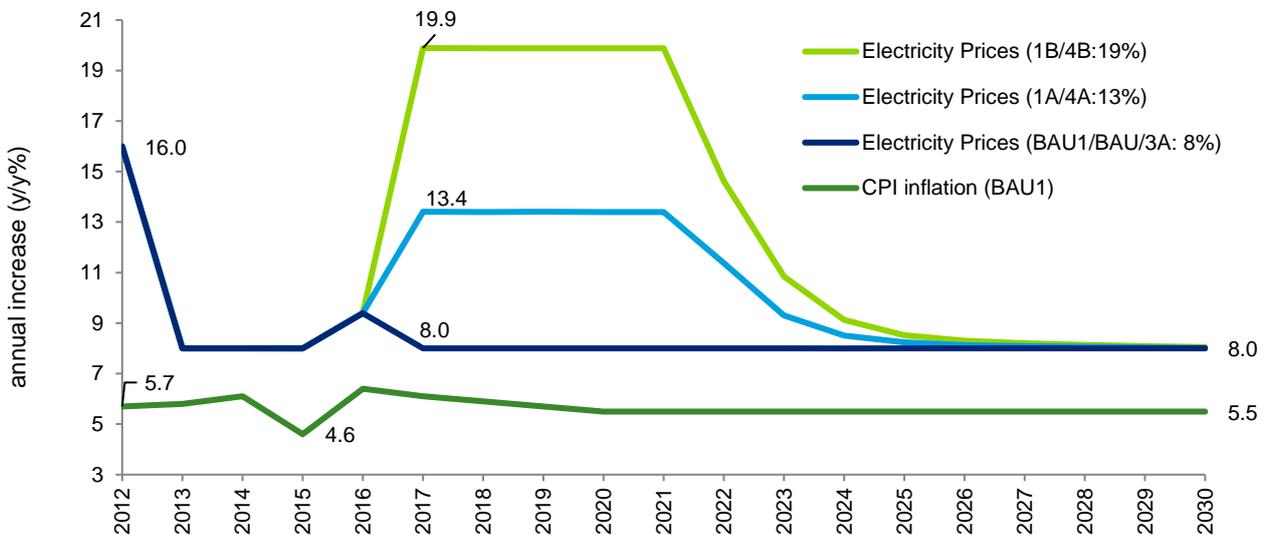
Tax - raise VAT to cover shortfall

- **3A: 8%, VAT** – In this scenario the govt. budget deficit is exogenously set to the level generated in scenario 1B, with a general sales tax on all products endogenously changing to meet this condition. This scenario shows the economy-wide impact of closing Eskom’s funding gap via a higher general sales tax, instead of higher electricity prices as modelled in scenario 1B.

3.3.2.4 Long-term electricity price path assumed across the five simulations

The electricity price path that was assumed for each of the five scenarios modelled, over the period 2017 to 2030, is illustrated in Figure 11. The assumed average annual changes in consumer price inflation (CPI) for the baseline scenario (BAU1) is also shown. The annual change in CPI inflation is determined endogenously in all other scenarios.

Figure 11: The electricity price path assumed relative to CPI inflation (2017 to 2030)



4. Simulation results

We present the comparative results of our policy simulations in the sections below. The results of all policy simulations are presented relative to the baseline scenario (BAU1: 8%, debt). The relative effects of the various policy simulation on the following key macro variables have been highlighted:

- GDP growth
- the budget deficit
- debt-to-GDP ratio
- CPI inflation,
- Total employment

An Excel sheet containing a summary of all policy simulation results is available from the study authors upon request.

4.1 Comparative results – impact on GDP

The comparative impacts of alternative scenarios to meet Eskom's revenue requirement on economic activity or GDP are summarised in Figure 12, Figure 13 and Table 6.

In the baseline scenario (BAU1:8% debt) real annual GDP growth is expected to average 2.3% in the 5 years to 2021 and 3% thereafter. As anticipated, in the scenarios where higher electricity price increases of 13% and 19% are applied (1A and 1B respectively), GDP growth will be *slightly lower* than in the baseline (BAU1):

- **In scenario 1A: 13%, debt**, GDP is expected to grow at an annual average rate of 2.2% (2017 to 2021) which is just *0.1 percentage points lower* than in the baseline (BAU1).
- **In scenario 1B: 19%, tariff**, average annual GDP growth from 2017 to 2021 will be *0.3 percentage points lower* than in the baseline - with GDP expanding at an average of 2.0% y/y compared to 2.3% y/y in BAU1. A series of five annual increases of 19% under 1B will shave a cumulative 1.3 percentage points off GDP growth over 5 years relative to the baseline (BAU1) (Table 6).

We note that these results are more or less consistent with the results presented in an assessment in 2013 of the economic impact of tariff increases by NERSA in its reason for decision on Eskom's MYPD3 application (NERSA, 2013). While NERSA (2013) did not model a 19% annual increase it noted that a *16% tariff increase was expected to lower average annual GDP growth by 0.3 percentage points*, reducing forecast GDP growth from 3.7% to 3.4%.

In BAU1, tariff increases are insufficient to meet Eskom's total revenue requirement and so we have assumed that Government/Eskom raises debt to cover the shortfall with no further consequences. The

negative impact of lower tariff increases on government's budget deficit and rising government debt-to-GDP ratios associated with BAU1 are illustrated in Section 0 below. There is however a considerable risk, that the rising budget deficit and debt-to-GDP ratios that are associated with BAU1 will trigger a sub-investment grade credit rating downgrade. This risk is intensified by South Africa's already high and rising debt-to-GDP ratio (55% in 2016) and the recent warnings by ratings agencies that an unforeseen increase in the debt of state-owned enterprises is one of potential triggers of a S-IG downgrade. If this risk is realised, the alternative baseline BAU2: 8%, downgrade is the more appropriate benchmark:

- In the alternative baseline - **BAU2: 8% downgrade**¹² *annual GDP growth will be 0.3 percentage points* lower than in BAU1 (In Figure 13). The negative impact of the downgrade baseline scenario (BAU2) on GDP growth is roughly equivalent to the impact of a 19% annual average tariff increase (1B) - with GDP growth expected to average 2.0% y/y from 2017 to 2021, in both cases. In other words, if the rising government debt burden that will be associated with an 8% annual tariff increase triggers a S-IG downgrade, the negative impact on economic growth will be as great as under a 19% annual tariff increase. In addition, under the alternative baseline South Africans would, in all likelihood, be worse-off than under the annual 19% tariff increase scenario, as borrowing costs (or the required return on investment) will rise by 1 percentage point (100bps), debt-to-GDP ratios climb higher and the range of market distortions caused by tariff subsidies will also persist.
- In scenario **3A:8%, VAT** we assumed that Government (in a bid to avoid the accumulation of debt that is associated with increased risk of a downgrade), increases the electricity tariff by an average of 8% and simultaneously increases taxes (VAT) to cover Eskom's revenue shortfall. This strategy however is likely to prove self-defeating - Figure 12 shows the negative impact on GDP growth is in fact marginally worse than the tariff-only scenario 1B:19%. There would be additional concerns regarding the fairness (it would be preferable to get electricity users rather than general consumers to pay for the rising cost of electricity) and efficiency (reduced incentive to become electricity-efficient and the other wide-ranging consequences of electricity subsidies apply).

¹² where electricity prices rise by 8% but rising debt triggers an S-IG downgrade and interest rates/return required by investors subsequently rises by 1 percentage point,

Figure 12: Impact on trend in real GDP growth – 1A, 1B, 3A relative to BAU1 and BAU2

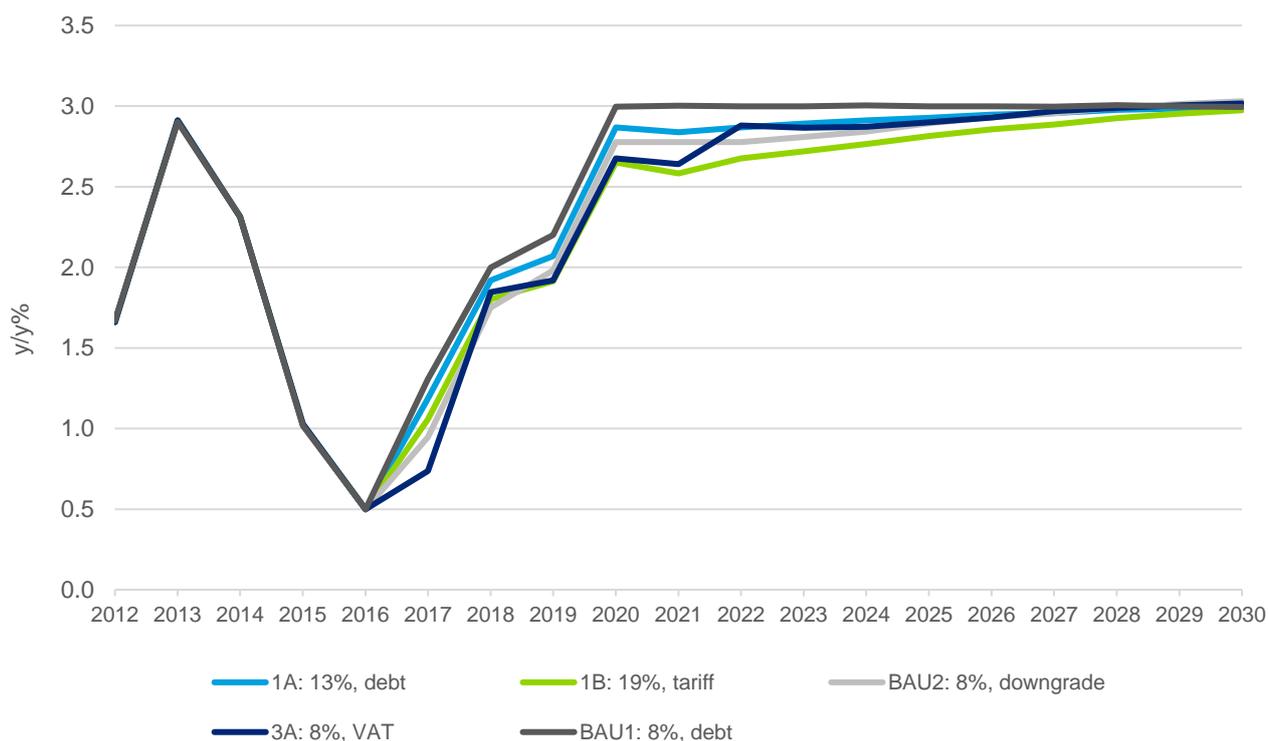


Figure 13: Average impact on GDP growth over periods '2017 to 2021' and '2022 to 2030'

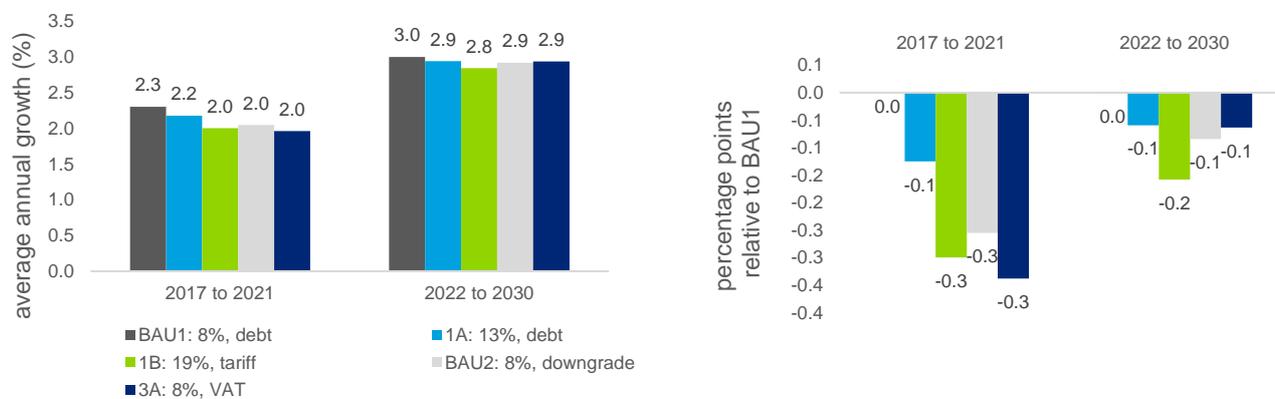


Table 6: Average impact on GDP growth over periods '2017 to 2021' and '2022 to 2030'

	Average annual growth (%)		Average annual deviation from baseline (Percentage points)		Cumulative growth over 5 years 2017 to 2012	
	2017 to 2021	2022 to 2030	2017 to 2021	2022 to 2030	%	Percentage points dev.
BAU1: 8%, debt	2,3	3,0			10,6	
1A: 13%, debt	2,2	2,9	-0,1	-0,1	10,0	-0,5
1B: 19%, tariff	2,0	2,8	-0,3	-0,2	9,3	-1,3
BAU2: 8%, downgrade	2,0	2,9	-0,3	-0,1	9,6	-1,0
3A: 8%, VAT	2,0	2,9	-0,3	-0,1	9,4	-1,2

4.2 Comparative results – impact on budget-deficit and debt-to-GDP

The cumulative impact of each scenario on Government’s general budget deficit is summarised in Figure 14, Figure 15 and Table 7.

In the baseline scenarios (BAU1 and BAU2) the rising government debt associated with lower-than-required tariff increase of 8% means that the nominal budget deficit rises steadily at an annual average rate of ~13% between 2017 and 2030 (Figure 14 and Table 7). In Scenario 1A: 13%, debt, the government budget deficit rises at a somewhat slower average annual rate of roughly ~10.5% (as a greater proportion of Eskom’s costs are recovered via the tariff) and by 2030 is a cumulative R400bn lower than the baseline path (BAU1).

In Scenario’s 1A and 3A where all of Eskom’s required revenue is recovered via the tariff (1A) or a combination of tariff and higher taxes (3A) the nominal budget deficit increases at an average annual rate of 5.2% which means that it falls in real terms (increases at a slower rate than CPI inflation). By 2030 the budget deficit is a cumulative ~R900bn lower than it would have been under the baseline scenarios (BAU1 and BAU2).

