Wheeling of Electricity: A Friend or Foe in the Energy Transition

The Consequences of Electricity Wheeling for eThekwini Municipality

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I. ABSTRACT

This study highlights South Africa's existing frameworks for wheeling electricity and the revenue implications for eThekwini Municipality should wheeling be allowed in the current context. Despite allusions to several regulations and acts, wheeling has not yet attained widespread adoption. However, the requirement to deliver electricity to consumers is gaining popularity due to increasing liberalisation in the electrical sector that enables private generators. EThekwini Municipality is aware of the broader implications and potential benefits of wheeling in a fully liberalised market; nonetheless, the current tariff structures and price regimes are insufficient to allow wheeling without inflicting revenue losses for municipalities. In eThekwini Municipality, a wheeling penetration rate of 100% among industrial customers would result in a loss of R 520 million. The revenue loss is R 260 million at a wheeling penetration rate of 50% and R 130 million at a wheeling penetration rate of 25%. Permitting wheeling in the Business sector also results in losses. With a wheeling penetration rate of 25%, 50%, and 75%, the corresponding financial losses are R273 million, R546 million, and R819 million, respectively. Changing the pricing mechanisms and tariff structures adopted by municipalities to recover customer network expenses independent of energy charges is one technique municipalities can adopt to avert revenue losses. Changing recovery methodologies, however, is time-consuming and will impact revenue recovery for other customers. Therefore, there must be an intense effort to migrate to wheeling frameworks that minimise revenue losses to municipalities while maximising the benefits of wheeling.

II. KEYWORDS

Electricity wheeling, distribution use of system charges (DUOS), energy trading, transportation of energy

1.0 INTRODUCTION

1.1 BACKGROUND

The historically low price of electricity did not allow for a competitive environment and hence did not promote private generation to a large extent. Without private generation, there was no demand for wheeling. However, with the recent change to schedule 2 of the electricity regulation act, generation facilities up to 100MW are now exempt from a licence condition [1]. The licence relaxation, coupled with the higher grid electricity prices, naturally created a more conducive environment for the rise of private generators. As more generators intend to join the grid, there is a need for more off-takers. With the current geographical topology prevalent in South Africa, certain regions tend to support particular generation technologies better than others.

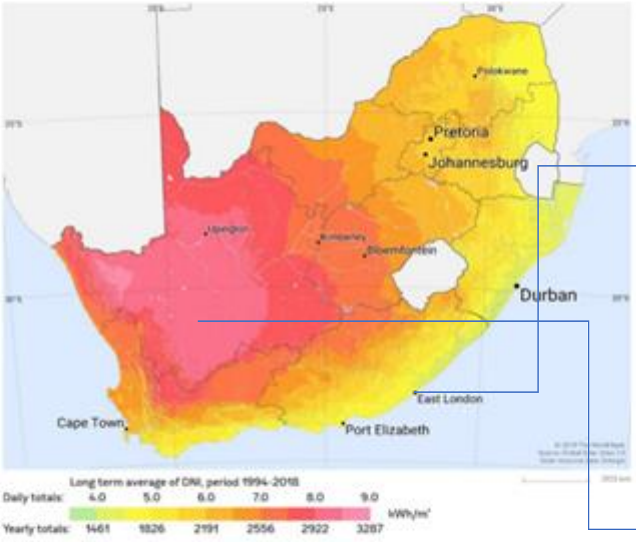


Figure 1 Solar Resource Map [2]

Coastal Region

Coastal locations, mainly from East London to the Western Cape and the neighbouring areas, are windy due to the consistently increasing airflow. For instance, the average yearly wind speed at Cape Point is 14,1 meters per second, with 42,1% of wind speeds exceeding 8 meters per second [3].

Interior Region

Due to the higher sun irradiation, the western interior regions of South Africa are optimal for solar PV. Recent trends show that solar-specific energy projects are widely implemented in these regions. Having achieved a significant concentration of independent private generators, the search for electricity off-takers has intensified. Many off-takers are located within municipal boundaries and contribute to the municipal revenue base.

Transporting electricity from private producers to end-users is essential for both generators and consumers, as grid-supplied electricity is currently more expensive than solar/wind generating systems. Moreover, the economic case becomes more compelling as electricity prices continue to increase annually at a rate that exceeds inflation.

The graph below depicts the ten-year increase in the price of electricity, and the solar PV and wind prices tendered during the fifth bid window of the Renewable Energy Independent Power Producer Program (REIPPP).

