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Implications of migration to cost-reflective tariffs in Eswatini's electricity sector

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Abstract:

The study investigates the possible impacts of migrating to cost reflective tariffs in Eswatini's electricity sector. This involves assessing the electricity consumptions patterns of the different electricity customer categories in relation to the electricity tariffs to estimate potential responses to future price changes that might be induced by cost-reflective tariffs. For the domestic customer category, the study uses the own-price elasticity method while for the non-domestic customer it estimates the elasticities using the Seemingly Unrelated Regression adopted from Inglesi-Lotz and Blignaut (2011). The study finds that a 2 cent real increase in electricity tariff is associated with a decrease in average consumption of 185.6 kWh for the domestic customer. Average elasticity over the 21-year period is -0.58 implying that domestic customers do not respond much to changes in electricity tariffs. For the non-residential customers, the industrial customer group is the only group significantly impacted by changes in electricity tariff. The elasticity coefficient for the industrial customer group is -0.157, which implies that even though this customer group responds to changes in electricity tariff, a proportionate increase in electricity price results in a less than proportionate decrease in electricity consumed. Overall, the study finds that demand for electricity for both domestic and non-domestic customer group is not responsive to changes in electricity tariff, that is, demand is inelastic. This means the cost reflective tariffs will most likely decrease intensive use of electricity in Eswatini, especially for low income households, which will make extending the grid and supplying electricity to low income households a much more expensive endeavour for the utility. The study recommends that before implementing the cost-reflective tariffs, the energy regulator (ESERA) should ensure that the utility (EEC) establishes efficiency improvements on the supply and distribution of electricity in Eswatini. In the long-run Eswatini should expedite national plans to increase local production of power to reduce the cost of power.

Keywords: *electricity pricing, price elasticities, cost-reflectivity*

1. INTRODUCTION

Eswatini has witnessed significant reforms and restructuring within the electricity sector. Some of these include improved access to electricity from 45% in 1997 to 61% in 2013 mainly through the rural electrification project funded by the Government of the Republic of China on Taiwan and the Government of Eswatini. Following the conversion of the former Swaziland Electricity Board to the Eswatini Electricity Company in 2007, and the establishment of the energy regulator, that is, Eswatini Energy Regulatory Authority (ESERA), the electricity sector now operates under an improved and approved National Energy Policy as of 2018.

One of the policy objectives highlighted is the need to provide electricity at affordable prices in order to stimulate industrialisation and economic growth. The problem though is that the current electricity tariff system allows cross-subsidies between consumer categories. Electricity subsidies have macroeconomic and socioeconomic consequences that tend to discourage investment in the sector, encourage inefficient use of electricity, and tend to benefit high-income households who consume far more electricity than the lower income households (Deloitte, 2017). Therefore, one of the key changes that need to take place in Eswatini for these reasons is to restructure electricity tariffs to reflect the true long-run marginal cost of electricity supply, and to that effect, the Government of Eswatini (GoE) has since approved migration to cost-reflective tariffs.

While rebalancing the tariffs to introduce cost-reflectivity, the result will be higher tariff increases, particularly for the domestic customer category, which can in turn induce undesirable electricity consumption patterns that may or may not undermine the goals of the National Energy Policy. With 58.9% of Eswatini's population living below the poverty line (EHIES [Eswatini Household Income and Expenditure Survey], 2017/18), the approved migration to cost-reflective tariffs could severely hamper the country's efforts of improving access to modern energy services that could bring about improvements in standard of living in Eswatini.

Indeed, the Southern African Development Community (SADC) adopted the principle of cost-reflective tariffs since 2004. To date, many of the SADC countries are still struggling to migrate to cost-reflective electricity tariffs because of affordability issues that are fueling the need to cushion consumers from high electricity prices. Nonetheless, research by the Regional Electricity Regulators Association of Southern Africa (RERA), which Eswatini is a member, indicates that the region's energy sector is not self-sustaining (Sikwanda, 2016). To illustrate, in 2015 only Tanzania and Namibia had attained cost reflective tariffs while the rest of the other SADC countries were still in the process of migrating to cost reflectivity. Yet, at a meeting in Lusaka Zambia, the SADC Council of Ministers approved the migration of electricity tariffs towards cost reflectivity within five years and set a deadline of December 2013. As a result of the delayed migration to charging the true cost of supplying electricity to consumers, the region operates on a power capacity shortfall of 8,247 Megawatts (MW) to meet current energy demand (RERA, 2015). The energy deficit is a major concern to the SADC community because it threatens the economic viability and development prospects of the region.

According to Regional Electricity Regulators Association (RERA), the regulators, utilities, and developers in SADC have long recognised that the electricity supply challenges facing the SADC are due to the inadequate investment in electricity infrastructure, particularly in the generation and transmission sectors (2015). The insufficient investments in generation and transmission infrastructure can be attributed to low tariffs that do not provide adequate incentives to promote new investments by enabling investors to recover all their costs. Hence, the drive towards cost-reflective tariffs has become a top priority for regulators in the SADC region, including Eswatini's own energy regulator, ESERA (RERA, 2015). Cost reflectivity is a necessary condition for long-term viability and sustainability of the electricity industry for all countries in the SADC region. The RERA Tariff Report (2014) explains cost reflective tariffs as the true cost of supplying electricity: it removes reliance on external subsidies to cover the variance between the current tariffs and the true cost of electricity supply.

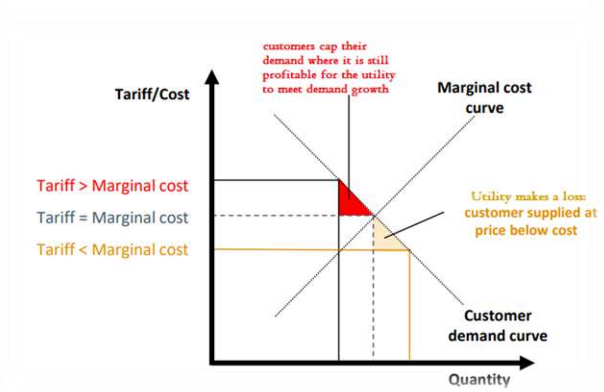
Therefore, to understand the possible impact of implementing cost-reflective tariffs in Eswatini's electricity sector, this study assesses the electricity consumptions patterns of the different electricity customer categories in relation to the electricity tariffs to estimate potential responses to future price changes that might be induced by cost-reflective tariffs. The purpose of the study is to examine how the domestic and non-domestic customers have responded to price changes in the past and use that information to estimate the potential impact of an electricity price increase due to cost reflective tariffs. Overall, the study uses the price elasticities of electricity demand for the domestic and non-domestic customer categories in Eswatini to explain how the electricity pricing influences the electricity demand patterns among these customer categories. This study contributes knowledge on how electricity prices influences electricity consumption patterns and whether these changes are in congruity with the National Energy Policy. Moreover, the study is important in generating information that can inform policymakers on how the major electricity customers in Eswatini use electricity and how they are likely to engage with different types of tariffs that will be set by energy regulator as the sector matures to cost reflective tariffs.