Figure 14: Cumulative impact on government’s general budget deficit - 1A, 1B, 3A relative to BAU1 and BAU2

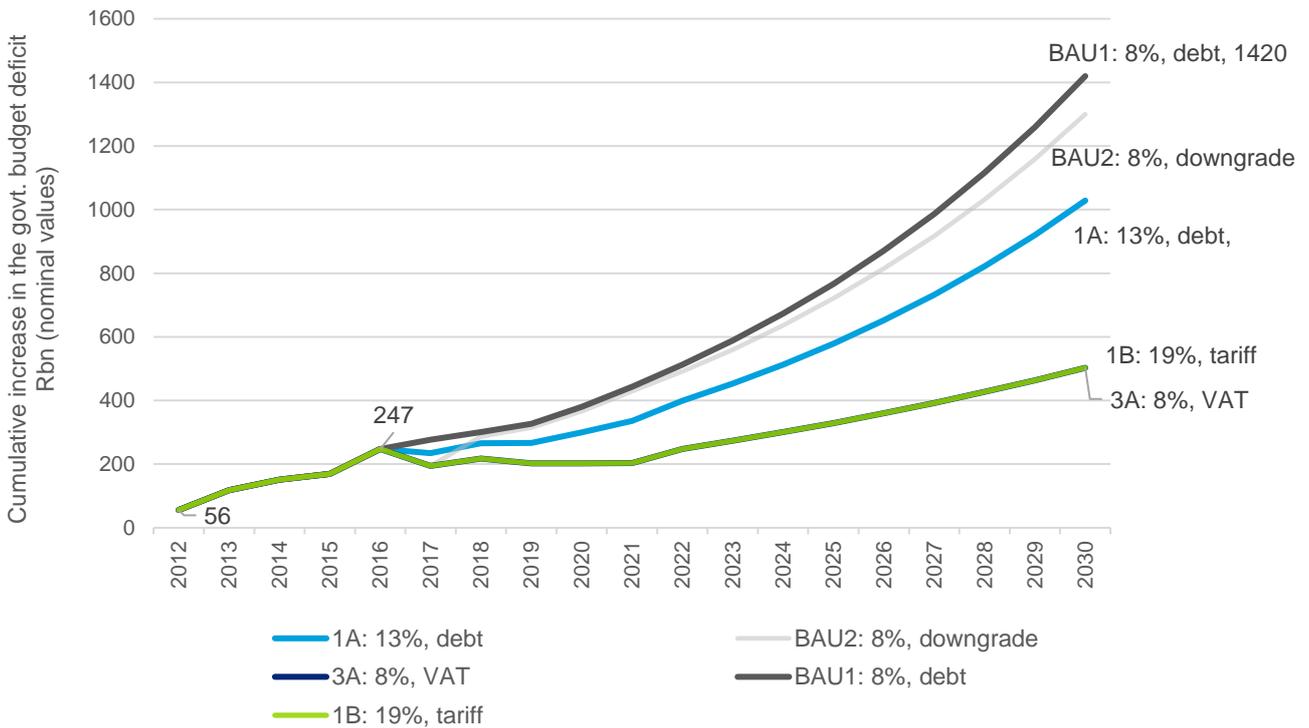


Figure 15: Cumulative deviation in government deficit from baseline in 2021 and 2030

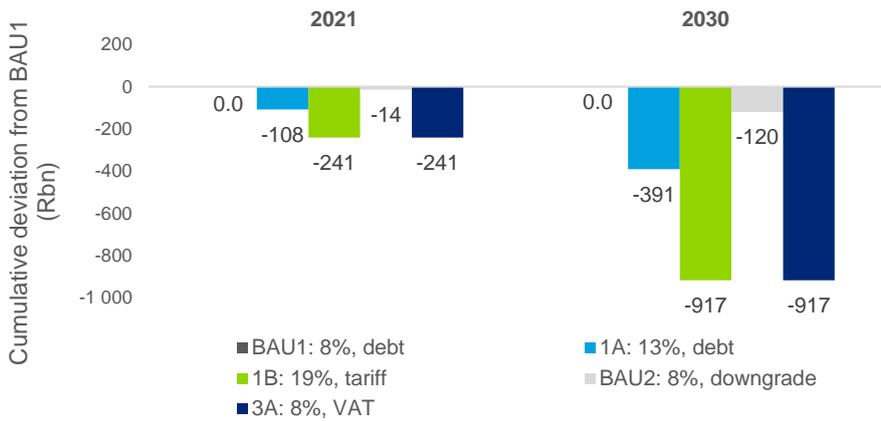


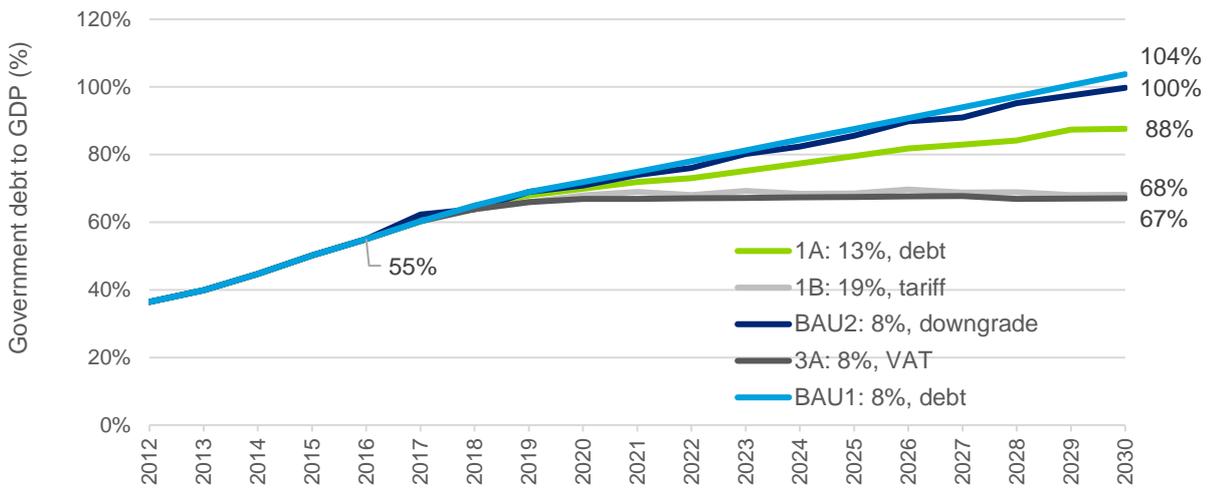
Table 7: Average annual growth in budget deficit

Average annual growth in nominal budget deficit	
%	
2017 to 2030	
BAU1: 8%, debt	13,3
1A: 13%, debt	10,7
1B: 19%, tariff	5,2
BAU2: 8%, downgrade	12,6
3A: 8%, VAT	5,2

The impact of each scenario on the government debt-to-GDP ratio is summarised in Figure 16.

- In the **baseline scenarios** (BAU1 and BAU2) the government debt-to-GDP ratio rises steadily from ~55% in 2017 to ~100% by 2030. This is because the annual tariff increase of 8% awarded to Eskom from 2017 2021 results in a growing annual revenue shortfall and we have assumed in the baseline scenarios that government covers the shortfall by raising debt.
- In **Scenario 1A: 13%, debt**, the government debt-to-GDP ratio rises albeit a somewhat slower rate than in the baseline scenarios from ~55% in 2016 to ~88% by 2030.
- In **Scenario’s 1A and 3A** where all of Eskom’s required revenue is recovered via the tariff (1A) or a combination of tariff and higher taxes (3A) the government debt-to-GDP ratio rises from ~55% in 2016 to ~67% by 2020 and stabilises at this level thereafter.

Figure 16: Impact on government debt-to-GDP ratio - 1A, 1B, 3A relative to BAU1 and BAU2



In summary, while the 19% annual tariff increase required to meet Eskom’s revenue requirement has a slightly negative impact on GDP growth relative to the baseline (BAU1), it also results in much lower government debt-to-GDP ratios and greatly reduces the risk that a rise in Eskom-related-debt will trigger a S-IG sovereign credit ratings downgrade. The 8% tariff baseline scenario (BAU1) by contrast, is associated with a steady deterioration in government’s budget balance and with debt-to-GDP ratio expected to reach 75% by 2021 and 104% by 2030, there is a substantial risk in our view that the downgrade scenario (BAU2) would materialise.

4.3 Comparative results – impact on CPI inflation

The comparative impacts of alternative scenarios to meet Eskom’s revenue requirement on CPI inflation are summarised in Figure 17 and Figure 18 and Table 8.

In the baseline scenario (**BAU1:8% debt**) CPI inflation is expected to average 5.7% y/y in the five years to 2021 and 5.5% thereafter.

The scenarios with higher annual electricity price increases of 13% and 19% (**1A and 1B** respectively) have very little impact on CPI inflation - *inflation rises in both cases by less than 0.1 percentage point*, averaging 5.8% y/y in the five-year period from 2017 to 2021 and 5.5% y/y thereafter. A series of 5 annual electricity price increases of 19% will add a marginal 0.6 percentage points (cumulatively) to inflation over the five years to 2021.

Our results suggest that the impact of a series of 19% electricity tariff increases on CPI inflation will be more muted than what NERSA (2013) reported in its previous assessment. NERSA reported that a series of five 16% tariff increases (starting in 2013) would add 4.6 percentage points (cumulatively) to CPI inflation, whereas we found that a series of five annual 19% increases would add only 0.6 percentage points. While the low-CPI impact associated with relatively high tariff increases may seem counterintuitive, it can be attributed to the fact that higher tariff increases have a slightly negative impact on GDP growth and relatively subdued GDP growth over the period is likely to keep inflation in check.

Scenario 3A: 8%, VAT is the only scenarios where there is a noticeable increase in CPI inflation relative to the baseline, but only in the first five years. CPI inflation is expected to average 6.0% y/y from 2017 to 2021 (~0.3 percentage points higher than in the baseline and other scenarios) and 5.5% y/y thereafter. The tax scenario is associated with slightly higher inflation because higher VAT increases the prices of all vatiable goods and services.

Figure 17: Impact on trend in CPI inflation – 1A, 1B, 3A relative to BAU1 and BAU2

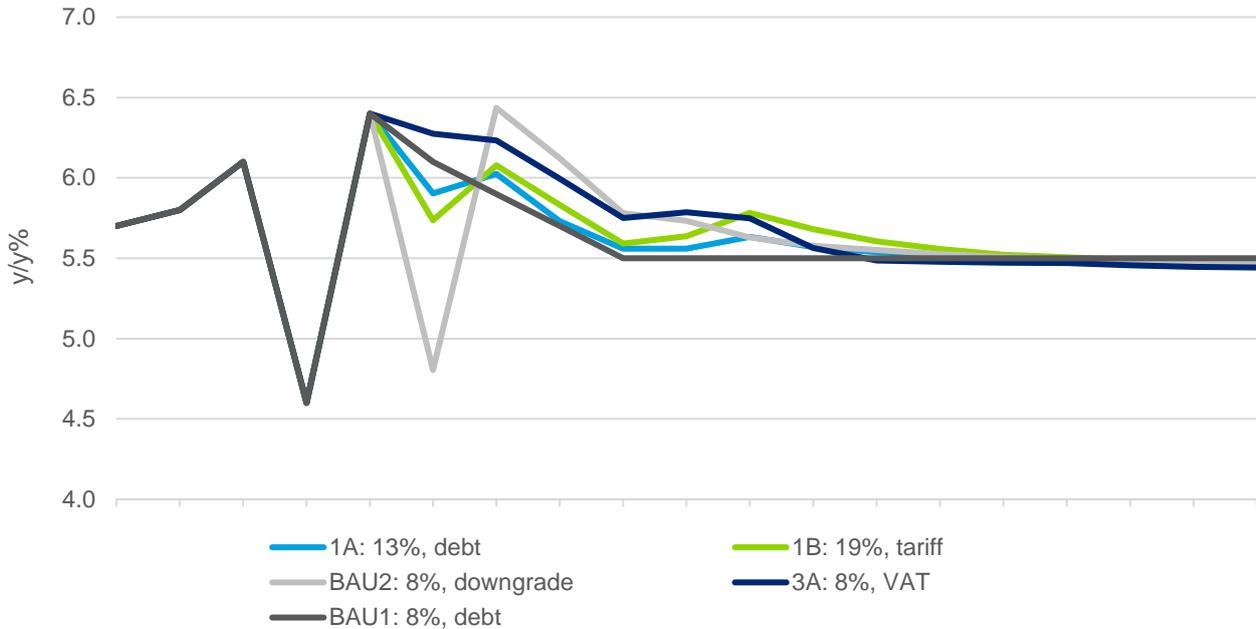


Figure 18: Average impact on annual CPI inflation over periods '2017 to 2021' and '2022 to 2030'

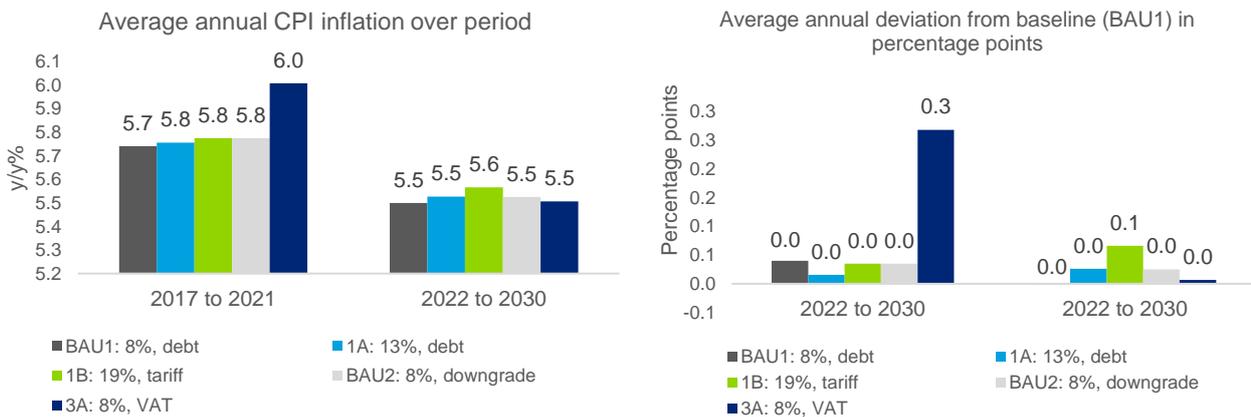


Table 8: Average impact CPI inflation in periods '2017 to 2021' and '2022 to 2030'

	Average annual growth %		Average annual deviation from baseline (percentage points)		Cumulative growth over 5 years (2017 to 2021)	
	2017 to 2021	2022 to 2030	2022 to 2030	2022 to 2030	%	percentage point deviation
BAU1: 8%, debt	5,7	5,5	0,0	0,0	24,59	
1A: 13%, debt	5,8	5,5	0,0	0,0	24,91	0,32
1B: 19%, tariff	5,8	5,6	0,0	0,1	25,22	0,64
BAU2: 8%, downgrade	5,8	5,5	0,0	0,0	26,33	1,74
3A: 8%, VAT	6,0	5,5	0,3	0,0	25,97	1,38

4.4 Comparative results – impact on total employment

The comparative impacts of alternative scenarios to meet Eskom's revenue requirement on total employment are summarised in Figure 19, Figure 20 and Table 9.

In the baseline scenario (**BAU1:8% debt**) growth in total employment is expected to average 1.2%/y/y in the five years to 2021 and 1.5% thereafter. As anticipated, in the scenarios where higher electricity price increases of 13% and 19% are applied (1A and 1B respectively), growth in total employment will be slightly lower than in the baseline (BAU1).