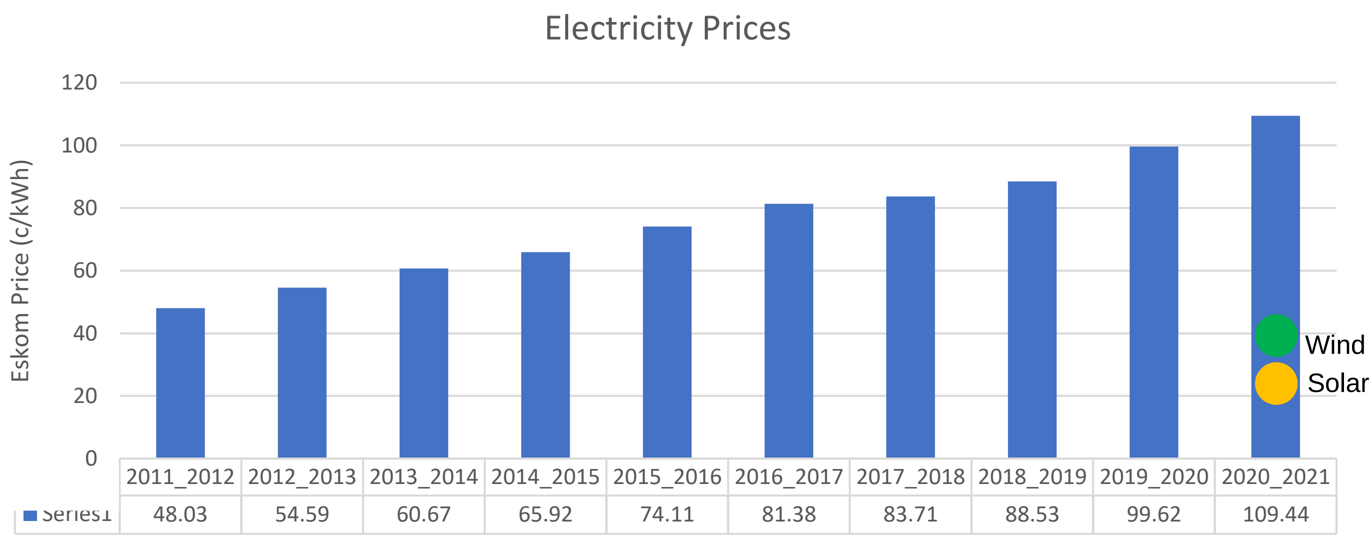
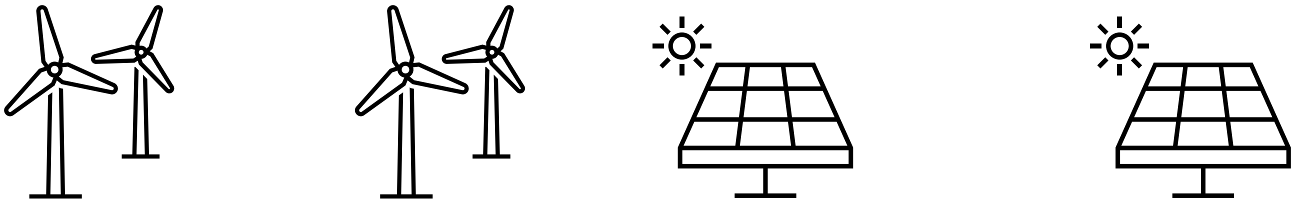


Figure 2 Electricity Prices: Eskom vs bid prices – Own elaboration based on [4], [5]

Table 1: REIPPP bid window five rates for wind and solar projects. [4]



Facility	R/ MWh	Facility	R/ MWh
Dwarsrug Wind facility	344.25	Kentani Solar Facility	374.79
Beaufort West Wind Facility	427.41	Klipfontein Solar Facility	374.79
Trakas Wind Facility	427.41	Klipfontein 2 Solar Facility	374.79
Sutherland Wind facility	428.27	Leliehoek Solar Facility	374.79
Rietrug Wind Facility	428.27	Braklaagte Solar Facility	374.79

1.1.1 Technology Advancement

Technology advancements and a maturing alternate energy sector promoting economies of scale in South Africa have drastically dropped solar and wind prices. Solar and wind are intermittent generation sources; therefore, comparing these prices directly with non-intermittent sources distorts the picture. The cost of suitable backup must be included to affect a fair comparison. With that said, the case of alternate generation at reduced prices is now a reality in South Africa. Impressing the business case would be where alternate energy could be made available per its intermittence, and backup is taken care of by another service provider. The arrangement then gives rise to wheeling, where the generator will make electricity available per the technology's intermittency. This energy is wheeled to prospective off-takers, and the utility would make provision for the backup/shortfall in the customer's demand. In the electricity sector, there are various definitions for the word wheeling. Simply stated, wheeling refers to utilising the network and infrastructure of the utility for conveyance by another person. An alternate definition summarises wheeling as the movement of electrical power between a seller and a buyer via a network owned by another party [6]. Within the Electricity Pricing Policy (EPP) [7], wheeling is defined as the transportation of electricity by an electricity supplier (utility) to a third party through a network not owned, controlled or leased by either party.
The financial case for a wheeling transaction can be lucrative as renewable energy can be generated at almost one-third the price compared to traditional generation. Furthermore, wheeling to a customer at a municipal level makes the financial case even more attractive as distribution charges are also factored in.

1.1.2 Energy Shortage / Load Shedding

As a result of South Africa's electricity shortage, the demand for wheeling has also increased. The energy shortage results in frequent load shedding plaguing the country into darkness. Private power investment can quickly introduce new generation capacity to the grid; however, there would need to be an understanding and framework that would detail how electricity would be transported from generator to off-taker. Amendments to Schedule 2 of the ERA currently allow the generation of up to 100MW without needing a licence. The amendment is a clear message from the national level that there is support for large-scale alternate energy generation. However, energy generated must be transmitted and/or distributed; therefore, a key enabler to quickly growing the generation capacity is to ensure that the transport mechanism for electricity generated is developed and implemented. Such a transport mechanism is commonly referred to as wheeling.