2. LITERATURE REVIEW

2.1. The role of cost reflective tariffs in the electricity sector

Cost reflective pricing is grounded on the idea that the most efficient allocation of resources is achieved when consumers pay the full cost of the goods they consume. In that vein, a cost reflective tariff is one that covers the cost to purchase, transmit, distribute, and supply electricity to a final consumer (Consumer Utilities Advocacy Centre [CUAC], 2015). Cost reflective tariffs are economically efficient and require that the tariff paid by the customer should be equal to the marginal cost of supply as illustrated in Figure 2.1.1.

Figure 2.1.1: Cost reflective tariffs and marginal cost of supply



Source: Author based on literature.

Generally, it costs the electricity sector much more to build electricity networks but comparatively little to use the networks to supply electricity to the different types of customers. There is growing policy and regulatory interest to better align electricity tariffs with the cost of providing network services to customers: to provide a better price signal for economically efficient use of the network, and reduce cross subsidies between different customers (Passey, Haghdadi, Bruce, and MacGill, 2017). The motivation for cost reflective tariffs have always been to reach revenue adequacy for the utility company, economic efficiency, and distributional effects both between sectors like residential-services-industry, and between large and small consumers within each sector (Stokke, Doorman, and Ericson (2009). In terms of the actual cost reflective electricity tariff, it has to have provisions to generate adequate revenue for the variable costs and the capital intensive investments by putting weights on the fixed part, the part related to peak demand and on the part related to the general consumption of electricity (the energy rate) (Stokke, Doorman, and Ericson (2009). As a result, many countries have adopted a combined demand charge also known as the Hopkinson tariff, and energy rate for both for the industry and services sectors, and just a pure energy rate for the household/residential sector.

The issue is that though a bulk of the network costs come from building the infrastructure as opposed to using it when the traditional pricing of electricity does not accommodate for this factor. Hobamn *et al.* (2016) assert that one of the significant factors perpetuating inefficiencies between the cost of producing and supplying electricity versus the price actually paid by customers is overinvestment in network infrastructure against continuous growth in peak demand. They further deduce that regardless of the demand on the electricity grid, many residential customers are still on traditional flat-rate tariffs where the price per kilowatt hour of electricity used remains stable over times thus insulating the residential customer from moment-by-moment fluctuations in wholesale prices on the electricity market. Jones (2015) explains that a majority of the costs that do not relate to electricity usage are added on/hidden across charges for usage. The reason these fixed charges for renting the electricity network infrastructure are hidden as part of the usage charges is that consumers have a preference for usage charges over fixed charges, and partially due to networks not having a great deal of information about individual households’ consumption before the widespread installation of smart meters.

What it means is that consumers have traditionally been presented with artificial prices on their bills that do not reflect the underlying cost of delivering electricity to them, the network charges are built in on the per kilowatt hour (kWh) fixed tariff charge even though these have little to do with kWh consumed by each customer category (Gill, 2015). Thus cost reflective tariffs are meant to provide a price signal that more accurately convers the true cost of electricity generation and supply and (at least in theory) incentivise consumers to reduce or shift electricity usage to different off-peak time, thereby flattening peak demand. Several different types of cost-reflective pricing have been cited in the literature, ranging from the simplest form of time-of-use (TOU), to more dynamic forms of critical peak pricing (CPP), peak time rebate (PTR), variable peak pricing (VPP) rates and real-time pricing (RTP) (Faruqui and Sergici, 2013 and Nicolson Fell, and Huebner, 2018).

Overall, it is important that SADC countries consider migrating to cost reflective tariffs because of the potential investments on electricity infrastructure that could be made to provide sufficient and quality service. However, policymakers have to make the tough decisions of balancing between cost reflective tariffs and special subsidised tariffs or pro-poor tariffs to cushion low income households. For example, as Jones (2015) explains, a change in price might, in isolation, cause harm to particularly socioeconomic groups, but equity of such a change should be considered in light of any compensation that could be paid to those disadvantaged group if appropriate. Maria & Cecilia (2011) affirm that most policymakers are caught in between balancing the act between cost reflectivity and affordability. These considerations have to keep in mind the benefits that cost reflective pricing could provide not only to customers in potential savings, to industry in reducing peak demand and improving electricity supply and reliability, and to the economy as whole in restoring fairness and equity (Hobman *et al.*, 2016).

At the very least, the cost reflective pricing principle seeks to implement fairness and equity by ensuring that beneficiaries of service bear the cost of that service. Through cost reflective tariffs, the "user pays" principle gets applied through horizontal equity whereby consumers in the same circumstances and on average engaging in the same behaviour are treated equally and pay the same price (Jones, 2015). Though cost reflective tariffs could mean certain consumers are pushed to the edge of unaffordable electricity prices, it is equally important to consider the fact that non-cost reflective tariffs limit the extent to which existing generation and grid network can be maintained (World Bank, 2015). In practise, implementing cost-reflective tariffs can be a difficult process because of reasons on equity and ability to pay. Markham (2019) of the Australian Energy Council notes that cost reflective tariffs unravel cross subsidies, which are universally a bad thing. This makes the implementation of cost reflective tariffs a complex task that must be carefully done bearing in mind the complexities, fairness, and political acceptability of the proposal. Notwithstanding the fact that access to electricity qualifies as a public good, low tariffs can be detrimental to the sector as they can slow down the rate at which those without access can receive connections (World Bank, 2015). Furthermore, low electricity tariffs that do not cater for the cost of service only benefit those with existing electricity connection in the short-term and in the long-term compromise the quality and reliability of supply. Lawrenz (2014) offers a bigger picture on the issue, which is the point that a self-financing, economic viable and sustainable electricity sector would allow governments to use the money that they current spend on the electricity sector to direct it to other public goods such as health and education. Given that a majority of the SADC countries including Eswatini still have to migrate to cost reflective tariffs, there are significant price increases that will have to be incurred by the electricity sectors in these countries. This paper investigates the consumption patterns of the different electricity customer categories in Eswatini to infer how the customers might respond to price changes induced by the cost reflective tariffs.

2.2. Consumer demand changes to electricity price changes

Customer behaviour in the electricity sector has significant influence on the operation and development of the electricity power system. There is a dearth of literature in recent decades that quantifies the responsiveness of electricity consumers on electricity prices signals (Lawrence and Aigner, 1979; Aigner, 1984; Filippini, 1995, Vaage, 1995; Aubin *et al.*, 1995; Henley and Peirson, 1998; Baladi *et al.*, 1998; Braithwait, 2000; Matsukawa, 2001; Faruqui and George, 2005; and Ericson, 2006). Much of the literature on changes in electricity demand due to changes in electricity prices focuses on the USA because of data availability and vast differences in pricing between states. Some researchers use aggregate data for states (Alberini and Filippini, 2010) while other use samples of household's bills for electricity (Reiss and White, 2008).