In scenario 1A: 13%, debt, employment is expected to grow at an annual average rate of 1.1% (2017 to 2021) which is 0.1 percentage points lower than in the baseline (BAU1). Under the 19% tariff increase scenario, 59000 fewer jobs will be created and sustained annually from 2017 to 2021 (relative to BAU1) and 110 000 fewer jobs created (and sustained) annually on average thereafter (Table 9). The annual loss of 59 000 job opportunities represents about 0.4% of total employment in the five-year period.

In scenario 1B: 19%, tariff, the 19% annual tariff increase applied will shave an average of 0.3 percentage points off employment growth from 2017 to 2021 – employment will increase at an average rate of 0.9% y/y compared to 1.2% y/y in BAU1. Under the 19% tariff increase scenario, 137000 fewer jobs will be created and sustained annually from 2017 to 2021, relative to BAU1) and 237 000 fewer jobs created (and sustained) annually on average thereafter (Table 9). The foregone job opportunities are due to the slightly negative impact of higher tariffs on GDP growth.

In its previous assessment of the economic impact of tariff increases NERSA (2013) noted that a series of five 16% tariff increases would compromise 652 654 jobs. If we assume that NERSA was referring to the cumulative number of jobs that would be foregone over 5 years, then our results are similar. Our results suggest that 137000 fewer jobs will be created and sustained annually under the 19% tariff scenario (1A) relative to the BAU1 over the five years to 2021. If this is expressed differently, the cumulative deviation in the total employment from baseline (BAU1) in 2021 is 685 000 jobs. This represents about 0.9% of total employment over five years to 2021 – that is total employment will be ~1% lower in scenario 1B:19%, tariff than in the baseline (BAU1).

While our results suggest that higher tariffs will have a negative impact on growth in total employment relative to BAU1, there is a considerable risk that the rising budget deficit and debt-to-GDP ratios that are associated with BAU1 (as illustrated in Section 0) will trigger an S-IG credit rating downgrade. If this risk is realised, the alternative baseline BAU2: 8%, downgrade is the more appropriate benchmark:

- In the alternative baseline - **BAU2: 8% downgrade**¹³ *total employment growth is expected to average 1.0% y/y which is an average of 0.2 percentage points* lower than in BAU1 (Figure 19). The number of jobs foregone in the alternative baseline (BAU2) is slightly less than under 1B: 19%, tariff only but is almost double the jobs foregone in scenario 1A: 13%, debt. In other words, if the rising government debt burden that will be associated with an 8% annual tariff increase triggers a S-IG downgrade, the negative impact on employment growth will be much greater than under a 13% annual tariff increase. This serves as another example of the economic trade-offs that need to be considered– while higher tariff increases slow employment growth, employment growth will be stronger in a scenario where tariffs rise by 13% annually than if the rapid accumulation of debt associated with an 8% annual tariff increase triggers a S-IG downgrade (and BAU2 therefore materialises).
- In scenario **3A:8%, VAT** we assumed that Government (in a bid to avoid the accumulation of debt that is associated with increased risk of a downgrade), increases the electricity tariff by an average of 8% and simultaneously increases taxes (VAT) to cover Eskom's revenue shortfall. This scenario however compromises more job opportunities than any of the other alternatives, including a series of five tariff increase of 19%. In scenario 3A, *total employment growth is expected to average 0.8% y/y over the period 2017 to 2021 which is an average of 0.4 percentage points lower than in the baseline.* As mentioned above there would also be additional concerns regarding the fairness and efficiency and implicit electricity subsidies would persist.

¹³ where electricity prices rise by 8% but rising debt triggers an S-IG downgrade and we assumed that the interest rate/return required by investors subsequently rises by 1 percentage point,

Figure 19: Impact on trend in employment growth – 1A, 1B, 3A relative to BAU1 and BAU2

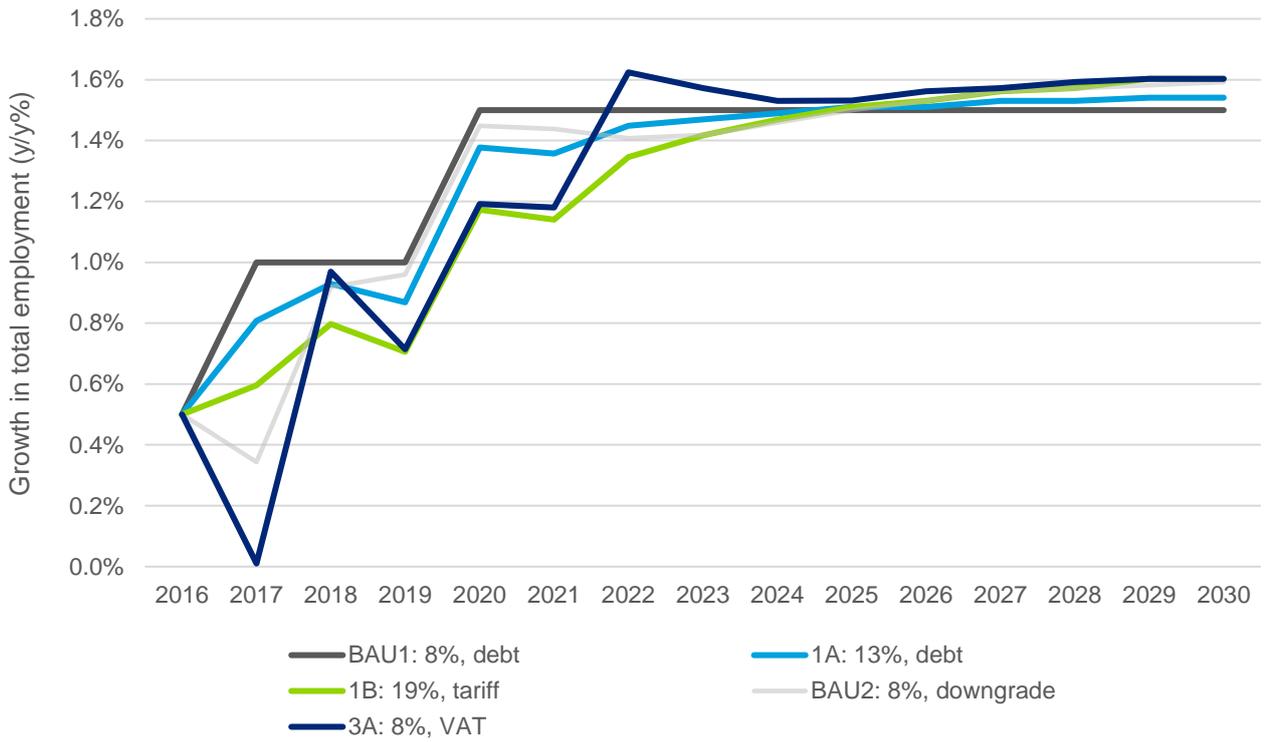


Figure 20: Impact on total employment (jobs in millions) – 1A, 1B, 3A relative to BAU1 and BAU2

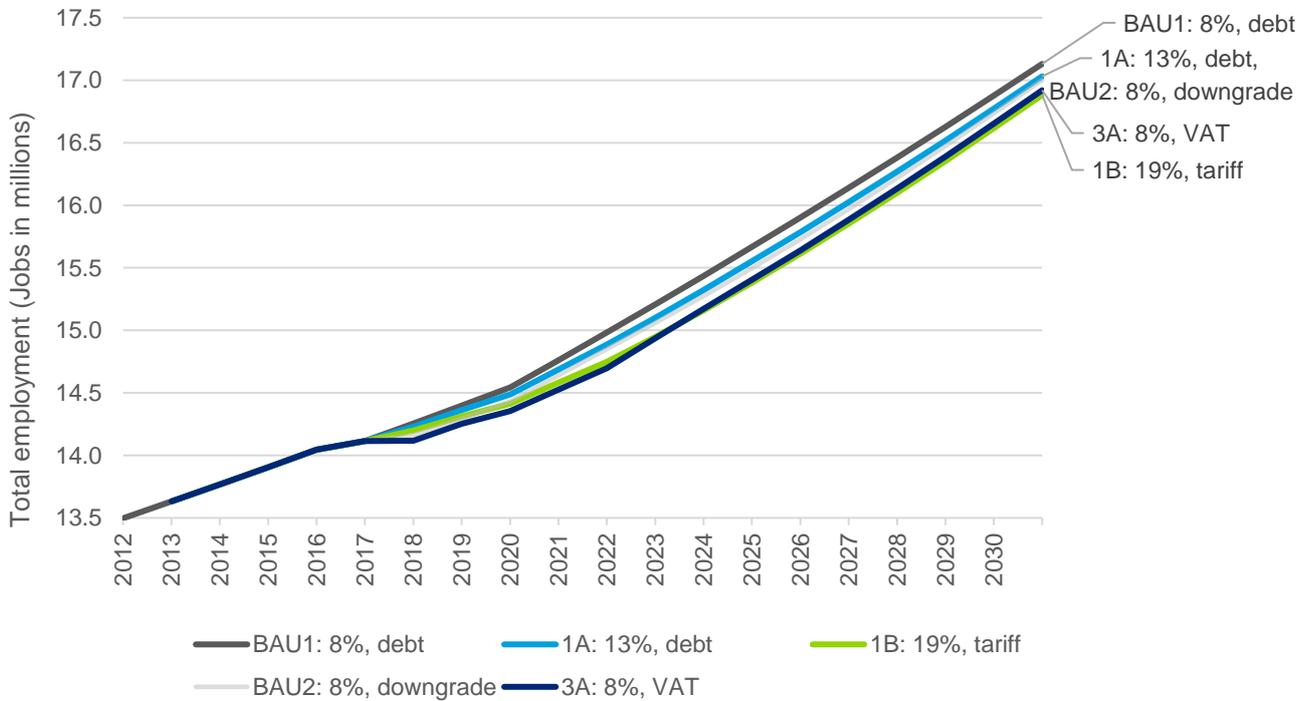


Table 9: Average impact CPI inflation in periods '2017 to 2021' and '2022 to 2030'

	Average annual growth %		Average annual deviation from baseline (percentage points)		Average annual deviation from baseline in ('000s of jobs)	
	2017 to 2021	2022 to 2030	2017 to 2021	2022 to 2030	2017 to 2021	2022 to 2030
BAU1: 8%, debt	1,2%	1,5%				
1A: 13%, debt	1,1%	1,5%	-0,1	0,0	-59	-110
1B: 19%, tariff	0,9%	1,5%	- 0,3	0,0	-137	-274
BAU2: 8%, downgrade	1,0%	1,5%	-0.2	0,0	-113	-157
3A: 8%, VAT	0,8%	1,6%	-0,4	0,1	-198	-249

4.5 Interpreting results of model simulations post-downgrade

As explained above, the tariff increases that were assumed in each scenario are hypothetical. In addition, since the finalisation of the modelling in January 2017, the potential S-IG downgrade we modelled under the 'alternative baseline' (BAU2:8%, debt) has already transpired. While the magnitude of the tariff increases chosen are hypothetical the scenarios still usefully illustrate the relative macroeconomic impacts of the various options available to meet Eskom's revenue requirement which include 1) Increasing the tariff alone 2) a combination of low tariff increases and raising government debt and 3) a combination of low tariff increases and tax hikes.

Furthermore, while the anticipated S-IG downgrade has already occurred, it does not mean that credit-rating downgrade risk associated with debt accumulation under a 'much lower-than-required' tariff increase is now irrelevant or even diminished. As RMB (2017) notes, countries that are downgraded to sub-investment-grade typically experience a continual negative feedback loop. Following a SI-G event, as sentiment sours and interest rates increase, the fiscal position deteriorates. As the fiscal position deteriorates, interest rates rise and economic growth slows, further credit rating downgrades within 'junk' territory are triggered. As RMB (2017) notes, "countries take seven to nine years, on average, to recoup their investment-grade rating, following a downgrade, to speculative grade".

The risk now that the SI-G event has already occurred is that government debt accumulation under 'much lower-than-required' tariff increases (e.g. 8% scenario) could (together with an ailing economy) trigger further sovereign credit rating downgrades moving South Africa lower within 'junk' territory (Table 10).

Table 10: Rating equivalence across 'Big 3' rating agencies – long-term foreign currency rating

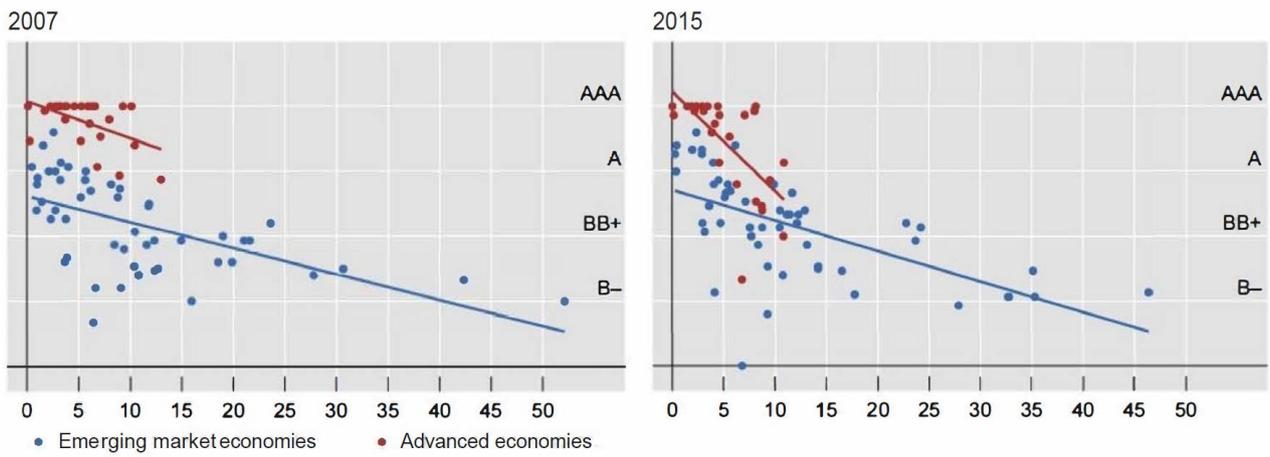
Standard & Poor's	Fitch	Moody's	Credit Quality
Investment Grade			
AAA	AAA	Aaa	Extremely strong capacity
AA	AA	Aa	Very strong capacity
A	A	A	Strong capacity
BBB+	BBB+	Baa1	Adequate capacity to meet financial commitment unless political/economic conditions worsen
BBB	BBB	Baa2	
BBB-	BBB-	Baa3	
Sub-investment grade, junk			
BB+	BB+	Ba1	There is a risk that major ongoing uncertainties or exposure to adverse economic & business conditions will reduce government's capacity to meet its debt obligations
BB	BB	Ba2	
BB-	BB-	Ba3	
B+	B+	B1	More vulnerable to non-payment, but can currently meet obligations
B	B	B2	
B-	B-	B3	
CCC+	CCC	Caa1	Currently vulnerable to non-payment, depends on favourable external conditions to meet obligation.
CCC		Caa2	
CCC-		Caa3	
CC	CC	Ca	Default imminent, inevitable
D	DDD DD D	C	In default, bankruptcy, administration

South Africa's long-term foreign currency ratings as at 8 April 2017.