1.1.3 Climate Targets / Goals

In accordance with the United Nations Framework Convention on Climate Change (UNFCCC) and its Paris Agreement (PA), South Africa has pledged to contribute to global climate change efforts. Many customers, primarily large multinational corporations, have also agreed to the framework agreement's principles and set goals to transition to cleaner and greener energy sources. Entering into wheeling agreements with renewable energy suppliers is one way to meet and sustain these commitments.

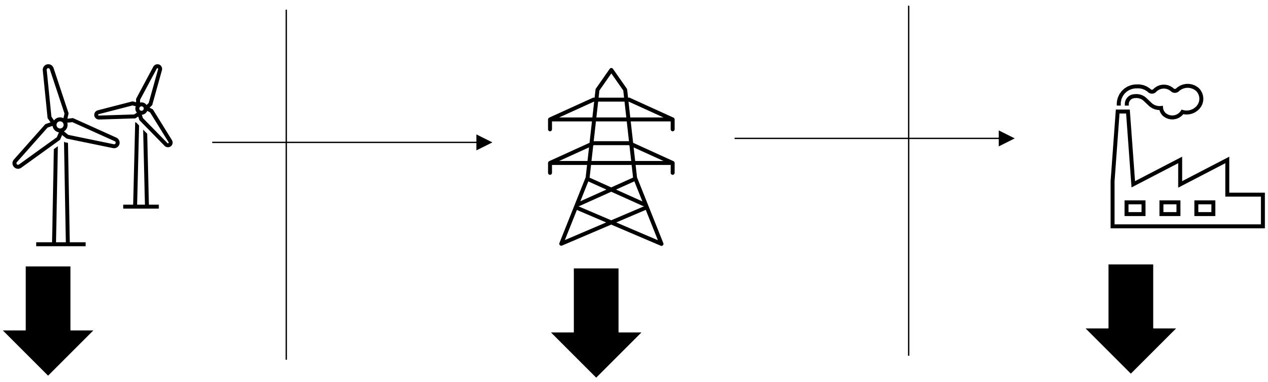
1.2 IMPORTANCE OF WHEELING

Notwithstanding the challenges associated with wheeling, there must be a progressive implementation plan, as it is not only policy driven but is now becoming a crucial component of connecting private generators to off-takers. If there is a failure to accommodate wheeling, there is a risk of underutilised generators. Moreover, the relationship between private generators and off-takers is becoming economically more robust in value as grid-priced electricity continues to grow above inflation yearly. Municipalities will therefore continue to feel the pressure to implement wheeling frameworks to enable the virtual flow of energy from private generators to off-takers.

1.3 UNDERSTANDING THE THEORETICAL CONCEPT OF WHEELING

A wheeling transaction depends on three main aspects, a generator, a network, and an off-taker. There could also be multiples of each within the transaction. However, note that this relationship is conceptual as it does not correlate with electron flow.

The Generator - Seller | **The Transporter – Network / Municipality** | **Off-Taker – Buyer**



The creation of a wheeling transaction is based on the availability of a generator with excess capacity. Such a generator must be able to produce electricity at a price cheaper than the prevailing retail price. An added advantage would be if the generator can produce electricity from cleaner sources compared to the conventional supply. With changes to Schedule 2 of the ERA, there is a growing number of generators within the South African industry.

With an available generator, a transporter of the electricity is required. Although the electricity would not flow from the generator to the buyer per se, a theoretical path is required to complete the transaction.

Due to the path being theoretical, the perceived transport costs are not incurred. However, deemed to occur as none of the seller's energy is flowing to the buyer. Furthermore, in most cases, the networks to allow for the flow of energy are already constructed, and hence, it is perceived that wheeling does not impose charges on the network.

The network charge is an essential factor in the value chain as it drives the total cost of the transaction. Therefore, a lower wheeling fee would enhance the business case of the transaction and vice versa.

A critical component of the wheeling transaction is to be able to find a willing buyer.

Customers can enter into bilateral trading agreements directly with generators. Further, with the drive to a low carbon economy, customers seek alternate suppliers that can offer electricity generated via cleaner energy sources.

Buyer willingness is enhanced when alternate energy prices are cheaper than the conventional supply.

Figure 3 Single line diagram depicting the concept of wheeling. Own elaboration based on [8], [9]

EThekwini Municipality currently procures electricity from Eskom at the transmission level at an average rate of 109 c/kWh. However, the average retail price of electricity in the industrial sector is approximately 191 c/kWh. Therefore, the difference of 82 c/kWh (average) contributes to the costs incurred by the municipality for the distribution and related activities.

In the case of a wheeling arrangement, energy can be generated at 37.5 c/kWh, and the green electricity becomes more marketable to customers. Assuming that customers would still be prepared to pay 191 c/kWh, the wheeling transaction could earn a gross margin (excluding wheeling fees) of 153.5 c/kWh. This rate is 46% higher than what is available, considering the municipality's traditional purchase and sale of electricity. Therefore, the wheeling tariff becomes a crucial component in determining the final margin generated from the transaction. Hence it is clear that the development of wheeling tariffs in South Africa will be subject to severe scrutiny. Furthermore, with the ongoing liberalisation of the sector, determining wheeling tariffs is becoming more complicated and crucial [10].

1.4 TYPICAL PRICING PHILOSOPHIES FOR WHEELING AT THE TRANSMISSION LEVEL

A range of wheeling pricing methodologies applies to the movement and management of electricity via the transmission network. Whilst this paper focuses on the distribution network, understanding the principles of transmission wheeling pricing is valuable as it illustrates the various cost recovery methods and their advantages and disadvantages. Similar approaches and principles could be emulated within the distribution network.