In general, the literature finds that consumers respond to short-term price signals with price elasticities ranging between -0.02 to -1.4. Furthermore, the literature indicates significant difference between consumer responses to price changes in different regions/states within a country as well as between different categories of population (Bernstein and Griffin, 2006 and Bekhet and Othman, 2011). Silva, Soares, and Pinho (2017) also find that an increase in the electricity price due to, for instance, policy intervention would, in fact, decrease electricity use. In addition, in their income quintiles analysis, the researchers find that there are significant differences in the elasticities depending on the income group. Their cross price elasticities indicate that electricity and gas are substitutes (Silva, Soares, and Pinho, 2017), which means that political interventions in the electricity sector may have important redistributive effects.

Specifically, on price changes induced by cost reflective tariffs, Braithwait and Amstrong (2012) including Navigant Consulting (2011), find that demand response is typically confined to a small sub-sample of population, that is only a small minority of customers exhibit demand responsiveness. In other words, models of historical data to determine the price elasticity of demand for electricity indicate that the majority of the population are relatively price inelastic, that is, their electricity consumption is largely unresponsive to price changes, with only a small proportion substantially price elastic. The implications of these findings is that a widespread introduction of cost reflective tariffs needs can be met with wide resistance and the electricity sector needs to offer something of value to the majority of electricity customers because they each have unique needs, wants, interests, and face different constrains and supports when it comes to using electricity (Hobman, 2016). Researchers such as Rai, Reedman, and Graham (2014) posit that the fact it is not surprising that household electricity demand, in the aggregate, appears to be relatively price inelastic and they explain this trend as a function of the fact that on the whole, householders have already made the bulk of possible reductions and substitutions in electricity consumption (whether by behavioural means or via the adoption of energy-efficient technology/appliances). Likewise, this study models the consumption changes induced by changes in electricity tariffs to determine which of the Eswatini electricity customer categories are elastic or inelastic.

2.3. An Overview of the Electricity Sector in Eswatini

The Eswatini Electricity Company (EEC) dominates the electricity sector as it is the sole transmitter of the country's power but distribution is open to other players. Generation has been opened up to Independent Power Producers (IPPs) and co-generators, although at present IPPs are expected to sell their power to the national utility EEC. All the electricity providers, be it, generators, transmitters, distributors, operate under the regulator, ESERA. The regulator ensures power security by regulating electricity tariffs and quality of supply and services offered by the electricity licensees.

The total installed capacity accounts for only 14-24% of the total electricity consumed in the country. Power generation figures from the EEC's 2015/16 Annual Report show that in decreasing order of contribution to domestic generation, Maguga contributes 50%, Edwaleni (25%), Ezulwini (14%), and Maguduza hydropower station contributing 11% of the country's domestic generation. The country has an average peak demand of 221 MW. Given that the country has capacity to generate only 14-25% of its electricity demand, the country has a power deficit and therefore heavily relies on electricity imports from the neighbouring countries, particularly, South Africa. Even though the country is able to meet its power deficits through imports, there is significant upward pressure to keep increasing electricity prices in Eswatini due to increasing electricity prices in South Africa which ultimately trickle into the Eswatini economy.

End-user electricity tariffs in the SADC region range from USc 3.10/kWh to USc 16.04/kWh as of August 2015 or using the US$1: E13.29 exchange rate in 31st August 2015, the tariffs translate to E0.41/kWh to E2.13/kWh. Tanzania had the highest average electricity tariff at USc 16.04/kWh (E2.13/kWh) followed by Namibia at USc 15.00/kWh (E1.99/kWh). In contrast, Angola had the lowest average tariff of USc 3.10/kWh (E0.14/kWh) followed by Zambia with an average tariff of USc 6.00/kWh (E0.80/kWh). Important to note is that both Tanzania and Namibia have cost-reflective tariffs, hence the high tariffs in these countries.

On the other hand, having cost-reflective tariffs does not necessarily imply high electricity tariffs (Sikwanda, 2016). Sikwanda (2016) explains that a country can still implement cost-reflective tariffs even with relatively low tariffs. The electricity supply structure in a country is the key determinant of the average end-user electricity tariffs. For instance, since Namibia just like Eswatini relies heavily on imports to feed electricity to its grid system, the cost of electricity is likely to be higher relatively to a country that generates a bulk of its power (Sikwanda, 2016). On the other hand, Eswatini has a lower domestic generation capacity compared to the other SADC countries and has even smaller hydropower plants compared to its counterparts in the SADC region. Similar to Eswatini, Lesotho has installed generation capacity of 72 MW with relatively lower end-user tariffs (USc 9.3/kWh or E1.24/kWh) though not cost-reflective but due to government intervention. Overall, these tariffs indicate that gone are the days of electricity tariffs below the E1/kWh. Most of the SADC countries are now on the cusp of average tariffs above E2/kWh.

Generally, electricity prices in Eswatini do not reflect the true economic cost of supply for a majority of the customer categories. For several years, the Eswatini Electricity Company (EEC) has maintained tariffs that are below the long-run marginal cost of supplying power. For example, the Eswatini Subsidy Framework estimates the average EEC tariff in 2014 to be around 41% below the long-run marginal cost with significant cross subsidies among customer categories. The electricity tariff subsidy framework report indicates that the lifeline tariff and the domestic consumers receive cross-subsidies from the general purpose, the small commercial (PP), the small commercial (CM), the small holder irrigation and the time of use high, medium and low voltage (TOU MV at HV, TOU MV and TOU LV) tariff categories (Economic Consulting Associates, 2016). A 2018 Cost of Service Study commissioned by the ESERA the energy regulator in Eswatini reveals that tariffs are expected to increase from E1.86/kWh in 2018/19 to E2.02/kWh in 2020/21. The tariff increase is mainly attributed to growing power purchase costs and transmission investment costs (Norconsult and ECA, 2018). According to the study, the most significant impact from the introduction of cost-reflective tariffs would be on domestic customers both in tariff increase and the number of customers affected. The findings reveal that domestic customers pay E0.80/kWh less than their cost of reflective level such that their tariffs should increase by 66% raising the tariff from E1.75/kWh to E2.90/kWh by 2019/20. Other customer categories that will be impacted include smallholder irrigation customers with an expected tariff increase of 10%, large irrigation tariffs expected to increase by 7%, and street lighting tariffs expected to increase by a staggering 218%.

At this rate of electricity tariffs, Eswatini has to attain efficient pricing of electricity supply and the proposed cost reflective tariff strategy could be an added strain on the average end-user electricity tariffs. The country has to tread carefully as it rolls out its cost reflective tariffs on electricity so that it does not reach electricity prices that are too high and exclusionary to the average electricity consumer, especially household consumers. If the tariffs keep increasing they might reach a "choke price", a point price where demand for electricity ceases. High tariffs might reduce overall electricity consumption, especially that of low-income households, and industries that are heavily reliant on electricity as input in production.

3. METHODS

3.1. Theoretical Approach

Economic theory dictates that a consumer's sensitivity to price changes can be measured by the coefficient of price elasticity, that is, the percentage change in demand over the percentage change in price. Usually, the demand of a good will fall as the price increases, holding all other factors constant. Introducing cost reflective tariffs on electricity in the Eswatini economy is essentially an added cost or an increase in the price of electricity to reflect the true cost of electricity provision. Also, a price increase on a product or service affects the production and level of consumption for end users. The changes in the electricity prices in Eswatini will reflect in production and other costs and benefits incurred by the different segments of the economy where electricity is either an input for production or a service consumed by agents of the economy.