Source: Own analysis based on EU committee report on sovereign credit ratings 2011, S&P website and others.

While there is no simple linear relationship between subsequent credit rating downgrades (post a SI-G event) and interest rates the two are inversely correlated and as downgrades occur, interest rates tend to rise. A graph presented in an analysis by the Bank of International Settlements (2015) illustrates how the proportion of total revenue that Governments spend servicing interest on debt tends to rise sharply as the foreign currency rating falls into sub-investment grade territory. As further credit rating downgrades take place governments' find they have less and less 'fiscal space' or flexibility in their spending choices and are forced to focus on preserving and improving their financial position and trying to meet obligations to deliver essential services (e.g. social grants, health and education).

Figure 21: Foreign currency rating vs. interest payment burden



¹ Interest payments as a percentage of general government revenue. [http://www.imr.org.za](#)

Source: Bank of International Settlements (2015).

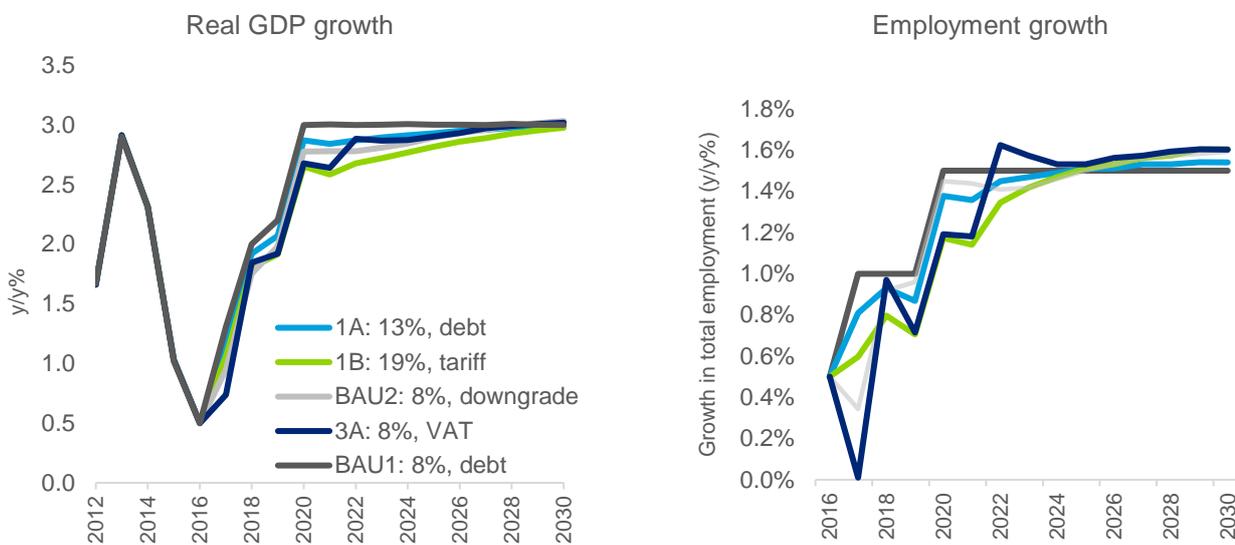
5. Key findings and conclusions

5.1 Key findings

The results show that an annual tariff increase of 19% is expected to have a slightly negative impact on GDP and employment growth relative to the baseline scenario (where tariffs rise by 8% a year and government borrows the shortfall). For example, under the 19% tariff scenario (1B), GDP is forecast to expand at an average rate of 2.0% y/y, which is 0.3 percentage points lower than the 2.3% y/y growth forecast in the baseline (BAU1) (Figure 22).

Total employment is expected to grow at an average rate of 0.9% y/y under a 19% tariff increase compared to 1.2% y/y in BAU1 (Figure 22). This implies that under a 19% tariff increase scenario, 137000 fewer jobs will be created and sustained annually over the period 2017 to 2021, relative to BAU1. These results are consistent with those NERSA (2013) obtained when it presented the economic impact of similar tariff scenarios in its reason for decision on Eskom’s MYPD3 tariff application¹⁴.

Figure 22: Impact on trend in real GDP and employment growth – 1A, 1B, 3A relative to BAU1 and BAU2



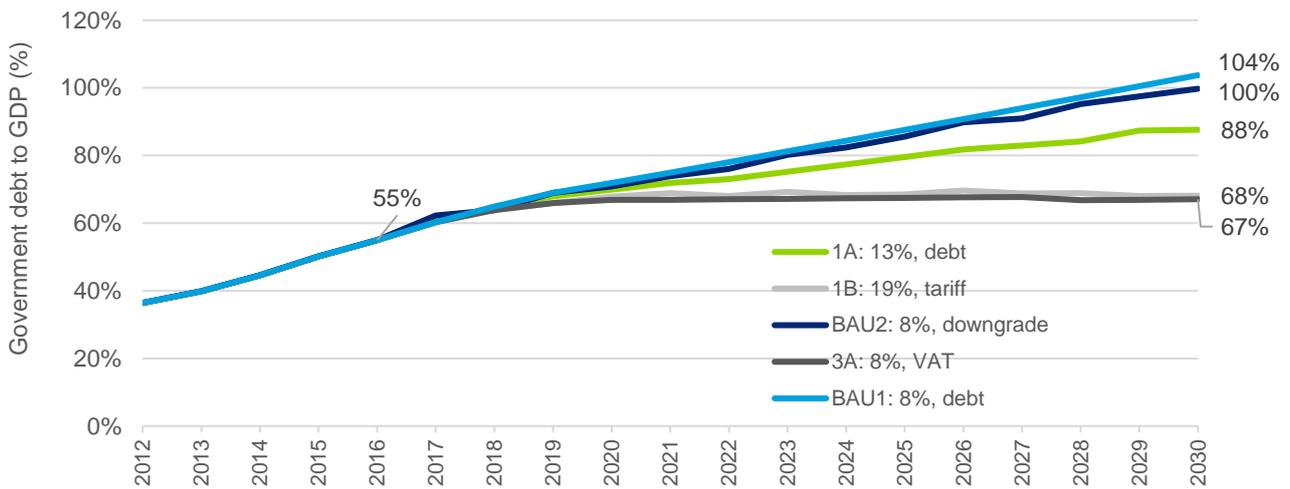
Our results however suggest that the impact of higher tariff increases on CPI inflation over the next five-year period would be more muted than what NERSA (2013) previously indicated. The simulation results suggest that scenarios with higher annual electricity price increases of 13% and 19% (1A and 1B respectively) have very little impact on CPI inflation - inflation rises in both cases by less than 0.1

¹⁴ NERSA noted in its economic impact study that a 16% annual tariff increase over a five-year period was expected to lower average annual GDP growth by 0.3 percentage points, reducing forecast GDP growth from 3.7% to 3.4%. NERSA also found that a series of five 16% tariff increases would compromise 652 654 jobs. We assume that NERSA was referring to the cumulative number of jobs that would be foregone over 5 years in which case our results are similar. Our results suggest that 137000 fewer jobs will be created and sustained annually under the 19% tariff scenario (1A) relative to the BAU1 over the five years to 2021. If this is expressed differently, the cumulative deviation in the total employment from baseline (BAU1) in 2021 is 685 000 jobs.

percentage point, averaging 5.8% y/y in the five-year period from 2017 to 2021 and 5.5% y/y thereafter. While the low-CPI impact associated with relatively high tariff increases may seem counterintuitive, it can be attributed to the fact that higher tariff increases are expected to have a negative impact on GDP growth and employment. Given that GDP growth was already expected to be relatively subdued over this period (relatively to potential GDP growth of 3%), sluggish demand is likely to keep inflation in check.

We noted previously that in the economic analysis that NERSA presented in 2013, the regulator did not acknowledge the fiscal consequences of 'lower-than-required' tariff increases. Our results show that under the 8% tariff baseline scenario (BAU1) there is a steady and marked deterioration in government’s budget balance and that the government debt-to-GDP ratio is expected to reach 75% by 2021 and 104% by 2030 (Figure 23). By contrast under the 19% tariff scenario, the debt-to-GDP ratio stabilises at ~66% (Figure 23). Given the sharp accumulation of government debt under a 'much-lower-than-required tariff increase', we also noted that it was likely that BAU1: 8%, debt would trigger a sub-investment grade credit rating downgrade and as such that it would be more accurate to compare the economic impacts of a 19% tariff scenario with a scenario where an 8% tariff increase triggers a SI-G downgrade (BAU2:8%, downgrade).

Figure 23: Impact on government debt-to-GDP ratio - 1A, 1B, 3A relative to BAU1 and BAU2



As noted earlier, the risk of a S-IG downgrade that we modelled under the 'alternative baseline' (BAU2:8%, debt) has in effect, already materialised. On the 3rd of April 2017, Standard & Poor’s announced the downgrade of South Africa’s long-term foreign currency sovereign credit rating to sub-investment grade.

The results of our downgrade scenario show that when the rise in government debt that is associated with a 'much-lower-than required' tariff increase is sufficient (together with other economic and political risk factors) to trigger a sovereign credit-rating downgrade (BAU2: 8%, debt), South African’s end up worse-off than under a 19% annual tariff increase and the negative economic impacts are likely in aggregate to be more severe¹⁵ for the following reasons:

¹⁵ The way in which the effects of a potential downgrade were modelled was conservative -we assumed that the key impact of a S-IG event would be that interest rates (or the return required on capital investment) would rise by an average of 100 basis points over the five-year period.

Firstly, our results show that under the 'BAU2:8%, downgrade' scenario, growth in GDP and employment will slow by almost as much as they would under a 19% annual tariff increase. Simulation results show that under both the downgrade scenario (BAU2: 8% downgrade) and 19% tariff scenario (1B:19%, debt) annual GDP growth will be 0.3 percentage points lower than in BAU1. Similarly, under BAU2 and total employment growth is expected to average 1.0% y/y which is an average of 0.2 percentage points lower than in BAU1, while under scenario 1B: 19%, tariff employment will increase at an average rate of 0.9% y/y or 0.3 percentage points lower than BAU1.

Secondly, while our results suggest that the negative impact on GDP and employment that follow a downgrade due to debt accumulation under a 'much-lower-than-required' tariff is almost equivalent to a 19% tariff increase, South Africans are likely to end up worse-off in aggregate under the downgrade scenario because of a simultaneous rise in debt and interest rates that doesn't occur under the tariff only scenario. Borrowing costs (or the required return on investment) will rise by 1 percentage point (100bps) under BAU2 relative to the 19% tariff scenario (1B) and the government debt-to-GDP ratio will rise steadily reaching ~75% by 2021 and 100% by 2030 under BAU2, while under the 19% tariff scenario, the debt-to-GDP ratio stabilises at ~66%.

Finally, under any scenario (including BAU1, BAU2 and 1B) where the revenue collected via the tariff is insufficient to cover Eskom's prudently and efficiently incurred costs, the price of electricity is being implicitly subsidised. As the World Bank (2010:22) notes, "Subsidising energy use involves providing it at a price below opportunity cost. This includes non-collection or non-payment, selling electricity at a cost that does not reflect the long-run marginal cost of supply including capital maintenance."

The economic harm and distortions that are caused by energy subsidies, including artificially low electricity prices, is well-documented in the international literature. Some of the potential macroeconomic, environmental, and social consequences of energy subsidies, as documented by the IMF (2013) were summarised in Deloitte (2017) as follows:

- **Energy subsidies crowd-out growth-enhancing or pro-poor public spending.** Energy subsidies, while often intended to protect consumers crowd-out other priority spending (such as on social welfare, health, and education) and place an unnecessary burden on public finances. Energy subsidies (unless specifically targeted) are a poor instrument for distributing wealth relative to other types of public spending.
- **Energy subsidies discourage investment in the energy sector and can precipitate supply-crises.** Energy subsidies artificially depress the price of energy which results in lower profits for producers or outright losses. This makes it difficult for state-owned enterprises to sustainably expand production and removes the incentive for private sector investment. The result is often an underinvestment in energy capacity by both the public and private sector that results in an energy supply crisis which in turn hampers economic growth. These effects have been felt in SA.
- **Energy subsidies create harmful market distortions.** By keeping the cost of energy artificially low, they promote investment in capital-intensive and energy-intensive industries at the expense of more labour-intensive and employment generating sectors.

- **Energy subsidies stimulate demand, encourage the inefficient use of energy and unnecessary pollution.** Subsidies on the consumption of energy derived from fossil fuels leads to the wasteful consumption of energy and generate unnecessary pollution. Subsidies on fossil-fuel derived energy also reduces the incentive for firms and households to invest in alternative more sustainable forms of energy.
- **Energy subsidies have distributional impacts.** Energy subsidies tend to disproportionately benefit higher-income households who consume far more energy than lower income groups. Energy subsidies directed at large industrial consumers of energy benefit the shareholders of these firms at the expense of the average citizen.

In Deloitte (2017) goes on to give specific examples of the economic harm and distortions that can be attributed to the historic under-pricing or implicit subsidisation of electricity in South Africa these is argued include:

1. Artificially low electricity tariffs discouraged investment in the South Africa's electricity supply industry and helped to precipitate the 2008 power supply crisis. The subsidised tariffs frustrated attempts by the government to attract private investment in the early 2000s and helped to precipitate the supply crisis of 2008.
2. Subsidised electricity prices promoted investment in capital intensive industries in South Africa at the expense of more labour-absorbing sectors. Kohler (2014) who traced the 40-year change in electricity intensity across a number of countries and country groups and found that South Africa has amongst the highest electricity intensity globally.
3. Subsidised electricity prices, encourage the inefficient use of energy and contributed South Africa to becoming one of the single-largest contributors to global GHG emissions. Subsidies on the consumption of electricity generated by Eskom which was mostly coal-based have arguably contributed South Africa becoming the 18th largest country-level contributor to global CO₂ emissions¹⁶.

5.2 Concluding remarks

It may be tempting to conclude that by limiting electricity tariff increases to 8% per annum and requiring that Eskom and/or government to borrow the revenue shortfall (and effectively implicitly subsidising the price), it is possible to minimise the negative impacts of rising electricity prices on GDP and employment growth in the short-term.

However, the results of the economy-wide impact analysis show that the fiscal and economic consequences of awarding Eskom a tariff that is much lower than what it requires (to recover its prudently and efficiently incurred costs), do eventually (and arguably have now) become evident. Our results show that when the gap between the required and actual tariff increases is large (an 8% increase awarded over five years when we assumed 19% was required) and the shortfall is covered by raising debt, there is a steady and marked deterioration in government's budget balance and debt-to-GDP ratio. For example,

¹⁶ Based on data from the EDGAR – emissions databased for global atmospheric research. 2015. Available online at: <http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts1990-2015&sort=des9>

under the baseline 8%, debt scenario government debt-to-GDP ratio is expected to reach 75% by 2021 and 104% by 2030. By contrast under the 19% tariff scenario, where all the required revenue is raised via the tariff, the results show the debt-to-GDP ratio stabilising at ~66%.