Low **Level of Efficiency: Network Management** **High**

Postage Stamp	MW-kM Distance	MW–kM Load Flow	Nodal Pricing
The postage stamp method is hailed for its implementation simplicity as it allocates network costs to users based on their proportion of the peak loading on the grid. Based on the methodology, a charge is levied based on expenses divided by the peak load, equating to a flat rate charge. It also allows for the recovery of initial / sunk costs. However, low load factor customers are disadvantaged due to the charging method.	The MW-kM distance method expands on the postage stamp method; however, it now includes the distance between generation and load. The distance is usually considered a straight-line path between where the energy enters the network and where it leaves. The calculation is then completed by proportionally allocating a charge of the MW-KM identified to the total MW-KM cost. While the system is simple to implement and comprehend, the actual flow of electricity is not considered, resulting in inefficiencies.	The MW-kM load flow uses the actual loading and flow of power per transaction, and a charge is levied in proportion to the total load flow. A load flow model is used to determine the flow caused by the wheeling transaction. Transactional load flow necessitates the need for computer-aided software and introduces a level of complexity.	Nodal pricing is known for its complexity and accuracy of recovery. The method entails pricing for nodes within the network based on marginal costs of losses and congestion at that node. With this method, wheeling charges are based on the nodal flow of electricity irrespective of the assets within. As it is based on marginal costs, the fundamental disadvantage of the nodal technique is that it may result in the under-recovery of fixed, previous expenses.

Low **Level of Complexity: Implementation** **High**

Figure 4 Methods of calculating wheeling costs: Own Elaboration based on [11], [12], [13]

There are no unified rules for calculating the wheeling charge; however, there are recommended approaches as it is impossible to colour code an electron [6]. As a result, each method varies in accuracy and complexity when calculating wheeling charges. In addition, the calculation becomes more complex when wheeling occurs across multiple municipalities through the Eskom network. In these cases, charges will be raised by all of the network operators, and the methodology of charging may be different as there is no uniform method of charging at this stage nationally.

1.5 UNDERSTANDING THE CURRENT CHALLENGES OF WHEELING WITHIN MUNICIPAL NETWORKS

When trying to integrate such wheeling principles within current municipal frameworks, there is a lack of harmony, tariff discrimination and, in many cases, the loss of revenue to the municipality.

Recovery of costs on the distribution grid is carried out via cost pooling per voltage level. This methodology is regulated amongst municipalities. This cost recovery method will either be a kWh recovery, a kVA recovery, or a combination of both. The costs allocated to the voltage pool, the number of customers participating, the loading size and the load factors are essential factors in determining the cost recovery method. In times of high growth coupled with high load factor customers, a kWh recovery method is most plausible as it spreads costs amongst a more prominent aspect of a tariff component. The kWh recovery method has the effect of reducing the average tariff for all customers.

1.5.1 Costs and Tariff Mismatch: Deviation from Cost of Supply

The third-party transportation rule document states that the increase in UOS charges must be indexed to CPI [14]; however, the UOS charges are indexed to actual costs experienced. Further, the UOS charge is calculated by dividing the total cost by the total sales; should sales drop significantly, the UOS charge rises significantly, irrespective of CPI.