Own-price elasticity of a good, for example electricity, is a useful measure of how customers adjust to increases in the price of electricity by adjusting their consumption of electricity. Niemeyer (2001) provides that own-price elasticity is the ratio of the percentage change in the quantity demanded of a good or service to the percentage change in its price after controlling for all other factors that might affected demand such as weather, the level of economic activity, etc. To determine the own-price elasticity of electricity demand for the different customers (domestic, industrial, commercial, and agricultural), the study uses the following equation from Fan and Hydman, (2015);

$$\varepsilon = \frac{\%\Delta\text{demand}}{\%\Delta\text{price}} = \frac{\Delta q/q}{\Delta p/p} \qquad \ldots(1)$$

where ε is the price elasticity, q is the electricity demand, and p is the electricity price. Therefore, the numerator and denominator are expressed as percentage of the change. The price elasticity coefficient ε represents the relative change in the demand for electricity as a result of the change in the price of electricity. For a price increase along a demand curve from price P_0 to P_1, the elasticity can be calculated from the corresponding change in quantity, using the averages of prices and quantities, from:

$$\varepsilon = \frac{(Q_1 - Q_0)}{\text{average } Q_1 - Q_2} \div \frac{(P_1 - P_0)}{(\text{average } P_1 + P_0} \qquad \ldots(2)$$

Generally, own price elasticities are usually negative, which demonstrates the reciprocal relationship between demand and price because consumers tend to reduce consumption as prices rise. The interpretation of elasticities can either be inelastic or elastic, depending on market and consumer factors. Typical values tend to range in absolute value from zero to one, but can be larger than one.

Therefore, a price inelastic demand refers to a less than proportional change in demand for a given change in the price. If demand is inelastic (i.e., elasticity < 1 in absolute value), a price increase (decrease) will lead to higher (lower) expenditures. In the case of elastic demand, consumer demand responds with a greater than proportional change for a given price change. In this case the elasticity is > 1 such that a price increase (decrease) will lead to lower (higher) expenditures, (Niemeyer, 2001). Keep in mind that consumers' ability to respond to price changes tends to increase with the length of time that has passed since the price change. In the short run (0-2 years) consumers may only vary the intensity of use good/service whereas in the long-run (2-5+ years) consumers have sufficient time to adjust to the change in price level by changing the amount and/or nature of their capital equipment. Thus, long-run price elasticities tend to exceed short-run price elasticities of demand (in absolute value), Niemeyer (2001). The own-price elasticities are especially useful when evaluating longer-term adjustments to changes in prices. This study focuses on the own-price elasticity to determine how the possible changes in price of electricity will affect the annual electricity demand for the different customer categories.

A demand function explains different levels of any commodity that a consumer is willing or is able to buy provided that other factors remain unchanged. The quantity consumed depends on a number of factors which the important ones usually include price of the commodity (Pi), the price of other commodities, consumers' level of income, the number of consumers, and customer tastes and preferences (Bazzazan, Ghashami, and Mousavi, 2017). In the case of Eswatini, electricity prices are set by the energy regulator (ESERA) and for the purposes of calculating the own-price elasticities, the residential customer is treated the same in terms of income. Moreover, the residential customers do not have much choice, almost all of them are supplied by the Eswatini Electricity Company which holds a monopoly within the electricity sector. However, to differentiate between the customer categories, that is the residential and non-residential customers who have industrial output, the study further examines the elasticities using regression modelling. SUR model is a system of linear equations with errors that are correlated across equations for a given individual but are uncorrelated across individuals. Each of the equations contain exactly the same set of regressors but the regressors may or may not vary from equation to equation depending on the model.

Inglesi-Lotz and Blignault (2011) investigate the effects of electricity prices and industrial output in different economic sectors in South Africa. Egorova and Volchkova (2004) find that besides the consumption behaviour energy prices are a factor of other factors such as the output of the industries. To determine how the various sectors, respond to price changes in terms of their own production output, they use a Seemingly Unrelated Regression (SUR) model as follows:

$$\text{LnCons} = \alpha_{0,i} + \alpha_{1,i}\,\text{LnPrice}_{it} + \alpha_{2,i}\,\text{LnOutput}_{it} \ldots(3)$$

Where Cons is the electricity consumption, Price is the price of electricity and Output is the total output of the sector *i* at time *t*. The Ln denotes natural logs so that linearising the variables in a log-log function directly estimates the elasticities. The SUR signifies the importance of electricity prices in each of the non-domestic customer group. Different customer groups behave differently towards electricity use hence to need to estimate the effect of price separately. The coefficients of the variable Lnprice are the estimated price elasticities of electricity demand for each of the customer groups.

3.2. Data Sources

The study uses electricity consumption data from the Eswatini Electricity Company, which constitutes of time and customer type dimensions. The data provides the price as a tariff charged to each customer type per kilowatt hour of electricity consumed in that year and the customers are categorised into four groups, that is, domestic (residential), agriculture, commercial, and industrial.

For the domestic customer, the study calculates the own-price elasticity of demand for each year between over a 20-year period (1998-2018) based on the averages quantities consumed by each domestic customer given the price (tariff) changes in each year. The total electricity consumed by the domestic customers is divided by the number of domestic customers in that year to get the average quantity of electricity consumed. Households in Eswatini have little options for alternative power sources, most of the ones that are able to substitute electricity for solar or other alternative forms of power are in the minority as the very high income households. Therefore, for the purposes of this study, the elasticities are calculated as an aggregate since the study treats this customer segment as homogenous groups in terms of access to electricity and ability to shirk high electricity tariffs. The study also uses consumer price index (CPI) data from the Central Bank of Eswatini for the period (1998-2018) to convert the nominal tariffs in each year to real tariffs that can be compared against the consumption patterns of the domestic customer.