Over the past 10-years there has been a marked deterioration in both the financial position of Eskom and the fiscal health of the South African government and this is evident from the change in debt and credit metrics summarised in Table 11 and Table 12. Since 2008, South Africa's long-term foreign-currency rating has been downgrade by 3 notches from lower-medium grade to speculative grade or 'junk' by two of the three major rating agencies. Eskom's long-term local-currency corporate bond rating has been downgraded by between 5 and 10 notches, from upper-medium grade in 2008 is now rated 'highly-speculative' by Standard and Poor's.

Table 11: Change in South Africa and Eskom's credit ratings from 2008 to 2017 by 3 major agencies

Credit metric		2008 (May-08)		2017 (Apr-17)		2017 (change in notches)	
South Africa's long-term foreign-currency rating	S&P	Lower-medium grade	BBB+ (stable)	BB+		↓	-3
	Fitch		BBB+ (positive)	Speculative	BB+	↓	-3
	Moody's		Baa1 (positive)	Lower-medium	Baa2 (negative)	↓	-1
Eskom's long-term, local currency, corporate bond rating	S&P	Upper-medium grade	A+, stable	Highly specula	B+	↓	-10
	Moody's		A1	Speculative	Ba1- (review downr	↓	-7
	Fitch		A	Speculative	BB+	↓	-5

Source: Own analysis based on reports on credit history by 3 rating agencies

A summary of key debt metrics in Table 12, shows that since 2008 (when Eskom embarked on its massive capital expansion programme) the South African government's capacity to meet its debt obligations (and to raise additional debt or issue guarantees on debt of state-owned enterprises) has become far more constrained and as such vulnerability to eventual non-payment has increased. In terms of the National Treasury broad risk management guidelines (updated in 2008) –net loan debt, provisions and contingent liabilities should not exceed 50 per cent of GDP while the broader SADC macroeconomic convergence target was to limit the metric to 60 of GDP (National Treasury, 2008). While this metric stood comfortably within these prudential limits at 34.4% GDP in 2008, in 2017 it stands at 67% of GDP – exceeding both the self-imposed risk guideline and broader SADC convergence target. Net loan debt (excluding provisions and contingent liabilities) is expected to reach 47% of GDP in 2017/18 (up from 22.6% in 2007/8). Government now spends 11.5% of its total revenue service the interest on debt (up from 8.9% in 2007/8) illustrating how the fiscal space is becoming increasingly constrained.

It is also clear that substantial support provided by government to Eskom over the past 10 years both in the form of equity and guarantees has contributed meaningfully to the deterioration in Government's overall debt metrics (and subsequent credit rating downgrades). Eskom initially received support from government in the form R6bn shareholder loan which was converted into equity in 2015 and in the form of a further R23bn equity injection completed in March 2016 (Moody's Investor Service, 2017). Government also approved R350bn worth of guarantees on Eskom's debt of which Eskom had drawn on R218bn worth by 2017/18 (the agreement is to be extend to 31 March 2023). Government guarantees of SOE debt rose

from R65bn in 2008 to a total of R445bn in 2017 and 77% of this is for the electricity sector which also cover Eskom's power purchase agreements with IPPs.

Table 12: Change in South Africa Government's key debt metrics between 2008 and 2017

	2008		2017		Change (2008 to 2017)
Net loan debt as % GDP	22.6%	2008/9	47%	2017/18	up to almost 50% of GDP
Net loan debt, provisions and contingent liabilities as % GDP	34.4%	Mar-08	67%	2016/17	now over 60% of GDP
Debt service cost as % GDP	2.4%	2008/9	3.4%	2017/18	up 1 percentage point
Debt service cost as % general government revenue	8.9%	2008/9	11.5%	2017/18	up 2.6 percentage points
Government guarantees Eskom -exposure (Rbn)	26	2007/8	218	2016/17	192
Government guarantees IPPs - exposure (Rbn)	0	2007/8	126	2016/17	126
Government guarantees (Rbn)	65	2007/8	445	2016/17	381
Electricity sector as % of total govt. guarantees	40%	2007/8	77%	2016/17	37 percentage points higher

Following the sub-investment grade downgrade of South Africa's long-term foreign currency in April 2017 and subsequent downgrade of Eskom's corporate debt by S&P to 'highly-speculative grade', neither Eskom nor the South African government will be in a position raise further debt to meet Eskom's future revenue requirement without the risk of triggering further sovereign credit rating downgrades.

In the present context, if Eskom is awarded much-lower-than-required tariff increases, it will put South Africa at greater risk of remaining within the continual negative feedback loop that countries typically experience following an SI-G event. Our analysis shows that under low tariff scenarios, Eskom's revenue shortfall grows, the fiscal position deteriorates, interest rates rise, sentiment sours, economic growth slows, further credit rating downgrades within 'junk' territory are triggered and the toxic loop repeats. As RMB (2017) notes, "countries take seven to nine years, on average, to recoup their investment-grade rating, following a downgrade, to speculative grade".

Our simulation results show that in terms of the overall economic impacts - even a sharp 19% annual tariff increase over five-years (although current information suggests a 12% annual increase may be sufficient to close the gap) would be preferable to a scenario where rapid debt accumulation associated with a much-lower-than-required '8% tariff increase triggers further credit rating downgrades.

While our results suggest that negative impact on GDP and employment that follow a downgrade due to debt accumulation under a 'much-lower-than-required' tariff is almost equivalent to a 19% tariff increase, South Africans are likely to end up worse-off in aggregate under the 'low-tariff downgrade scenario' because of a simultaneous rise in debt and interest rates triggered by a downgrade. In addition, in the low-tariff scenarios, the price of electricity remains implicitly subsidised, and outlined in detail in Deloitte (2017), energy price subsidies are associated with a wide-range of market distortions and economic harm. The following examples are discussed in Deloitte (2017), electricity price subsidies: discouraged private sector investment in the South African electricity supply industry and helped to precipitate the 2008 power supply crisis; have promoted investment in capital intensive industries at the expense of more labour-absorbing ones; and have encouraged the inefficient use of power leading to avoidable pollution.

In conclusion, it would be ill-advised for the regulator to continue to limit Eskom's tariff increases to 8% per year. It would also be incorrect given the current context and results of this analysis to assume that this will limit the negative impact on GDP and employment, even in the short-term. Our recommendation

is that tariff increases should at least be sufficient to transition Eskom towards a more cost-reflective electricity tariff (prudently and efficiently incurred) over the next 5 years. This will reduce of the risk of South Africa being trapped for a prolonged period in the continual negative feedback loop that countries typically experience following an SI-G rating downgrade.

Eskom has indicated that based on an analysis of their financial position as at May 2017, it seems unlikely that the utility will require an annual nominal tariff increase as great as 19% to close the gap between costs (prudently and efficiently incurred) and revenue over a five-year period. Eskom and its key stakeholders should also take care to ensure that the upside risks to forecasts of the tariff required to meet its revenue requirement over the next five years are carefully managed – these include obligations to purchase additional renewable energy capacity, risk of lower-than-anticipated electricity demand or sales and additional capital expenditure and associated costs that will be incurred if Eskom and the Department of Energy deems it prudent and necessary embark on a new build programme within the next five years.

Appendix 1: Review of modelling approaches and recent literature

I. Introduction

In this appendix to the report, we explore the potential approaches to modelling the macroeconomic impacts of rising energy prices or energy subsidy reform. We begin the chapter by identifying and describing the characteristics and main applications of the economic models used to simulate the economy-wide impacts of a change in energy prices. We go on to identify the key strengths and limitations of each of the identified families of models when used in both policy analysis and forecasting. We end the chapter with a brief review of the most recent literature on the macroeconomic impacts of rising energy prices in South Africa, noting the methodology employed and key findings. We also include a summary of the international literature on the impact of rising energy prices, taxes or subsidy reform noting the types of models commonly employed.

II. Assessment of alternative modelling approaches

There are three main families of macroeconomic models which are typically used to assess the economy-wide impacts of an exogenous shock such as an increase energy prices or policy action such as the removal of energy price subsidies:

- Time series macroeconomic models: Conventional Keynesian, Type II hybrid macro models (with error correction mechanisms (ECM), VAR, BVAR etc.).
- Computable general equilibrium models (CGE): static CGE and dynamic-recursive CGE models (DCGE) and stochastic general equilibrium models (DSGE).
- Partial equilibrium models: Supply-use tables (SUT), input-output models (IO), social accounting matrix (SAM).

The main characteristics and applications of each of these groups of models is summarised in Table 13.

Time series macro-economic models

The first of these families of models - time series macro-econometric (TSME) models involve solving a system of simultaneous equations using econometric methods based on long time series of economic data. We have also distinguished between two main types commonly in use – Hybrid macro-econometric models and vector auto-regressive (VARs):

- Hybrid type II macro-econometric models are structural models in the form of a system of simultaneous equations designed to capture the short-term fluctuations in economic variables as they

adjust back to equilibrium. While models are theory-based, estimated relationships in the models are derived from long time series of historical data.

- Vector autoregressive (VAR) models specify the value of each endogenous variable only in terms of the current and past values of all endogenous variables and the current value of all error terms. Unlike hybrid models, VARs in their standard form are atheoretical - no structure based on economic theory is imposed on the data – the 'data speaks for itself'.

In terms of their main applications, hybrid macro-econometric models are the primary models used by central banks and the US energy administration for forecasting purposes. They are also used in a wide range of policy analysis – can be used for the analysis of monetary policy and shocks that originate in the financial sector. The primary strength of VAR models is in short-term forecasting where it is said they often outperform theory-based models. They are also often used to analyse the decomposition of a historical shock such as a spike in energy prices. VARs can be used for policy analysis but only if identifying restrictions based on economic theory are imposed.

Computable general equilibrium models

The second family of models are computable general equilibrium (CGE) or 'optimisation' models built up to the macro-economy from microeconomic foundations. They consist of:

- 1) A system of equations describing the interaction between model variables; and
- 2) A database which takes the form of a social accounting matrix and a set of elasticities describing how product substitution takes place. The SAM describes the structure of the economy and interlinkages between industry sectors, households, government and the rest of the world at a detailed level.

The theoretical structure of the typical CGE models are based on neo-classical economic theory: consumers are assumed to maximize utility and firms maximize profits subject to resource constraints, preferences, and production possibilities (USEPA, 2015). CGE's are specified so that an exogenous shock will move the economy away from a business-as-usual baseline path but after a dynamic market adjustment process, will always tend back to general equilibrium.

The primary use of both CGE is for policy analysis and they are used in a wide range of applications (tax, energy, trade, environmental, social welfare etc.). They are not suitable for analysis of financial sector shocks or monetary policy. Because of rigorous microeconomic foundations they have become a standard tool for analysis of energy and climate policy.

Partial equilibrium models

The third category of models, Social Accounting Matrix (SAM) and similar models used in partial equilibrium analysis are related to CGE in that they form part of the CGE database. SAMs provided a static snapshot of the inter-linkages in an economy in a given year presented in a square matrix showing the circular flow of income and expenditure between firms, government and households and the rest of the world. The multiplier models based on SAMs are most often used to assess the partial equilibrium consequences of a demand shock on a regional or national economy and the distributional impacts on

firms and households (e.g. increase in demand for output of a particular sector or sectors due to a once-off investment).

While SAMs are useful in certain applications, where partial equilibrium analysis is appropriate, they are nevertheless relatively simple static models and their results are contingent on a number of fairly limiting assumptions. For example, they assume that 1) all prices are fixed so that only physical output and employment respond to an increase in demand 2) resources (land, labour, capital) are abundant and supply can always increase to meet demand 3) that a change in demand in one sector only affects those sectors directly impacted by the shock.

SAMs are most often used to assess the potential effects of exogenous demand shock on output, GDP and employment and to look at the distribution of the impact on household income groups, in a fixed price setting. They are only useful in analysing real-side effects of quantity-based shocks because of the assumption that prices remain fixed they cannot be used to simulate price shocks or ascertain price effects (Round, 2003).

Table 13: Thee main characteristics and applications of different types of macroeconomic models

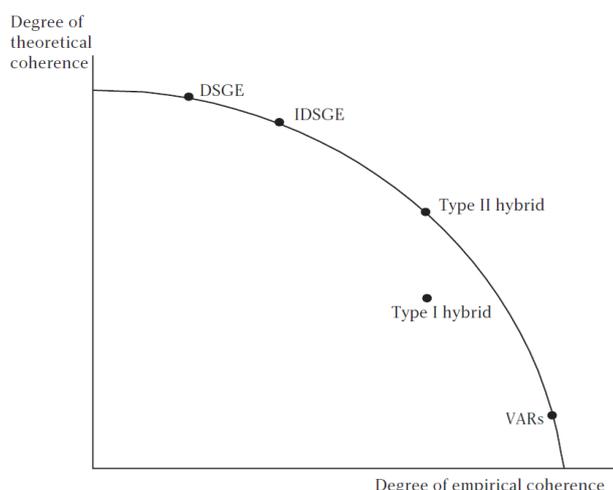
		Main characteristics	Main applications
Time series macro-econometric models	Hybrid macro-econometric models	<ul style="list-style-type: none"> Structural models in the form of a system of simultaneous equations simulate fluctuations in economic variables based on relationships evident in historical data. The short-run structure is based on Keynesian (ISLM) theory so that variable outcomes are demand-determined. Supply dominates in the long-run, which is based on the neo-classical growth model (Solow-swan). Attempt to strike balance between empirical and theoretical coherence - consistent with relationships evident in historical data but also make sense in terms of accepted economic theory. 	<ul style="list-style-type: none"> Hybrid macro-econometric models are primary models used by central banks and the US energy administration for forecasting purposes. Also used for a wide range of policy analysis – particularly monetary policy and financial sector shocks.
	Vector-autoregressive	<ul style="list-style-type: none"> In their standard form, VARs are a-theoretical in that no structure is imposed on the data – the 'data speaks for itself'. This means that it's not possible to distinguish correlation from causation and the model do not shed any light on the structural relationships within an economy. In structural VARs (SVAR) some identifying restrictions can be imposed on the model based on economic theory. Emphasise empirical coherence – models are well-specified in terms of historical data and relationships but shed light on theoretical relationships or causation between variables. 	<ul style="list-style-type: none"> Primary strength is forecasting, particularly short-term where often outperform theory-based models. Also, used to analyse the decomposition of a historical shock such as a spike in energy prices. Seldom used in standard form for policy analysis since results hard to interpret.
Computable general equilibrium		<ul style="list-style-type: none"> CGEs consist of a 1) system of equations describing the interaction between model variables and 2) a database which takes the form of a social accounting matrix describing detailed backward and forward linkages in an economy and a set of elasticities describing how product substitution takes place. These are 'optimisation' models that build up to the macro-economy from microeconomic foundations: consumers are assumed to maximize utility and firms maximize profits subject to resource constraints, preferences, and production possibilities. Dynamic CGE models such as UPGEM are designed to quantify the effects of a policy change, or exogenous shock, to the economy, over a period of time. To examine the impacts of an exogenous shock they compute the differences between a scenario in which the shock has occurred – the policy simulation – and a counterfactual scenario in which the particular shock under examination did not occur – the baseline scenario. Emphasise theoretical coherence (fit with accepted economic theory) even in short-run adjustment to equilibrium. 	<ul style="list-style-type: none"> The primary use of both CGE and DSGE models is for policy analysis and they are used in a wide range of applications (tax, energy, trade, environmental, social welfare etc.). Because of rigorous microeconomic foundations they have become a standard tool for analysis of energy and climate policy. Both can be used for forecasting macroeconomic variables by the likes of central banks but in practice only DSGE version is used in this instance.
Partial equilibrium models		<ul style="list-style-type: none"> SAMs are extensions of input-output and supply-use tables. They provide a static snapshot of the inter-linkages in an economy in a square matrix showing the circular flow of income and expenditure between firms, government and households and the rest of the world. 	<ul style="list-style-type: none"> SAMs are frequently used to assess potential effects of exogenous policy (or external) shocks on incomes, expenditures, and employment, etc., of different household groups, <u>in a fixed price setting</u>.