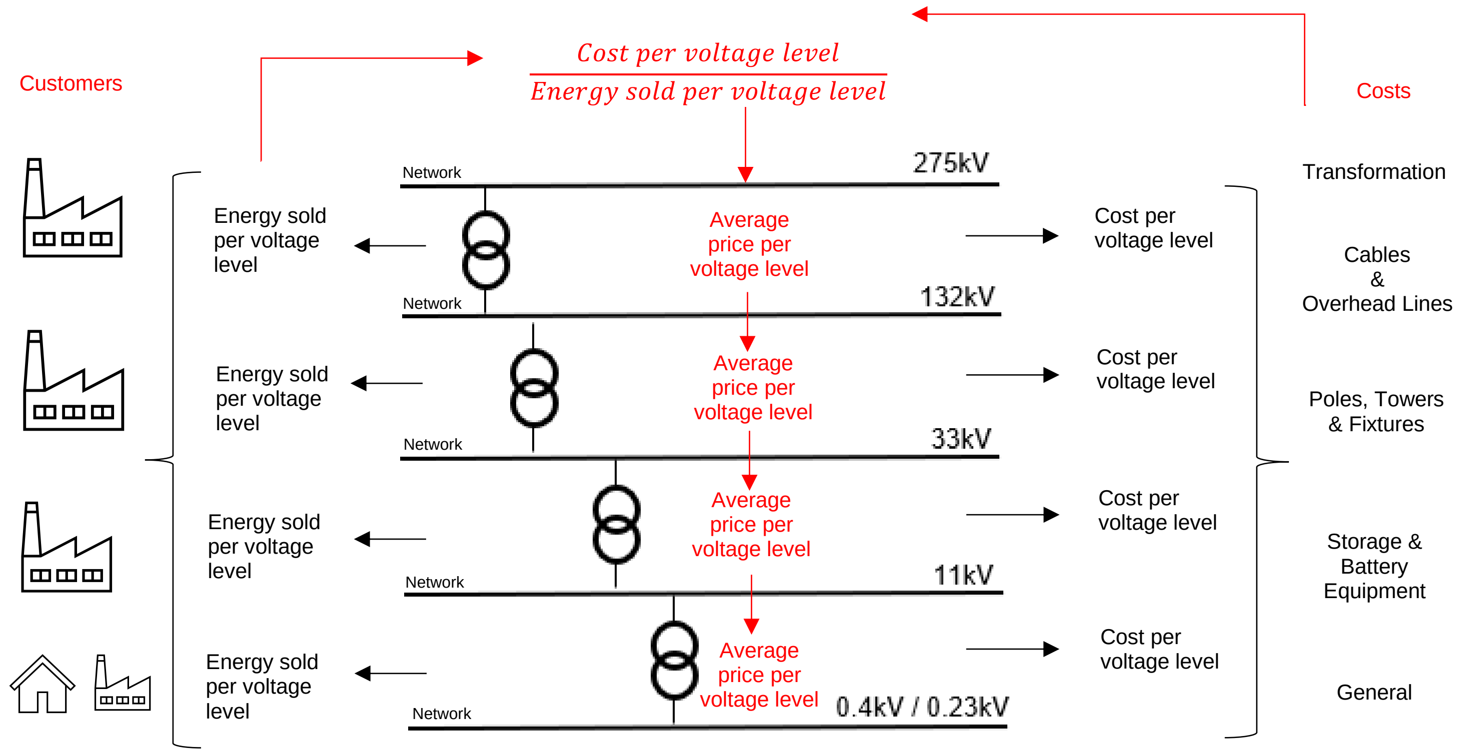


Figure 5 Illustration depicting voltage level model of eThekwini Municipality: Own Elaboration

In the case of EThekwini Municipality, a portion of the network-related costs is recovered via the sale of kWhs. As a result, any attempt to reduce the kWh sales contributes less to the network-related costs. As a result, the tariff for other customers must be increased to cater for this loss.

In this context, the implementation of wheeling is not gaining popularity in Municipalities. The following sections attempt to quantify and highlight these challenges and further try to provide realistic approaches to harmonise wheeling within the changing electricity supply landscape of South Africa.

1.5.2 Contractual Matters

Contractual arrangements become complex as multiple parties are involved in the electricity transaction. The transaction is affected when the generator is unable to supply electricity as agreed, the customer is unable to consume electricity as agreed, or the municipality is unable to provide the network as agreed. Network unavailability would generally be due to load shedding and or network faults. These scenarios would place a significant burden on the management of the transaction.

Generally, when a municipality is a party to a contract with financial obligations, a supply chain procedure is followed, and the duration of the contract is limited. It is uncertain if wheeling is exempt from supply chain procedures. There are compelling reasons against the necessity of following predetermined supply chain procedures. It would be of great use if the national treasury issued a circular directing municipality in this regard.

1.5.3 Billing and metering systems

Wheeling transactions necessitate expanding billing and metering systems to accommodate the necessary adjustments and offsets. Additionally, intercity electricity wheeling would necessitate increased collaboration, as the various systems would need to be integrated; otherwise, manual transactions would be required.

1.6 THE SOUTH AFRICAN WHEELING CONTEXT

2006 — **ACT** — **POLICY** — **CODE** — **RULE** — 2022

The Electricity Regulation Act [15]	**The Electricity Pricing Policy [7]**	**The Distribution Grid Codes [16]**	**Third-Party Transportation of Energy [14]**
The Electricity Regulation Act relates not to wheeling but rather to trading electricity. As defined, "trading" refers to the commercial purchase or sale of energy. Therefore, one may claim that wheeling constitutes trading because it involves buying and selling. Notwithstanding the lack of reference to wheeling, sections 2 (a) and (b) define the act's objectives as follows: *(a)* Achieve the efficient, effective, sustainable, and orderly development and operation of electricity supply infrastructure in South Africa. *(b)* Ensure that the interests and needs of present and future electricity customers and end users are safeguarded and met, having regard to governance and efficiency. Effectiveness and long-term sustainability of the electricity supply industry within the broader context of economic energy regulation in the *(c)* *F*acilitate investment in the electricity supply industry - (d), (e), (f), (g) also apply. It is evident within the objectives that effectiveness, sustainability and competitiveness must be supported.	Unlike the ERA, the electricity pricing policy of South Africa dedicates a paragraph to discuss the concept of wheeling. The principal points are highlighted as per policy position 5 below: 5 a) Fair and non-discriminatory access to and use of networks to all users of the relevant networks. b) The total cost to operate the networks is reflected in the various connection and use of system charges; therefore, no additional charges for wheeling electricity will be levied unless the wheeling action introduces incremental costs. c) Any incremental wheeling costs associated with a specific wheeling transaction and its fair share must be recovered as a connection charge. d) Wheeling of electricity can only be permitted if the action complies with all technical, safety and commercial requirements. e) A methodology for transmission and distribution wheeling, including the treatment of network congestion, must be developed by NERSA. The policy has forward stepped and pronounced on two specific issues of wheeling, including the access rights of wheeling (5a) as well as the pricing methods (5b,5c); however, it also pronounces in (5e) that NERSA must develop a methodology for wheeling.	The tariff grid code v6.2 states the following: 5.5.1. Embedded generators, including those that wheel, that use the distribution network to export power shall pay the Distribution generator use-of-system charges. 5.5. (2) All customers receiving a network service (including wheeling) shall pay the distribution use of system charges (DUoS), irrespective of any energy trading arrangement, which may or may not be unbundled depending on the tariff structure. 7. (5) All load customers, including those wheeling energy, shall be required to contribute to network-related subsidies. However, what form or quantity the customers shall contribute to subsidies is unclear.	Section 6.11 of the rules says generators' UOS system charges must be fixed and indexed annually to CPI. Unfortunately, not all costs are indexed to CPI; hence, municipalities may be under recovering in these cases where costs exceed CPI. Section 11.3 states, Upstream reinforcements costs shall not be raised from wheeling generators but an early termination guarantee for shared assets. The non-raising of costs can be viewed as municipalities funding infrastructure used by generators. 12.2 Generators connected below 11kV shall not be allowed to wheel energy.