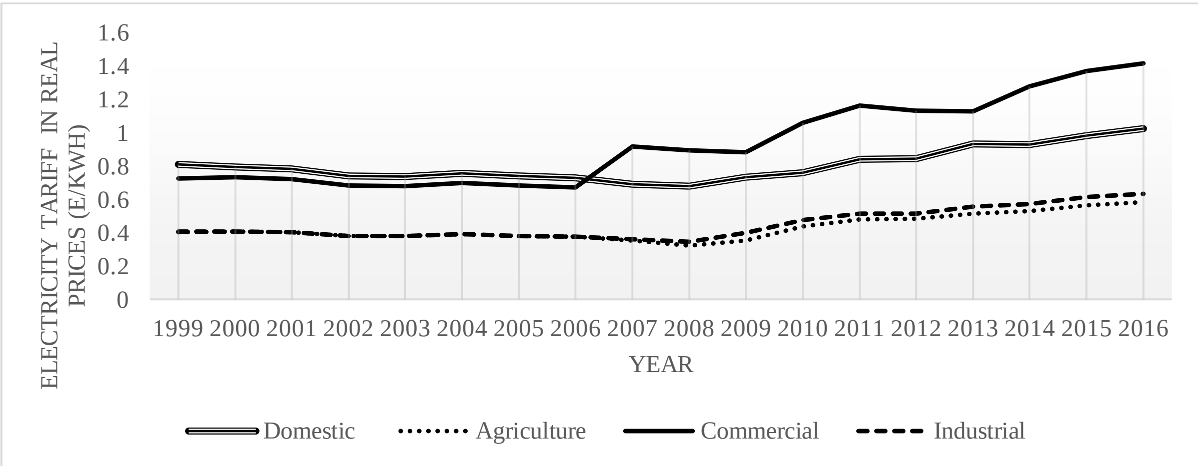
For the agriculture, commercial, and industrial customer segments, the study uses electricity consumption data from the utility between 2001-2017 to calculate the elasticities of each customer type using the seemingly unrelated regression. For these customer type, the data is only available for a 16-year period in which the sectoral gross domestic product or output of each sector is calculated using GDP data from the Central Statistics Office. Similar to the domestic customer, the study also compares the agriculture, commercial, and industrial real tariffs (having factored inflation) against the real output of each customer in each year under review. The study then calculates the elasticities of each of these customer types using the SUR in the log-log linear equation that allows to interpret the elasticities directly as the number given by the LnPrice.

4. RESULTS

4.1. Electricity Tariffs in Eswatini

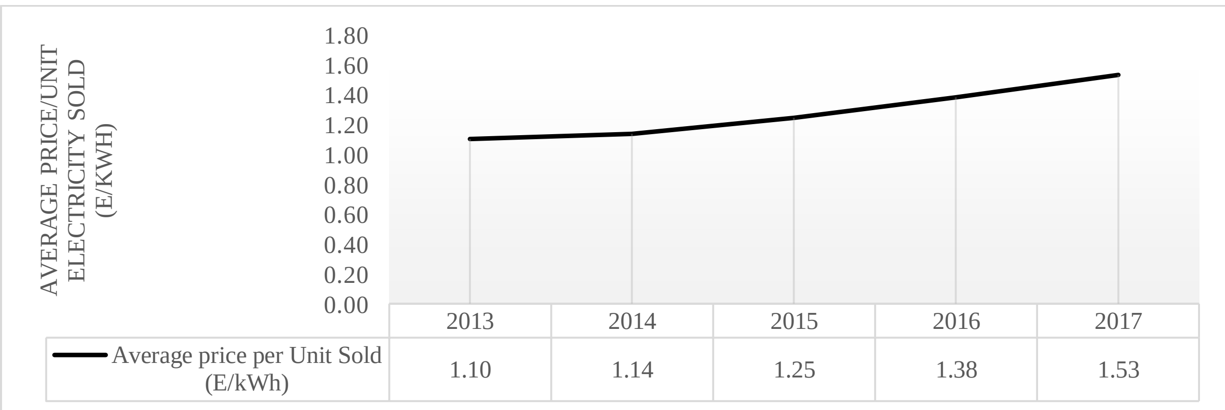
Figure 4.1.1 illustrates the long-term trend of average real tariffs in the specified four EEC customer categories from 1999 to 2016. From 1999 to 2006, the domestic customer category paid higher tariffs compared to the commercial customers, although the tariffs were decreasing in real terms. On the other hand, after 2007, the commercial customers have been paying the highest tariff compared to the other customer categories. Indeed, the commercial sector has been subsidising households hence the need for the domestic and agriculture customers to migrate to cost reflective tariffs.

Figure 4.1.1: Real Electricity Tariffs by Customer Category (1999-2016)



Even though some of the customers have not been paying the true cost of electricity supply, an analysis of the utility's annual reports reveals that the average price per unit of electricity sold in the last five years since 2013 has been increasing as demonstrated in Figure 4.1.2.

Figure 4.1.2: Average Price Per Unit of Electricity Sold (2013-2017)

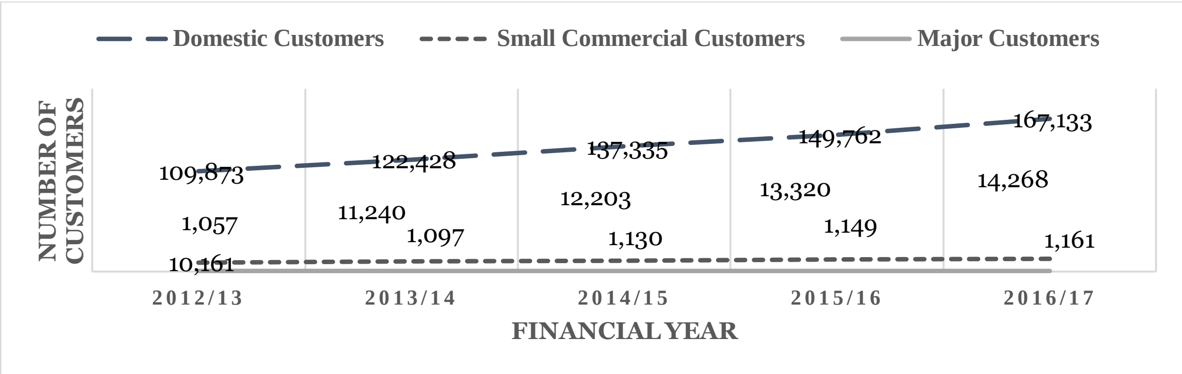


Source: Eswatini Electricity Company Annual Report 2017/18.

Notes: The average prices are the basic tariff paid by the different customer categories excluding the access, demand, and other charges paid by some of the customers.

Without factoring inflation, the Figure reveals that in the past 5 years, the average price per unit of electricity sold is on an upward trend, increasing from E1.10/kWh in 2013 to E1.53/kWh in 2017. It signifies a 39.1% increase in the average unit price of electricity so that rolling out of cost reflective tariffs could see electricity prices increasing by 100% for the domestic customer and by almost half for the commercial and industrial sectors within a short space of 5 years. In other words, electricity bills in Eswatini have been increasing year on year by an average of 10.8%. Yet the only time in the past 10 years the Kingdom of Eswatini has experienced inflation rates above 10% was in 2008 when the average inflation rate was 12.63%. In the past 5 years, inflation has been hovering between 5.63% in 2013 to 6.24% in 2017. Basically, the average price of electricity has incurred an increase that exceeds the cost of living in the country. As of 2016/17 Eswatini had 182,562 customers of which: 167,133 were domestic customers; 14,268 small commercial customers; and 1,161 major customers. Figure 4.1.3 shows that over the past 5 years, domestic customers have grown significantly by 52% from 109,873 to 167,133, small commercial by 40% from 10,161 to 14,268 and major customers by 10% from 1,057 to 1,161.