- Analyses based on partial equilibrium models like SAMs measure effects of policy action in creating equilibrium only in that market which is directly affected, assuming it has no effect on any other market or industry. The structural relationships between sectors and households in the economy are unaffected by exogenous changes in demand.
- SAMs assume fixed prices but allow for variable quantities. It’s assumed that any changes in demand therefore lead to a change in physical output and employment but not wages and prices. (Kambale, 2014).
- SAMs assume that resources (land capital and labour) are abundant (unconstrained) and any increase in demand can be met by an increase in supply without affecting supply in another sector.
- Because of their microeconomic level detail on economic structure they are useful for analysing the distribution of increase income and employment among different sectors and households.
- Only useful in analysing real-side effects of quantity-based shocks, they are not at all good at handling price shocks or ascertaining price effects. (Round, 2003).

Pagan (2003) notes that the different types of economic models that have emerged over the years reflect an attempt by modellers to solve a conflict between the distinct desires that a model should be both theoretically and empirically coherent. If a model is theoretically coherent its results should be consistent with an agreed-upon theoretical view about the way in which an economy functions. If a model is empirically coherent its results must be consistent with the way, the economy has behaved in the past as reflected in relationships evident in historical data. Pagan (2003) illustrates the trade-off between empirical and theoretical coherence in economic modelling, by plotting the main types of models on a curve (see Figure 24).

At the one end of the curve are entirely theoretical models that have never been exposed to an historical data set, while, at the other, there are models that fit every quirk in the historical data set but whose results are impossible to interpret. CGE and DSGE models are plotted on the far left as they are built to be consistent with theory and include limited time series data. On the other extreme are VARs that display a high degree of empirical coherence and in their standard form are atheoretical so that the ‘data speaks for itself’.

Figure 24: Trade-off between empirical and theoretical coherence across types of economic model



Source: Pagan (2003).

III. Advantages and disadvantages of different types of macroeconomic models

No macro-economic model, no matter how complex, is capable of perfectly describing reality. Models can only attempt to replicate the complex array of interactions that take place in an economy.

As Wickens (2012) notes, a limitation common to all macroeconomic models is that they have a tendency to flatline and to return to a steady state too fast. Another major criticism in recent years was the failure of all types of macro-models to anticipate major turning points and in particular the 2008/9 global recession.

Some types of models are designed to be very closely consistent with a widely accepted theoretical understanding of how an economy functions, while others are designed primarily to be consistent with statistical relationships found in historical data. Some models are better suited to forecasting, while others are more useful for policy analysis. Some are equipped to analyse shocks that originate at sector-level while others are better equipped to analyse financial sector shocks.

In selecting an appropriate model to the analysis trade-offs inevitably must be made – we have highlighted some of the main advantages and limitations of each group of models in Table 14.

Hybrid macro-econometric models

The main advantages of hybrid macro-econometric models relative to other types is that they are flexible and the core model can be easily augmented with by adding variables or modules to suit the research question. They can produce stable long-term forecasts as well as capture fluctuations during the short-term adjustment process. Multiple simulations can be performed simultaneously and they tend to fit historical data well. They are used for forecasting and a wide range of policy analysis – and unlike CGE-type models, can include detail on the financial sector and are therefore better suited for analysis of monetary policy and simulation of financial sector shocks such as the impact of a sovereign credit rating downgrade. (Bank of Japan, 2009) and (Arora, 2013).

The main drawbacks of using hybrid macro-econometric models, compared to CGE models, for policy analysis is that they lack the microeconomic foundations of a CGE and are not as disaggregated. This means they are less suited than CGE to policy analysis at a sector-level and to analysis of distributional impacts (welfare). Compared to CGE they are also likely to produce results that are less consistent with economic theory and that may be more difficult to interpret (Arora, 2013) and (Pagan, 2003).

Vector Auto-regression

The main advantage of VAR models is that there is no need for the modeller to impose a strict theory-based structure and this approach lets the data speak for itself. As a result, VARs are among the most empirically coherent types of macro-model meaning that are well-fitted to historical data. Arora (2013) notes that VARs often outperform other types of models when it comes to short-term forecasting.

The major disadvantage of VAR models is that they are ill-suited to policy analysis in their standard form since the atheoretical nature of the model mean that the results hard to interpret. It is possible to impose identifying restrictions on a VAR (based on theory) which makes the results easier to interpret.

Computable General Equilibrium

The primary strength of general equilibrium models is that they can be used to evaluate a broad range of policies (tax, energy, trade, environmental, social welfare etc.). Because of rigorous microeconomic foundations and the high-level of disaggregation they:

- Have become a standard tool for analysis of energy and climate policy (where sectoral detail is an advantage).
- Are better suited than other macro models to analysis of distributional impacts (income distribution, poverty etc.) (Arora, 2013).
- Can be used to analyse and track the flows of factors of production and goods in the economy and the change in relative prices (Bank of Japan, 2009).

Given their firm theoretical foundations of CGE models are unlikely to produce result that lead to an illogical explanation and a decent result can be obtained by using theory even when times series data is insufficient for other models.

A major limitation of general equilibrium models for use in policy analysis lies in their limited representation of the financial sector so they cannot be used to directly simulate shocks that originate in financial sector or for monetary policy analysis (Arora, 2013). The theoretical discipline makes it difficult to expand CGE type models to simultaneously analyse key variables such as overseas economies, oil prices, financial variables, and demographic changes (Bank of Japan, 2009). A traditional criticism of CGE and DSGE models is that they do not produce accurate numerical macroeconomic forecasts. More recently some including (Edge & Gurkaynak, 2010) have argued that while DSGE models do forecast inflation and GDP poorly, forecasts from traditional hybrid macro-models are equally poor. CGE type models may also partly rely on the theories rejected by empirical studies, since theoretical consistency takes priority.

Partial Equilibrium

The major advantage of partial equilibrium models like SAM multiplier models is that they are relatively easy to comprehend and generate simple and transparent insights. They can be used to assess the impact of a demand shock (assuming fixed prices) on employment and output and income distribution.

A major limitation is that they can only measure effects of policy action in creating equilibrium only in that market which is directly affected (*ceteris paribus*), assuming it has no effect on any other market or industry. One of the major deficiencies is that they are only useful in analysing real-side effects of quantity-based shocks, they are not at all good at handling price shocks or ascertaining price effects. (Round, 2003). The assumptions that prices are fixed and resources (land, labour and capital) are unconstrained means that they are included to overestimate the positive impact of demand stimulus on an economy. They are also too simplistic for economy-wide impact assessment and poverty analysis.

Table 14: Summary of the advantages and disadvantages of different families of macroeconomic models

		Main advantages	Main drawbacks
Time series macro-econometric models	Hybrid macro-econometric models	<p>According to Bank of Japan (2009):</p> <ul style="list-style-type: none"> Models are flexible and can be easily modified to suit the research question. Produce stable long-term projections while also capturing short-term fluctuations. Various simulations can be done in one model. Fit the historical data well. Are widely used forecasting and can be used for a wide range of policy analysis – well suited to analysis of monetary policy and financial sector shocks. 	<ul style="list-style-type: none"> hybrid-type models are inferior to dynamic CGE models in theoretical coherence. Results of policy analysis sometimes hard to interpret as results must be consistent with relationships in historical data and not necessarily theory. Can’t track the flows between sectors like in CGE-type models. Not as disaggregated as CGE model so more difficult to assess distributional impacts (welfare).
	Vector-autoregressive	<ul style="list-style-type: none"> Flexible models and modeller doesn’t need to impose a theory-based structure. Emphasise empirical coherence – models are well-specified in terms of historical data and relationships. VARs are routinely used by central banks for short-term forecasting and this is considered to be a strength of the models. 	<ul style="list-style-type: none"> Difficult to use standard form for policy analysis since results hard to interpret – must impose identifying restriction based on theory to use for policy analysis and these can be hard to defend.
Computable general equilibrium		<ul style="list-style-type: none"> The primary strength of general equilibrium models is that they can be used to evaluate a broad range of policies (tax, energy, trade, environmental, social welfare etc.). Because of rigorous microeconomic foundations they have become a standard tool for analysis of energy and climate policy where sectoral detail is advantageous. High level of disaggregation also means they are better-suited to analysis of distributional impacts (income distribution, poverty etc.) (Arora, 2013). Can be used to analyse and track the flows of factors of production and goods in the economy and the change in relative prices. Their firm theoretical foundations, such as optimisation by economic agents, are unlikely to lead to illogical explanation (Bank of Japan, 2009). A decent result can be obtained by using theory even when times series data is insufficient for other models. 	<ul style="list-style-type: none"> A major deficiency of general equilibrium models for use in policy analysis lies in their limited representation of the financial sector so they cannot be used to assess shocks that originate in financial sector or for monetary policy (Arora, 2013). The theoretical discipline makes it difficult to expand CGE type models to simultaneously analyse key variables such as overseas economies, oil prices, financial variables, and demographic changes. (Bank of Japan, 2009). A traditional criticism of DSGE models is that they are not predictive models and cannot produce numerically accurate macroeconomic forecasts. Partly rely on the theories rejected by empirical studies, since theoretical consistency takes priority.

<p>Partial equilibrium models</p>	<ul style="list-style-type: none"> • Can be used to assess how income is distributed among firm and households after demand shock. • Relatively simple to comprehend and to compute. • Simple insights and transparency. 	<ul style="list-style-type: none"> • Can only measure effects of policy action in creating equilibrium only in that market which is directly affected (<i>ceteris paribus</i>), assuming it has no effect on any other market or industry. • Only useful in analysing real-side effects of quantity-based shocks, they are not at all good at handling price shocks or ascertaining price effects. (Round, 2003). • Assumption that prices are fixed and resources unconstrained means the positive impact of demand stimulus on an economy is likely to be overestimated. • Too simplistic for economy-wide impact assessment and poverty analysis.
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IV. Review of local and international literature

Review of recent South African literature on the macroeconomic impacts of rising energy prices

In reviewing the recent South African literature on the impact of rising energy prices we found six recently published empirical studies and have summarised the summarised the results, approach and objectives in Table 15. Based on similarities in the study objectives and approach followed, the six studies fall into three groups which outlined below.

The first two studies - by Cameron and Rousseau (2012) and Boonzaaier, Goliger, Makrelov, & McMillan (2015) – both aimed to assess the impact of rising electricity prices on the profitability and competitiveness of individual firms across a range of sectors (primarily energy-intensive industries) and to determine the ‘tipping point’ at which rising electricity prices might threaten firm viability. They then sought to determine the broader potential economic impact of the risk of lower firm-level profitability on the South African economy. (Boonzaaier, Goliger, Makrelov, & McMillan (2015), who appear to have built on the approach followed by Cameron & Roussow (2012), begin by collating financial information from representative companies, they overlay this with sector level information from Supply-Use Tables and then feed it into a CGE model to assess the economy wide impacts. (Cameron & Roussow, 2012) concluded that 9 of the 150 Eskom key accounts might be in jeopardy because of higher prices and that 3 customers concentrated in metal products manufacturing sector might close under price hike scenarios. (Boonzaaier, Goliger, Makrelov, & McMillan, 2015) found that while all sub-sectors were like to suffer a decline in output, users in the more energy-intensive industries such as mining and metals fabrication would be the most severely impacted by electricity price increases. They did however conclude that own-generation was a viable alternative for the majority of firms included in the study.

The second two studies by Alton et al. (2013) and van Heerden et al. (2013), aim to simulate the economy-wide impacts of introducing a carbon tax in South Africa. This is equivalent to modelling the impact of an energy-price shock, as carbon taxes will indirectly increase the cost of all energy (including electricity) that is generated from fossil-fuel-related sources (e.g. coal, petroleum etc.). Both studies make

use of a dynamic CGE model to estimate economy-wide impacts. Alton, et al., (2013) calibrated their dynamic CGE to investment projections generated by an energy-sector model. Alton, et al. (2013) found that phased-in carbon tax of US\$30 per ton of CO2 could achieve national emissions reductions targets set for 2025. The preferred tax scenario was found to reduce national welfare and employment by about 1.2 and 0.6 percent, respectively but welfare/employment losses could be minimised if South Africa introduced border carbon adjustments. Van Heerden et al. found that a carbon tax would have a net negative impact on South Africa's gross domestic product (GDP) relative to the baseline but the negative impact of the carbon tax on GDP could be greatly reduced by recycling of tax revenue.

The last two studies reviewed, are concerned with modelling the impact of oil price shocks. Unlike the previous studies considered, Balcilar, van Eyden, Uwilingiye, & Gupta (2014) and Du Plessis & Ruch (2015) employed Vector Autoregressive (VAR) models to assess the impact of oil prices on GDP growth and inflation respectively. VARs, structural VARs and other time series econometric models are usually favoured over CGE type models where the objective is to examine and comment on the historical influence of energy prices on other economic variables and so empirical coherence takes precedence. Balcilar, van Eyden, Uwilingiye, & Gupta, (2014) found that oil prices do assist in predicting growth in output in the business cycle troughs while Du Plessis & Ruch (2015) found that food and energy price shocks have had a meaningful second-round effect on CPI inflation in the past.