Figure 6 Summary of selected wheeling references within the act, policy, grid code & rules

Electricity wheeling is supported within the electricity framework in South Africa. The framework alludes to principles and rules that would be best suited to enable wheeling; however, it is not necessarily feasible to implement currently. Therefore, migrating towards the electricity framework that supports wheeling will affect all electricity network users. Wheeling may therefore be ready to be enacted in theory but not necessarily in reality unless the matters are suitably addressed.

2.0 THE DILEMMA OF WHEELING: A CASE IN POINT

Large electricity users in eThekwini use the Industrial Time of Use (ITOU) tariff structure to purchase electricity [17]. Given the standard typology of wheeling, it would typically be applied to consumers who buy electricity through this tariff.

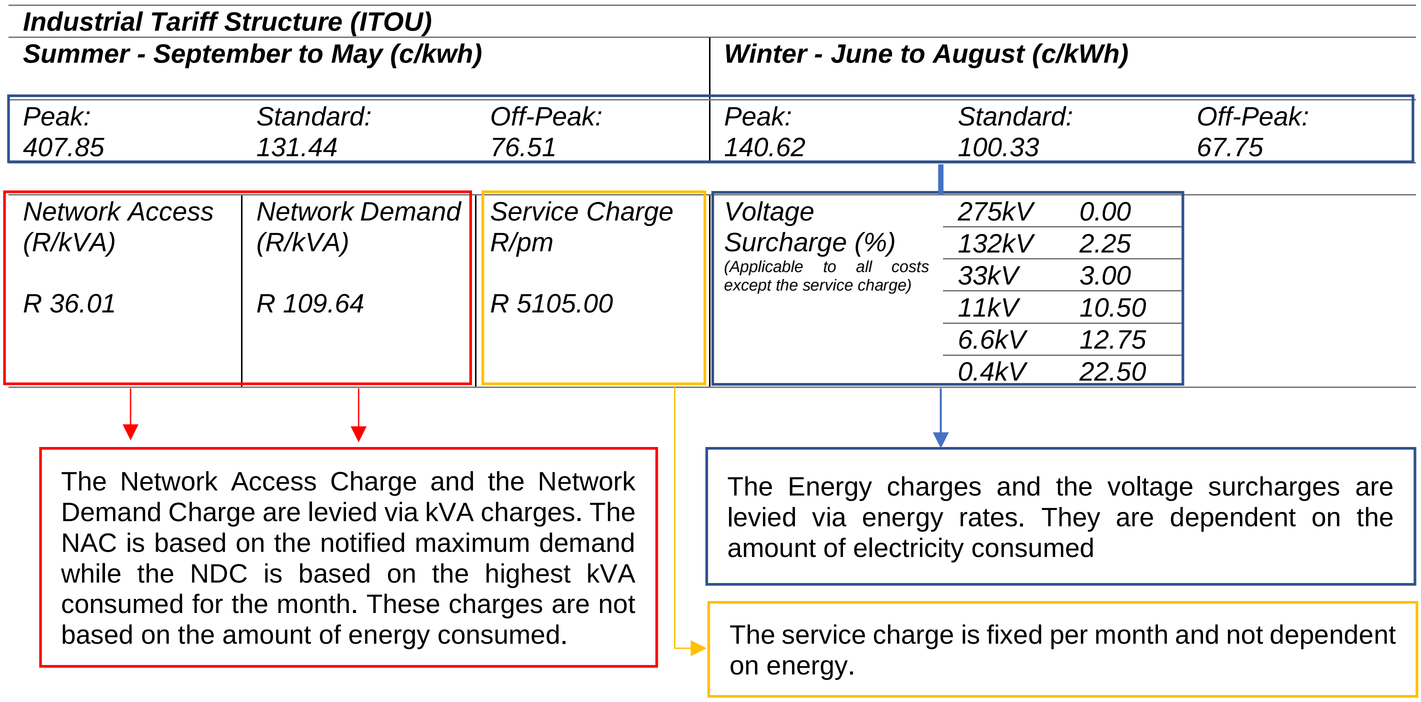


Figure 7 Industrial Time of Use (ITOU) tariff structure [17]

The tariff structure closely depicts that of Eskom Megaflex. The tariff is broken up into 3 energy periods, i.e., Peak, Standard and off-peak. It is further differentiated between summer and winter periods. In addition to the energy charge components, there is a fixed network access charge (kVA), a demand charge (kVA) and a fixed service charge. The fixed network access charge is based on the notified demand, while the maximum demand charge is based on the highest kVA drawn for the month.