Figure 4.1.3: Electricity Customers in Kingdom of Eswatini (2012/13 – 2016/17)

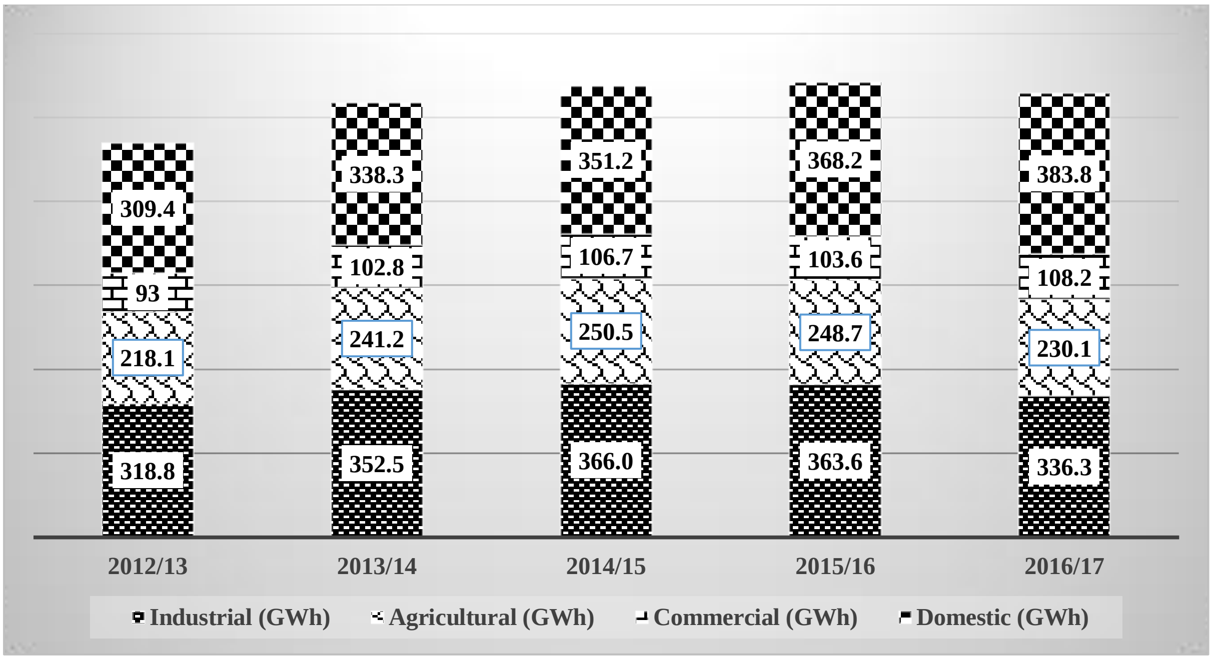


Source: Author

Though the major customers account for only 0.69% of the electricity customers, they use as much electricity as the domestic customers, and hence account for a large bulk of sales (see Figure 4.1.4. below). The Figure shows that even though households account for a bulk of the electricity customers, they only use about 383.8 GWh of electricity or 36.3% of the total number of electricity units used by all the different customer categories. Nevertheless, the Figure also shows that the total amount of electricity units used by the domestic customers increased by 24% in the past 5 years from 309.4 GWh in 2012/13 to 383.8 units in 2016/17.

The industrial and agricultural sectors use a bulk of the electricity accounting for 31.8% and 21.7%, respectively, of the electricity units consumed in 2016/2017. The commercial sector accounts for 10.2% of the electricity units in the same period. None of the sectors are showing a significant increase in the share of electricity units used over the five-year period. All the sectors use a comparable amount of electricity as they did the previous year. This is despite expansions in connections such as the rural electrification schemes across the country. The amount of units used by the agricultural and industrial sectors actually decreased in 2016/17 because of water rationing and slowdown in industrial activities such as agro-processing during the drought. In short the study finds that electricity demand is not growing in Eswatini.

Figure 4.3.2: Electricity Consumption by Customer Type (2012/13 – 2016/17)



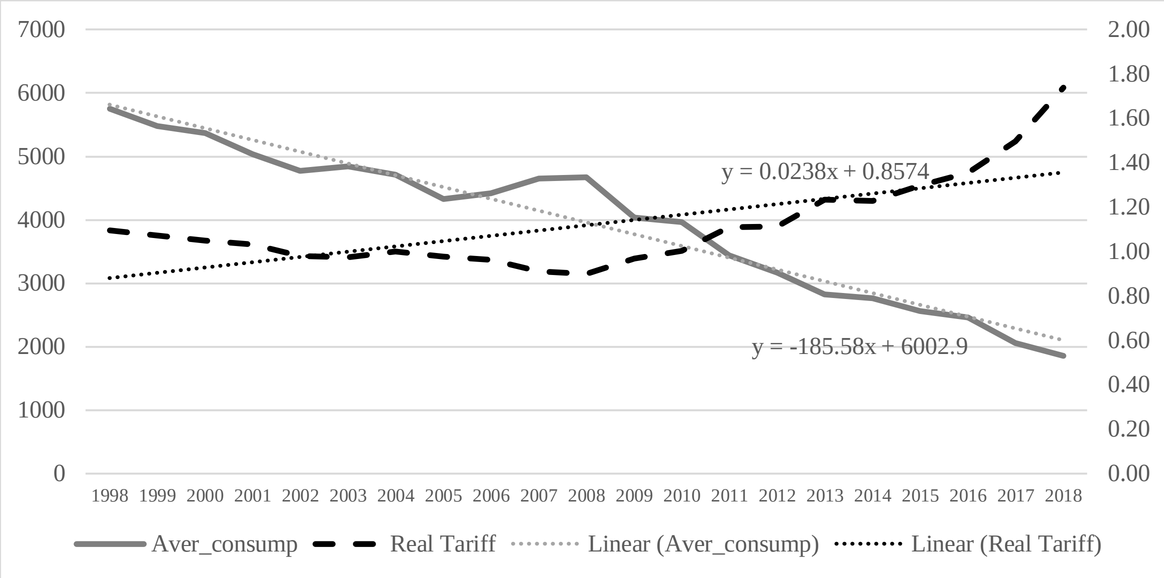
Source: Author

4.2. Price Elasticities

4.2.1. Domestic Customer

A descriptive analysis of the electricity consumption (average consumption per household) and tariff (E/kWh) shows that, on average, the real tariff for the domestic customer has been increasing by 2 cents annually since 1998. On the other hand, average electricity consumption has been, on average, decreasing by 185.6 kWh per annum (see Figure 4.2.1.1). Put differently, a 2 cent real increase in electricity tariff is associated with a decrease in average consumption of 185.6 kWh. The decrease in average consumption may be attributed to the use of more energy efficient appliances and/or reducing the number or duration of using appliances. Then again, this may also be due to the rural electrification initiatives which have seen a huge number of households being connected to the grid in rural Eswatini, most of which are low income, hence they consume less electricity. While ensuring universal access to electricity is a must, the electricity utility also has to recover the true cost of supplying electricity to all the geographic and socioeconomic types of households across the country. With low income households using relatively low amounts of electricity, it becomes an added challenge to recover the true cost of providing electricity services to all households across which exacerbates the need/drive to institute cost reflective tariffs.