Table 15: Summary of recent South African literature on the macroeconomic impacts of rising energy prices

Author	Year	Model(s) used	Title	Description
Cameron, M. and Rousouw, R.	2012	CGE and 'bottom-up' comparative static CoPTP-DSM model	Modelling the economic impact of electricity tariff increases on Eskom's Top Customer Segment	<ul style="list-style-type: none"> The aim was to develop an understanding of the impact of increasing electricity prices on an energy utility provider's main assets – its largest customers, by determining the broader potential economic impact of the risk of lower firm-level profitability on the South African economy. The electricity price increase scenarios modelled included annual increases over 5-year period of 16%, 25.8% and 30%. The authors developed a Cost of Production Tipping Point Decision Support model (CoPTP-DSM) based on data aggregated from Eskom's 150 key industrial customers to assess the likelihood of firm's closing due to higher electricity prices and used a Computable General Equilibrium (CGE) model of the South African economy (UPGEM) to assess the broader economic impacts. The authors concluded that 9 of the 150 accounts might be in jeopardy as a result of higher prices and that 3 customers concentrated in metal products manufacturing sector might close under price hike scenarios. CGE results suggested this could shave (all else equal) 0.73 percentage points off GDP growth and 1 percentage point off employment growth.
Boonzaaier, Goliger, Makrelov and McMillan	2015	Bottom-up 'tipping point model' based on company financial data and	The Tipping Point: The impact of rising electricity tariffs at a sector and	<ul style="list-style-type: none"> The aim of the paper was to estimate the potential impacts of rising electricity prices on the competitiveness of individual firms and their decisions, and the longer run impacts on electricity demand should certain "tipping points" be breached. The approach was to use financial information from representative companies in selected sectors, cost

		Supply-Use Tables and a CGE model	company level	<p>information for alternative generation and to overlay this with sector level information from the Supply-Use Tables which was fed into a computable general equilibrium framework to assess economy wide impacts. It appears to build on the approach of Cameron and Rousseau (2012).</p> <ul style="list-style-type: none"> The study considered two distinct groups of industrial consumers (energy-intensive and non-energy-intensive) and aimed to determine the impact that electricity price increases would have on their operating profits and the likelihood of their reaching a cost of production ‘tipping point’. The study found users in the more energy-intensive industries such as mining and metals fabrication were projected as being the most heavily impacted by electricity price increases. An input-output analysis was used to find that there would be output decreases across all of the major relevant sub-sectors, with mining of coal and lignite and manufacturing of electrical machinery and apparatus most negatively affected. The authors found that own-generation was a viable alternative for the majority of firms included in the study, particularly under the moderate and high tariff increase scenarios. Potential for own-generation was most prevalent amongst users in the mining and industrial sectors – the two energy-intensive sectors most vulnerable to electricity price increases.
Alton, T., Arndt, C., Davies, R., Hartleya, F., Makrelova, K., Thurlow, J. and Ubogua, D.	2013	Dynamic CGE model in tradition of Pauw (2007) calibrated to investment projections from an energy sector model.	Introducing carbon taxes in South Africa	<ul style="list-style-type: none"> This study evaluated the potential impacts of South Africa’s proposed carbon tax using a dynamic economy-wide model linked to an energy sector model including a detailed evaluation of border carbon adjustments. The model allows industries to invest in more energy efficient technologies in response to higher energy prices. The model is calibrated to a purpose-built database that reconciles energy and economic data. Results indicate that a phased-in carbon tax of US\$30 per ton of CO2 can achieve national emissions reductions targets set for 2025. Relative to a baseline with free disposal of CO2, constant world prices and no change in trading partner behaviour, the preferred tax scenario reduces national welfare and employment by about 1.2 and 0.6 percent, respectively. However, if trading partners unilaterally impose a carbon consumption tax on South African exports, then welfare/employment losses exceed those from a domestic carbon tax. South Africa can lessen welfare/employment losses by introducing its own border carbon adjustments. The mode for recycling carbon tax revenues strongly influences distributional outcomes, with trade-offs between growth and equity.
van Heerden, J. Blignaut, J. BohlmannI, H.; Cartwright, A.; Diederichs, N.; and Mander, M..	2013	CGE model (UPGEM)	The economic and environmental effects of a carbon tax in South Africa: A dynamic CGE modelling approach	<ul style="list-style-type: none"> In a 2013 paper, the National Treasury proposed a R120/tCO2-equiv. levy on coal, gas and petroleum fuels. The aim of this study was to model the possible impacts of such a tax on the South African economy using the computable general equilibrium (CGE) 53-sector model. The model found that the carbon tax has the capacity to decrease South Africa's greenhouse gas (GHG) emissions by between 1 900MtCO2-equiv. and 2 300MtCO2-equiv. between 2016 and 2035. The model showed the carbon tax to have a net negative impact on South Africa's gross domestic product (GDP) relative to the baseline under all exemption regimes and all revenue recycling options assessed. The negative

				<p>impact of the carbon tax on GDP was, however, greatly reduced by the manner in which the tax revenue is recycled. Recycling in the form of a production subsidy for all industries resulted in the lowest negative impact on GDP.</p>
<p>Balcilar, M., van Eyden, R., Uwilingiye, J. Gupta, R.</p>	2014	VAR	<p>The Impact of Oil Price on South African GDP Growth: A Bayesian Markov Switching-VAR Analysis</p>	<ul style="list-style-type: none"> The aim of this study was to investigate the role of oil price shocks in predicting the phases of the South African business cycle associated with higher and lower growth regimes. The authors investigate the impact of oil price shocks under two phases of the business cycle, namely high and low growth regimes. Using a Bayesian Markov switching vector autoregressive (MS-VAR) model and data for the period 1960Q2 to 2013Q3, they found the oil price to have predictive content for real output growth under the low growth regime. The results also show the low growth state to be shorter-lived compared to the higher growth state.
<p>Du Plessis, S. and Ruch, F.</p>	2015	SBVAR	<p>Second-Round Effects from Food and Energy Prices: an SBVAR approach</p>	<ul style="list-style-type: none"> Relative food and energy price shocks are important in South Africa and have contributed an average of 2.4 percentage points (or 39 per cent) to an average 6.1 per cent headline consumer price inflation from 2000 to 2014. In general, monetary policy can look-through these shocks as long as there are no second-round effects raising inflation expectations and salaries (expectations channel), and core inflation (cost channel through marginal cost) in the economy. The aim of this paper was to measure the importance of second-round effects of food and energy price shocks using a Structural Bayesian VAR with short- and long-run as well as sign restrictions in South Africa since 1994. The results show that there are second-round effects in SA with a one per cent shock to relative food, petrol and energy prices leading to a 0.3 per cent increase in both unit labour cost and core inflation about a year after the shock. Higher core inflation is due to both the cost and expectations channels with households and businesses bidding-up inflation expectations and wages (i.e. the expectations channel) and firms increasing prices.

Imports International studies on economic impacts of energy price adjustments

A brief review of the recent international literature on the economic impacts of rising energy prices and/or energy subsidy reform shows that CGE models, in either static or dynamic form, were used in 9 of the 14 studies considered. The remaining five studies were based on partial equilibrium models including input-output tables and Social Accounting Matrices.

A summary of the studies, the type of model each employed and main economic variables that were assessed is presented in Table 16. Studies were selected based on their relevance to the current South African context, either due to a move towards cost-reflectivity (Ukraine, Australia, Indonesia, Thailand), the energy-intensive nature of the country’s newly-industrialised economy (China, Russia, Turkey), or the low-income and rural electrification concerns associated with tariff increases in the country (Senegal, Vietnam, Bangladesh).

Table 16: Summary of selected recent international literature on economic impacts of energy prices and/or subsidy reform.

Author	Year	Country Focus	Model(s) Used	Effects Measured	Variables Included
Ali Akkemik	2011	Turkey	SAM	Impacts of electricity price changes on price formation in the economy	Consumer prices (disaggregated by sector) Producer prices (disaggregated by sector)
Amin, Marsiliani & Renstrom	2015	Bangladesh	DCGE	Macroeconomic impacts of oil price shocks on the Bangladesh economy	Macroeconomic measures (GDP, Consumption, Industrial output, Total electricity supply, Use of substitutes)
Boccanfuso, Estache & Savard	2008	Senegal	CGE model	Distributional and poverty-related effects of price reform in the electricity sector of Senegal	Macroeconomic measures (GDP, Household income, Wage rates, Government savings and revenues) Sectoral measures (Value added, Rental rate of capital, Market prices) Poverty measures (Headcount, Depth, Severity, GINI index)
Cantore, Antimiani & Anciaes	2012	Multiple developing countries	CGE model	Effects of energy price changes on economies of developing countries	Macroeconomic measures (Total welfare, Allocative efficiency, Terms of trade, % Energy imports)
Chepeliev	2014	Ukraine	Static CGE	Distributional and poverty-related effects of price reform in the electricity sector of Ukraine	Macroeconomic measures (GDP, Output, Household income, Government consumption) Sectoral measures (Output)
Deloitte	2014	Australia	DCGE	Impacts of the renewable energy target scheme on the Australian energy market and the ensuing implications for the broader economy	Macroeconomic measures (GDP, GNP, Household consumption, Government consumption, Investment, Imports, Exports, Employment, Wage rates)
Hartono & Resosudarmo	2008	Indonesia	SAM	Impact on the Indonesian economy of energy policies aiming to improve the efficiency of energy use	Industry measures (Output) Household measures (Income)
He et al.	2010	China	Static CGE	Influence of coal-price adjustments on the electricity power industry, and the influence of electricity prices on the macroeconomy of China	Macroeconomic measures (GDP, Output, Imports, Exports, Household income, Household expenditure, Government expenditure) Sectoral measures (Prices, Output)
IERPCU	2007	Ukraine	Static CGE	Extent and impact of current and future energy price shocks on the Ukrainian economy	Macroeconomic measures (GDP, Welfare, Value added, Wage rates, Exports, Imports) Sectoral measures (Trade balance, Comparative advantage)
Kerkela	2004	Russia	Static CGE	Effects of price liberalisation in Russian energy markets	Macroeconomic measures (GDP, Income, Utility, Exports, Imports, Terms of trade, Welfare) Sectoral measures (Output, Prices, Domestic sales, Exports)
Kunimistru & Ueda	2006	Thailand	I-O	Macroeconomic impacts of installing rice husk electricity power plants in Thailand	Sectoral measures (Prices, Production, Imports)
Nguyen	2008	Vietnam	I-O	Impacts of a rise in electricity tariffs on the	Sectoral measures (Direct prices, Indirect prices)

				prices of other products in Vietnam	
Setyawan	2014	Indonesia	I-O	Impacts of domestic fuel price increases on prices in various sectors of the Indonesian economy	Sectoral measures (Direct input costs, Indirect input costs, Output)
Siriwardna, Meng & McNeill	2011	Australia	Static CGE model	Impact of a carbon tax on the Australian economy	Macroeconomic measures (GDP, CPI, Wage rates, Exchange rate, Exports, Imports, Terms of trade, Employment) Sectoral measures (Output, Employment) Household measures (Consumption costs, Real consumption, Energy consumption)

V. Conclusion on modelling approach

In conclusion, we note that both time series macroeconomic models (hybrid or VAR) and computable general equilibrium models can be used to assess the macro-economic impacts of rising energy prices or energy subsidy reform. It appears from our brief review of the literature and analysis of modelling approaches above, that CGE models are the most common type of model used for the analysis of energy policy and energy price shocks more specifically. Because of their rigorous microeconomic foundations, CGE models offer a higher level of sectoral disaggregation than their time series counterparts and are better-suited to the analysis of distributional impacts (income distribution, poverty etc.) (Arora, 2013). CGEs are also more theoretically coherent than their time series counterparts and as such their results are more likely to give rise to logical explanations of the effects of a price shock or policy intervention (Bank of Japan, 2009).

One of the major deficiencies of CGE models for use in policy analysis lies in their limited representation of the financial sector. As result, VARs or hybrid times series models are usually favoured when analysing shocks that originate in financial sector or for the analysis of monetary policy (e.g. impact of changing energy prices on inflation) (Arora, 2013). A CGE cannot be accurately used for example to simulate the impact of a sovereign credit rating downgrade but can be calibrated to the results generated by other macroeconomic models to show the approximate impact on output. VARs and hybrid times series models while also widely-used in policy analysis, have traditionally been favoured for use in forecasting and for studies where the understanding of historical relationships between macroeconomic variables is of interest.

Appendix 2: Introduction to CGE modelling

The University of Pretoria General Equilibrium Model (UPGEM) is typically used to conduct economy-wide analysis of exogenous changes or policy shocks on the South African economy. UPGEM is a flexible economic model that can be run in either comparative-static or recursive-dynamic mode. Various extensions to the basic model can be switched on when required, providing detail along regional dimensions, labour migration categories, electricity generation technologies and emissions data. For the purposes of this report, we use the standard recursive-dynamic version of UPGEM similar to that used in Bohlmann et al. (2015). The ability of CGE models, such as UPGEM, to recognise the many inter-linkages in the real economy, and account for price-induced behaviour and resource constraints in determining both the direct and indirect effects of an external shock on the economy over time, has made it one of the preferred methodologies for practical policy analysis around the world.

Four basic tasks distinguish CGE based analysis. **First is the theoretical derivation and description of the model.** UPGEM is based on the well-documented MONASH model described in Dixon & Rimmer (2002) and Dixon et al. (2013) developed by the Centre of Policy Studies (CoPS) in Melbourne, Australia. Following the CoPS-style of implementing a CGE model, based on the pioneering work of Johansen (1960), the general equilibrium core of UPGEM is made up of a linearised system of equations describing the theory underlying the behaviour of participants in the economy. It contains equations describing, amongst others: the nature of markets; intermediate demands for inputs to be used in the production of commodities; final demands for goods and services by households; demands for inputs to capital creation and the determination of investment; government demands for commodities; and foreign demand for exported goods.

The specifications in UPGEM recognise each industry as producing one or more commodities, using as inputs combinations of domestic and imported commodities, different types of labour, capital and land. The multi-input, multi-output production specification is kept manageable by a series of separability assumptions, as illustrated by Figure A2 in the Appendix. Figure A2 also illustrates how the optional electricity generation composite nest would feature in the model, if activated. This nested production structure reduces the number of estimated parameters required by the model. Optimising equations determining the commodity composition of industry output are derived subject to a CET function, whilst functions determining industry inputs are determined by a series of CES nests. At the top level of this nesting structure intermediate commodity composites and a primary-factor composite are combined using a Leontief or fixed-proportions production function. Consequently, they are all demanded in direct proportion to industry output or activity. Each commodity composite is a CES function of a domestic good and its imported equivalent. This incorporates Armington's assumption of imperfect substitutability for goods by place of production (Armington, 1969).

The primary-factor composite is a CES aggregate of composite labour, capital and, in the case of primary sector industries, land. Composite labour demand is itself a CES aggregate of the different types of labour distinguished in the model's database. In UPGEM, all industries share this common production structure, but input proportions and behavioural parameters vary between industries based on base year data and available econometric estimates, respectively.

The demand and supply equations in UPGEM are derived from the solutions to the optimisation problems which are assumed to underlie the behaviour of private sector agents in conventional neo-classical microeconomics. Each industry minimises cost subject to given input prices and a constant return to scale production function. Zero pure profits are assumed for all industries. Households maximise a Klein-Rubin utility function subject to their budget constraint. Units of new industry-specific capital are constructed as cost-minimising combinations of domestic and imported commodities. The export demand for any locally produced commodity is inversely related to its foreign-currency price. Government consumption and the details of direct and indirect taxation are also recognised in the model.