A voltage surcharge is a percentage levied on the sum of the energy and demand components. The percentage levied varies depending on the voltage level of operation. The voltage surcharge is levied on the sum of the energy and demand components. The tariff component aims to recover costs that vary based on energy, including losses and other energy-driven costs. Customers are billed monthly.

2.1 APPLICABILITY OF WHEELING AMONGST CUSTOMERS IN ETHEKWINI

Table 2: Applicability of wheeling amongst customer categories

RESIDENTIAL CATEGORY	BUSINESS CATEGORY	INDUSTRIAL CATEGORY
Most customers within eThekwini Municipality are residential customers that procure electricity on the low voltage on either credit or prepaid electricity. The residential sector consumes 34 % of the total electricity per annum and contributes 38% to the revenue stream. The retail price of electricity is 182.09 c/kWh. Therefore, wheeling to this customer base would make an excellent financial case; however, consumption is relatively low to attract wheelers. Therefore, it is unlikely that	There are 43587 Business customers in the city. They consume 2041 GWh per annum. Business customers are primarily serviced via low voltage credit meters and contribute 21% of the annual revenue stream. The retail price of electricity is 205.62 c/kWh. Therefore, wheeling to this customer base would make an excellent financial case. However,	There are 1100 customers consuming electricity via the ITOU tariff structure. They account for 43 % of the total electricity consumption. Furthermore, due to extensive electricity requirements at higher voltage levels and high load factors, this sector contributes 40 % to the total revenue stream.

the sector would be targeted for wheeling at this stage. A large contingent of informal settlements within eThekwini Municipality is not electrified. These informal settlements depend on subsidised connections and Free Basic Electricity (FBE) monthly due to their low level of affordability. However, there has not been a significant demand to wheel to these communities despite the sector's need for cheaper and cleaner electricity. There is little prospect of large-scale wheeling in this sector; therefore, this sector has been excluded from scenario modelling.	individual consumption is relatively low to attract wheelers at a large scale. Therefore, it is unlikely that this sector would be targeted for individual wheeling. Traders and aggregators may find it lucrative to wheel to multiple customers within this sector. Customers within this sector may also have set renewable energy targets, and wheeling external energy might be the only way to achieve them. Therefore, this sector (scale 1 tariff) has been included for scenario modelling.	This sector is the most likely to be targeted for wheeling electricity due to significant customer sizes. Further, companies within this category are progressively setting renewable energy goals, which may only be met through wheeling arrangements. This sector (ITOU tariff) has therefore been included for scenario modelling.

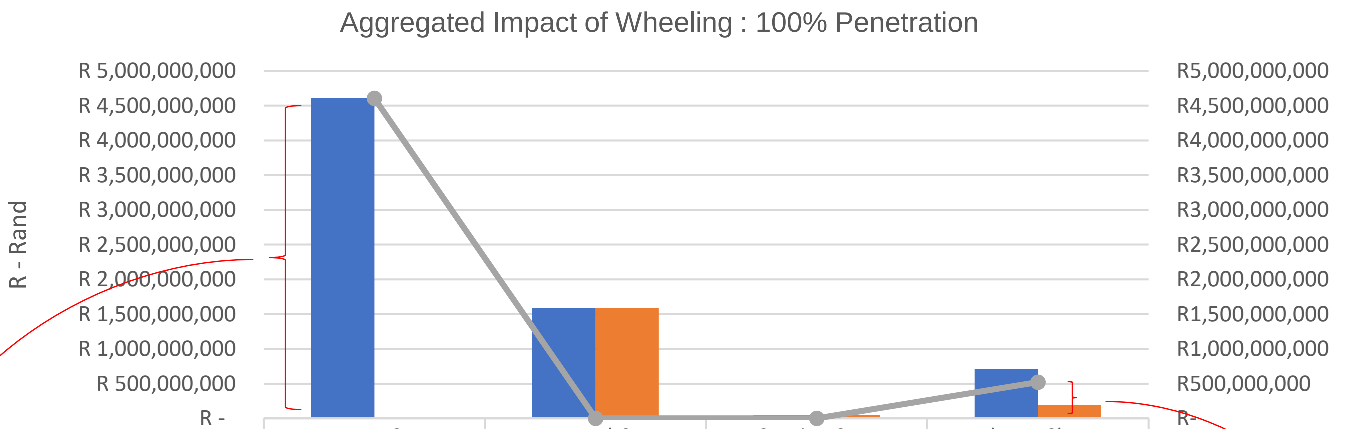
2.2 AGGREGATED CUSTOMER MODELLING

The municipality's loss will vary based on the scale of wheeling adoption, contingent on several circumstances. Therefore, the ITOU & Scale 1 customer base was modelled using four enumerated scenarios to provide higher and lower revenue loss thresholds based on predetermined wheeling penetration rates.

Note:
1. *Modelling assumed that all demand-related charges remain constant and only kWh are offset during wheeling.*
2. *Assumes that the ITOU tariff structure is cost-reflective*

Scenario 1:	**Industrial Time of Use Tariff**	**Extent of wheeling: 100%**

This scenario illustrates what would occur if all ITOU users' energy consumption was wheeled rather than purchased from the municipality.