Figure 4.2.1.1 Average Domestic Electricity Consumption versus Real tariff increase



Source: Author

In terms of actual domestic elasticities, Table 4.2.1.1 shows that percentage change in average consumption has remained largely negative, with an exception of year 2003, 2006, 2007, and 2008. A scrutiny of the point elasticity estimates, demand for electricity has been largely inelastic with an exception of year 1998, 2001, 2005, and 2007. Average elasticity over the 21-year period is -0.58 implying that domestic customers do not respond much to changes in electricity tariff. For instance, a 10 percent increase in electricity tariff would result in a 5.8% decrease in demand for electricity. It follows therefore that a 66% increase in domestic tariffs due to cost reflectivity could lead to a 38.28% decrease in domestic electricity demand. This result is expected given that most household use electricity for basic things such as lighting and other basic appliances. Therefore, there is not much they can do to reduce their consumption level apart from resorting to not lighting outside light at night or reduce the time duration of using some appliances. This means that in an event of a tariff increase, consumer will have no choice but to face the brunt of the higher prices. An inelastic electricity demand implies that a price increase will result in an increase in sales revenue for the utility with an impact on disposable income for households in Eswatini as they will be spending a larger share of their incomes buying electricity units.

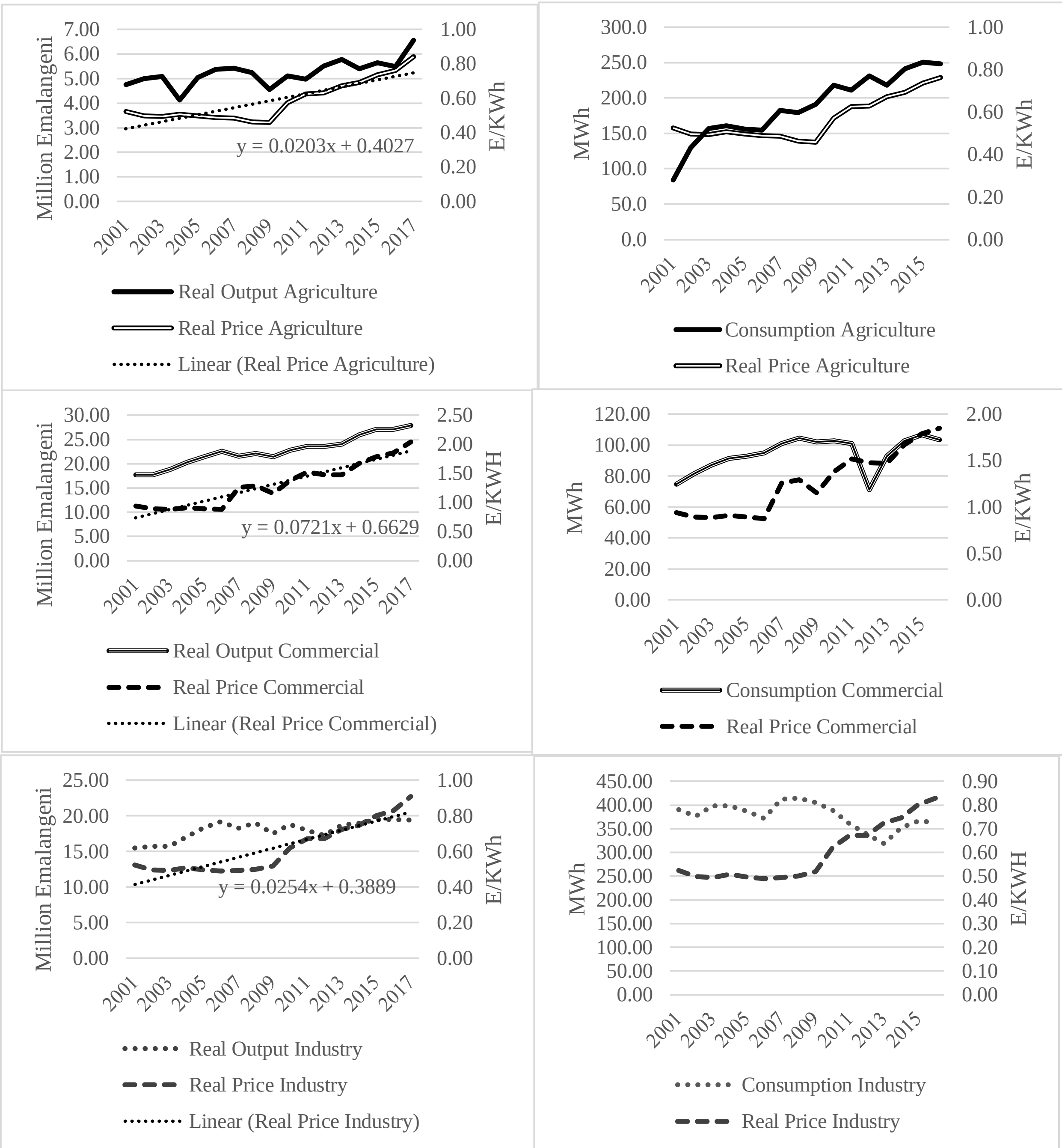
Table 4.2.1.1: Domestic Customer Econometric Analysis of Elasticities

Year	Tariff (E/kWh)	Average consumption (kWh)	% change Tariff	% change Average consumption	Point elasticity
1998	0.29	5755.37			
1999	0.30	5475.68	3.45	-4.86	-1.41
2000	0.33	5370.50	8.60	-1.92	-0.22
2001	0.35	5040.43	5.99	-6.15	-1.03
2002	0.37	4776.96	5.99	-5.23	-0.87
2003	0.39	4839.74	6.50	1.31	0.20
2004	0.41	4716.78	6.39	-2.54	-0.40
2005	0.42	4331.84	2.41	-8.16	-3.38
2006	0.44	4424.38	3.79	2.14	0.56
2007	0.46	4649.06	4.36	5.08	1.17
2008	0.51	4672.82	10.87	0.51	0.05
2009	0.59	4036.60	15.69	-13.62	-0.87
2010	0.64	3969.07	8.47	-1.67	-0.20
2011	0.75	3441.81	17.19	-13.28	-0.77
2012	0.82	3164.99	9.33	-8.04	-0.86
2013	0.96	2820.42	17.07	-10.89	-0.64
2014	1.01	2766.15	5.21	-1.92	-0.37
2015	1.12	2557.90	10.89	-7.53	-0.69
2016	1.26	2459.59	12.50	-3.84	-0.31
2017	1.48	2061.16	17.46	-16.20	-0.93
2018	1.74	1861.38	17.57	-9.69	-0.55
Average domestic customer elasticity					**-0.58**

4.2.2. Non-domestic customers

In the period 2001 to 2017, electricity tariffs for the non-domestic customer have been on average increasing, not only in nominal terms but also in real terms, as shown in Figure 4.2.2.1. On average, the customer groups; agriculture, commercial, and industrial have experienced annual increase of 2 cents, 7 cents, and 3 cents, respectively. On the consumption side, only the agricultural customer group shows an increase in electricity consumption (average of 8.2491 GWh per year) over the period 2007 to 2017. Electricity consumption has been decreasing, on average, by 0.0982 GWh and 7.7703 GWh for commercial and industrial customer groups, respectively.