The recursive-dynamic behaviour in UPGEM is specified through equations describing: physical capital accumulation; lagged adjustment processes in the labour market; and changes in the current account and net foreign liability positions. Capital accumulation is specified separately for each industry and linked to industry-specific net investment in the preceding period. Investment in each industry is positively related to its expected rate of return on capital, reflecting the price of capital rentals relative to the price of capital creation. For the government's fiscal accounts, a similar mechanism for financial asset/liability accumulation is specified. Changes in the public-sector debt are related to the public sector debt incurred during a particular year and the interest payable on previous debt. Adjustments to the national net foreign liability position are related to the annual investment/savings imbalance, revaluations of assets and liabilities and remittance flows during the year. In policy simulations, the labour market follows a lagged adjustment path where wage rates respond over time to gaps between demand and supply for labour across each of the different occupation groups.

The second task is calibration, which incorporates the construction of a balanced database and evaluation of coefficients and parameters. As required for CoPS-style models, the initial levels solution of the model is provided by the base year data. The database, in combination with the model's theoretical specification, describes the main inter-linkages in the South African economy. The theory of the model is then, essentially, a set of equations that describe how the values in the model's database move through time and move in response to any given policy shock. The current version of UPGEM uses a 2011 reference year database that draws mainly from the 2011 supply-use tables published in StatsSA (2014) and other data in StatsSA (2016) and SARB (2016). An added benefit of dynamic CGE models is that they allow for updating of the model's database structure by including historical information in the baseline. Figure A1 in the Appendix provides a stylized representation and description of the core UPGEM database. Regional and other extensions of the core database are dependent on availability of data across the required dimensions.

The third task is solving the model using a suitable closure. Dynamic CGE models such as UPGEM are designed to quantify the effects of a policy change, or exogenous shock, to the economy, over a period of time. A good way to examine the impacts of an exogenous shock is to compute the differences between a scenario in which the shock has occurred – the policy simulation – and a counterfactual scenario in which the particular shock under examination did not occur – the baseline scenario. Results are then reported as percentage change deviations over time between the first 'baseline' simulation run and the second 'policy' simulation run. The model's closure settings, that is, the choice of exogenous versus endogenous variables, can be considerably different between the two runs. In the baseline, we exogenise those variables for which reliable forecast information exists, which typically includes macroeconomic variables, such as the components of GDP, population growth and various price indices forecast by various macroeconomic specialists. Industries, such as electricity, which have explicit build programmes and a regulated pricing structure, may also have its available forecast data included in the baseline run. In the policy run, all the naturally endogenous variables are indeed set as endogenous, because we are interested in the impact of the policy change on them. This setting represents a more natural model closure where the variable for which the equation was written is typically set as endogenous. Standard baseline forecast and policy closures appropriate for UPGEM are described in Dixon & Rimmer (2002: 262-274).

UPGEM is implemented and solved using the GEMPACK suite of programs described in Harrison & Pearson (1996). GEMPACK eliminates linearisation errors by implementing shocks in a series of small steps and updating the database between steps. GEMPACK has also been proven the most efficient software package for solving large CGE models, such as the dynamic version of UPGEM (Horridge et al. 2013).

The fourth and final task involves proper interpretation of simulation results, drawing only on values given in the database, the underlying theory and the model closure. In this regard, we often use condensed back-of-the-envelope representations of the model combined with key aggregates in the database to explain simulation results, without having the burden readers with the specifics of the full model. Since it is not practical to describe the entire CGE methodology or UPGEM model used in this report here, readers interested in the finer details are encouraged to consult the various references, in particular Bohlmann et al. (2015) and Dixon et al. (2013).

Appendix 3: UPGEM database and production structure

Figure A1: Core database structure

		ABSORPTION MATRIX (USE TABLE)						
		1	2	3	4	5	6	7
		PRODUCERS	INVESTORS	HOUSEHOLD	EXPORT	GENGOV	STOCKS	TOTAL
	SIZE	IND	IND	HOU	1	1	1	ALL USERS
BASIC FLOWS	COMxSRC	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS	V0BAS BASIC
MARGINS	COMxSRCxMAR	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	N/A	V0MAR MARGINS
INDIRECT TAXES	COMxSRC	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	N/A	V0TAX TLSP
BAS + MAR + TAX = PUR VALUES	COM	V1PUR INTERMED USE	V2PUR INVESTMENT	V3PUR PRIV CONS	V4PUR EXPORTS	V5PUR PUB CONS	V6BAS STOCKS	TOTAL COM DEMAND
LABOUR COSTS	OCC	V1LAB						
PRODUCTION TAXES	1	V1PTX						
CAPITAL RENTALS	1	V1CAP						
V1PUR + V1PRIM = TOTAL COST	1	TOTAL IND COSTS						
		PRODUCTION MATRIX (SUPPLY TABLE)						
		IND	1	1	1	ALL SOURCES		
	SIZE	IND	1	1	1	ALL SOURCES		
	COM	MAKE SUPPLY TABLE	V0IMP IMPORTS	V0MAR MARGINS	V0TAX TLSP	TOTAL COM SUPPLY		
	1	TOTAL IND SALES						

The UPGEM database structure presented in Figure A1 has two main parts: an absorption matrix; and a joint-production matrix. The absorption matrix simultaneously shows total industry costs and total commodity demand across all users. The production matrix simultaneously shows total industry sales and total commodity supply. The main data source for the core UPGEM database is the supply-use table, or alternatively, the input-output table, published by Statistics South Africa. For particular applications, the model and database may be extended to include external matrices on emissions, migration, etc.

The first row in the absorption matrix, $V1BAS$, ..., $V6BAS$, shows flows in the base year of commodities to producers, investors, households, exports, government consumption and inventory accumulation. Each of these matrices has $COM \times SRC$ rows, one for each of COM commodities from SRC sources.

$V1BAS$ and $V2BAS$ each have IND columns where IND is the number of industries. The typical component of $V1BAS$ is the value of good i from source s used by industry j as an input to current production, and the typical component of $V2BAS$ is the value of (i,s) used to create capital for industry j . $V3BAS$ to $V6BAS$ typically each have one column, which refers to one representative household, one foreign buyer, one category of public demand and one category of inventory demand. These dimensions can be extended if necessary, for example, the single representative household may be split according to HOU number of household categories based on detailed income or ethnic group information found in social accounting matrices.

All of the flows in $V1BAS$, ..., $V6BAS$ are valued at basic prices. The basic price of a domestically produced good is the price received by the producer (that is the price paid by users excluding sales taxes, transport costs and other margin costs). The basic price of an imported good is the landed-duty-paid price, i.e., the price at the port of entry just after the commodity has cleared customs.

Costs separating producers or ports of entry from users appear in the input-output data in the margin matrices and in the row of sales-tax matrices. The margin matrices, $V1MAR$, ..., $V5MAR$, show the values of MAR margin commodities, typically trade and transport services, used in facilitating the flows identified in $V1BAS$, ..., $V5BAS$. The sales tax matrices $V1TAX$, ..., $V5TAX$ show collections of indirect taxes (positive) or payments of subsidies (negative) associated with each of the flows in $V1BAS$, ..., $V5BAS$.

Payments by industries for labour by occupation (OCC) or skill group are recorded in the matrix $V1LAB$, whilst payments by industries for the use of capital and land are recorded in the vectors $V1CAP$. The vector $V1PTX$ shows collections of net taxes on production. We may also include a vector $V1OCT$ (not shown in Figure A1) to capture other industry costs not elsewhere classified, where appropriate.

The remaining data items are $MAKE$ and $V0TAR$ (not shown in Figure A1). $V0TAR$ is a vector showing tariff revenue by imported commodity. The joint-product matrix, $MAKE$, has dimensions $COM \times IND$ and its typical component is the output of commodity c by industry i , valued in basic prices. The content of the $MAKE$ matrix is equivalent to the supply table.

Together, the absorption and joint-production matrices satisfy two balancing conditions. First, the column sums of $MAKE$ (values of industry outputs) are identical to the values of industry inputs. Hence, the j -th column sum of $MAKE$ equals the j -th column sum of $V1BAS$, $V1MAR$, $V1TAX$, $V1LAB$, $V1CAP$ and $V1PTX$. Second, the row sums of $MAKE$ (basic values of outputs of domestic commodities) are identical to basic values of demands for domestic commodities. If i is a non-margin commodity, then the i -th row sum of $MAKE$ is equal to the sum across the $(i, "dom")$ -rows of $V1BAS$ to $V6BAS$.

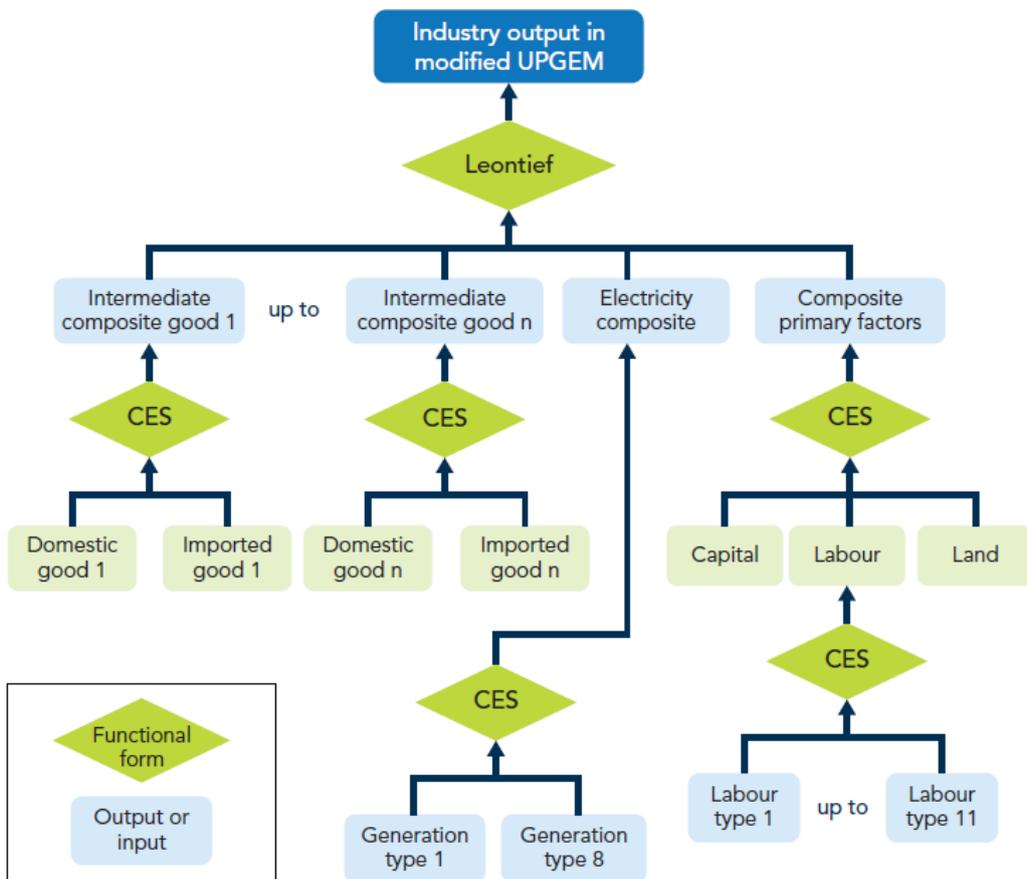
The presentation of Figure A1 also highlights certain national accounting conventions. The green cells indicate the value of total industry costs across all categories; and total industry sales of domestically produced commodities. As noted above, the column totals for each industry in both the cost and sales

matrices should match. Similarly, the blue cells indicate the value of total commodity demand across all users; and total commodity supply from all sources, at purchasers prices. As a balancing condition, the row totals for each commodity in both the demand and supply matrices should match.

One more cell deserves some explanation. The V1CAP cell is commonly interpreted as the cost of capital rentals, including land, to industries in the production process. However, in national accounting this cell represents the gross operating surplus (including mixed income) of an industry. Gross operating surplus (GOS) is defined in the context of national accounting as the balancing item in the generation of income account. GOS differs from profits shown in industry accounts for several reasons. Only a subset of total costs is subtracted from total sales to calculate GOS. Essentially, GOS is gross output or sales less the cost of intermediate goods and services to give gross value added, and less compensation of employees. It is gross because it makes no allowance for consumption of fixed capital (CFC). By deducting CFC from GOS one calculates net operating surplus (NOS).

When adapted to the structure of the UPGEM database, the gross operating surplus (V1CAP) can be calculated as the value of total sales (MAKE) less intermediate input costs (V1PUR), less labour input costs (V1LAB), less production taxes (V1PTX) and less other costs not elsewhere classified (V1OCT). V1CAP then represents the value of capital rentals – the money earned by investors as their compensation for the effort, risk and opportunity cost related to ownership, maintenance and financing of the industry capital stock.

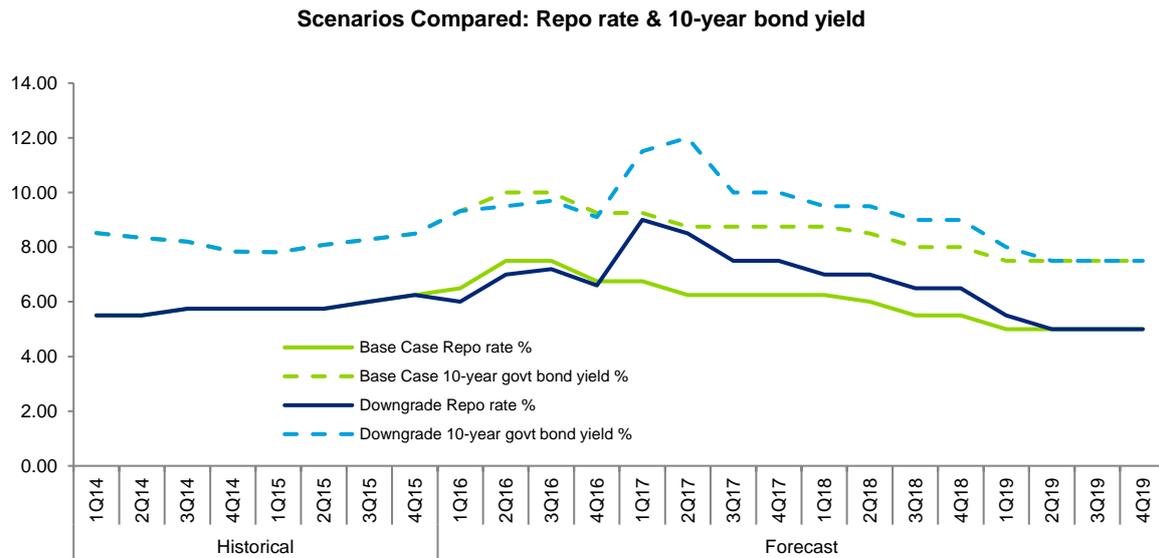
Figure A2: Production structure



Industries in UPGEM are modelled to combine various composite intermediate goods, including an optional electricity composite, in fixed proportion to composite primary factor bundles. For each top-level composite in the production recipe, CES sub-nests allow price-induced substitution between imported and domestically produced versions of each good, electricity generation types (not included in the version of UPGEM used in this research report), primary factors and labour types.

Appendix 4: Impact of downgrade on bond yields

Figure 25: Modelling of impact of a sub-investment grade downgrade on bond yields



Source: Deloitte analysis, 2016.

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