Figure 4.2.2.1 Electricity consumption, price and economic output for the Agriculture, Commercial, and Industrial Customer groups



Source: Author

The study uses a seemingly unrelated regression model (SUR) to capture the importance of electricity prices in each of the non-domestic customer groups. The coefficients of the variable Lnprice (natural logarithm of price) are the estimated price elasticities of electricity demand for each of the customer groups. All sectors have negative coefficients implying that they were all negatively impacted by an increase in electricity tariff. However, the industrial customer group is the only customer group, which responded or was affected significantly ($p < 0.1$) by changes in electricity tariff. This implies that even though electricity tariff increase affected demand of all the sectors, the industrial sector is the only sector, which saw a significant reduction in demand for electricity.

The elasticity coefficient for the industrial customer group is -0.157, which implies that even though this customer group responds to changes in electricity tariff, a proportionate increase in electricity price results in a less than proportionate decrease in electricity consumed. In quantitative terms, a 10 percent increase on electricity tariff for the industrial sector would result in a 0.157 percent decrease in electricity demanded by the sector. This low responsiveness implies that the industrial sector has less room to evade the brunt of an electricity tariff increase.

The results of the current study are similar to findings reported by Inglesi-Lotz and Blignaut (2011). They found demand for industrial sector of South Africa to be inelastic (elasticity = – 0.869) as shown in Figure 4.2.2.2. Output for agricultural is positively and significantly associated with electricity consumption ($p < 0.01$). However, there is no statistically significant association between the output of the commercial and industrial sectors and the amount of electricity consumed by these sectors.

Table 4.2.2.1: Seemingly unrelated regression

Variables	**Agriculture**	**Commercial**	**Industry**
Lnprices	-0.045 (0.139)	-0.222 (0.209)	-0.157* (0.092)
Lnoutput	0.727*** (0.196)	0.412 (0.274)	0.088 (0.185)
Constant	4.371** (0.365)	3.415** (0.768)	5.555*** (0.381)

Notes: Standard errors in parentheses
Significance level: *** p<0.01, ** p<0.05, * p<0.1

Figure 4.2.2.2: Elasticity estimates for the South African Economy

SUR model results

Lncons	Industrial	Transport	Commercial	Agriculture	Mining
Lnprice	-0.869 **0.004**	-1.220 **0.229**	0.677 **0.145**	0.152 **0.865**	0.204 **0.506**
Lnoutput	0.712 **0.004**	-0.242 **0.694**	0.767 **0.029**	0.032 **0.955**	0.030 **0.954**
Constant	3.059 **0.132**	8.749 **0.001**	6.081 **0.005**	10.076 **0.000**	11.430 **0.004**
Adjusted R-squared=0.967 Total number of observations: 65					

Source: Inglesi-Lotz and Blignaut (2011)
Notes: *p* values in bold

5. CONCLUSION

The study calculates price elasticity of demand for Eswatini’s electricity customers given that the energy regulator’s approval to migrant to cost reflective tariffs. Depending on the responsiveness of quantity demand to changes in price (elasticity), pricing is used to either promote efficiency or generate revenue for the supplier of the good or service. Pricing promotes efficiency if demand is elastic (quantity demand responsive to changes in price). On the other hand, when demand is inelastic (demand not responsive to changes in price) pricing can only be used to generate revenue but not to improve efficiency.

The study finds that demand for electricity for both domestic and non-domestic customer group is not responsive to changes in electricity tariff, which means demand is inelastic. This implies that the schedules increase in electricity tariffs will be more effective in generating revenue for the utility (Eswatini Electricity Company) than in improving efficient use of electricity. Elasticity also determines whether a good or service is a necessity or luxury. Inelastic demand, such as the one estimated in this study, means that electricity is a necessity for all the electricity customer types in Eswatini. This result implies that there is a need for policymakers to consider equity issues in their quest to introduce cost reflective tariffs. For the domestic customer, the migration to cost reflective tariffs will increase domestic tariffs by 66% from E1.75/kWh to E2.90/kWh which according to the -0.58 elasticity could decrease demand by as much 38.3%. Furthermore, a E2 cents real increase in electricity tariff for the domestic customer is associated with a decrease in electricity consumption of 185kWh on average per household per year. This means the cost reflective tariffs will most likely decrease intensive use of electricity in Eswatini, especially for low income households which will make supplying and extending the grid to low income households a much more expensive task for the utility. As more and more households use less electricity, the utility may never recover the true cost of supplying electricity to a majority of the domestic customers. For the non-domestic customers, the study finds that they all have negative coefficients implying that they will all be negatively impacted the migration to cost reflective tariffs. However, the industrial customer group is the only customer group, which over the 16-year period that is affected significantly ($p < 0.1$) by changes in electricity tariff. This implies that even though electricity tariff increase affects demand in all the non-domestic customers, the industrial sector is the only sector which shows a significant reduction in demand for electricity. The elasticity coefficient for the industrial customer group is -0.157, which implies that even though this customer group responds to changes in electricity tariff, a proportionate increase in electricity price results in a less than proportionate decrease in electricity consumed. This implies that electricity is a key input of production for the industrial customer group and excessive increase in their electricity tariffs could hamper the productivity of this sector. In the long-run the migration to cost reflective tariffs will force both the domestic and non-domestic customers to substitute the stock of electric devices/equipment for ones that provide the same or equivalent service but using much less electricity in doing so. The major industrial customers might eventually invest into renewable energy power plants so that they can fix the total amount of electricity they buy from the utility and allocate the excess cost to renewable sources. The less dependency on the utility for baseload electricity could drive down sales and eventually put the utility in a position where it is not able to recover the true cost of supply. Access to energy will keep increasing with the Government of Eswatini Rural Electrification Project; however, the goals of the Energy Policy might not be fully realised because migration to cost reflective tariffs will most likely limit the total amount of electricity that each customer will afford to use.

6. RECOMMENDATIONS

Based on the findings, the study makes the following recommendations:

- ✓ Before implementing the cost-reflective tariffs, the energy regulator (ESERA) should ensure that the utility (EEC) establishes efficiency improvements on supply and distribution of electricity. For the most part, the utility's capital projects focus on expanding capabilities on reliability in transmission and distribution and does not address the inherent vulnerability/inefficiency of the system. The problem is that current pricing of electricity is clouded by inefficient supply of power (for example, a significant amount of power is lost through transmission). The cost reflective tariffs are based on a guaranteed revenue recovery for the utility regardless of the fact that the utility is not operating at an optimal level. Any inefficiencies incurred that increase the cost of delivering electricity to the different customer types are shifted to the electricity consumers.
- ✓ The utility should explore the establishment of mini-grids that use a combination of alternative energy sources for low-income households that are located in isolated areas of Eswatini. These mini-grids can be installed for low-intensity use consumers of electricity.
- ✓ Eswatini should expedite the national plans for promoting local production of electricity to reduce the cost of power. Since the utility imports well over 80% of the of the country's power, the revenue requirement requested by EEC from ESERA will continue to increase based on the tariffs that will continue to increase in South Africa and in the SADC region. This would be without much fair consideration on the structure of the Eswatini electricity market and its ability to absorb the price hikes necessitated by SEC's revenue requirement among other factors.

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