	Energy Cost	Demand Cost	Service Cost	Voltage Charge
Without Wheeling	R 4,607,619,199	R 1,586,772,318	R 50,529,290	R 709,472,176
With Wheeling	R-	R1,586,772,318	R50,529,290	R189,059,287
Loss	R4,607,619,199	R-	R-	R520,412,890

Reduction in Energy Costs

With a 100% wheeling penetration, the energy procurement from Eskom is reduced. EThekwini does not mark-up energy rates for the recovery of network costs (ITOU only). Hence the reduction in costs will not affect the municipal revenue model.

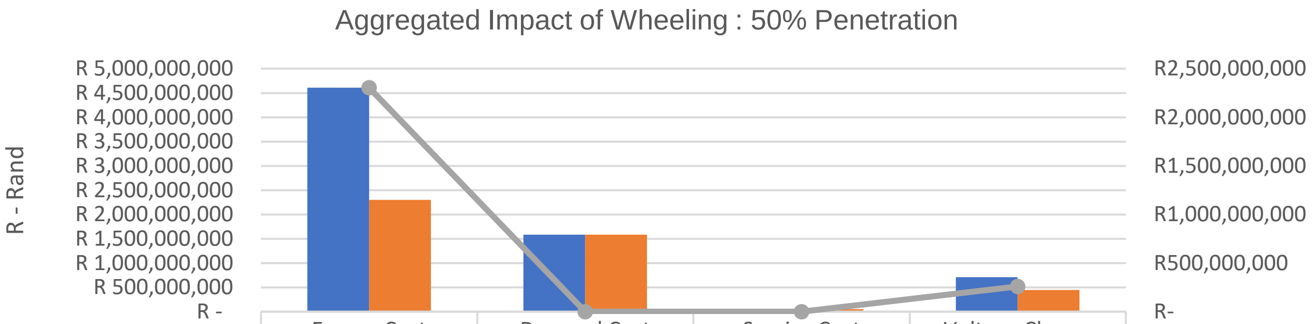
Reduction in Voltage Surcharge

The Voltage Surcharge is a tariff component that contributes to the network costs. The reduction of this cost directly impacts the municipality and will have an adverse impact on the ability to operate and maintain the grid.

Figure 8 Cumulative revenue impact at 100% wheeling penetration

Scenario 2:	Industrial Time of Use Tariff	Extent of wheeling: 50%

This scenario illustrates what would occur if half of all ITOU users' energy consumption was wheeled rather than purchased from the municipality.

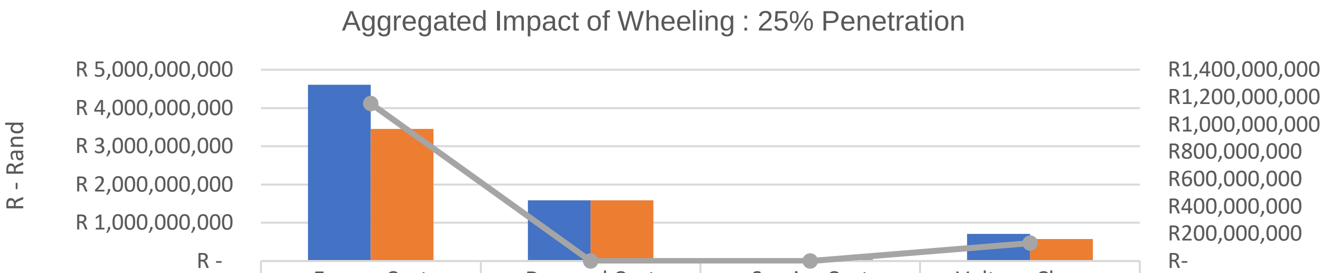


	Energy Cost	Demand Cost	Service Cost	Voltage Charge
Without Wheeling	R 4,607,619,199	R 1,586,772,318	R 50,529,290	R 709,472,176
With Wheeling	R2,303,809,600	R1,586,772,318	R50,529,290	R449,265,731
Loss	R2,303,809,600	R-	R-	R260,206,445

Figure 9 Cumulative revenue impact at 50% wheeling penetration

Scenario 3:	Industrial Time of Use Tariff	Extent of wheeling: 25%

This scenario illustrates what would occur if a quarter of all ITOU users' energy consumption was wheeled rather than purchased from the municipality.



	Energy Cost	Demand Cost	Service Cost	Voltage Charge
Without Wheeling	R 4,607,619,199	R 1,586,772,318	R 50,529,290	R 709,472,176
With Wheeling	R3,455,714,400	R1,586,772,318	R50,529,290	R579,368,954
Loss	R1,151,904,800	R-	R-	R130,103,222

Figure 10 Cumulative revenue impact at 25% wheeling penetration

In scenarios two and three, the characteristics of the financial losses remain. With a 50% penetration rate of wheeling, the municipality is subject to a shortfall of R 260 206 445, which will directly affect its ability to operate and maintain the grid. In scenario three, due to the reduced penetration of wheeling, the shortfall to the Municipality is R 130 103 222. This shortfall represents an under-recovery of network and related costs.

Scenario 4:	Business & General	Extent of wheeling: 25 / 50 / 75%

This scenario details the impact should wheeling occur within the Scale 1 tariff category.

Within the Scale 1 tariff, 96% of the network costs are recovered via the energy rate. The retail price per kWh for business customers is 205.62 c/kWh. On average, 100 c/kWh (49%) is attributed to network and services-related costs, while 105.62 c/kWh (51%) is attributed to direct energy costs.

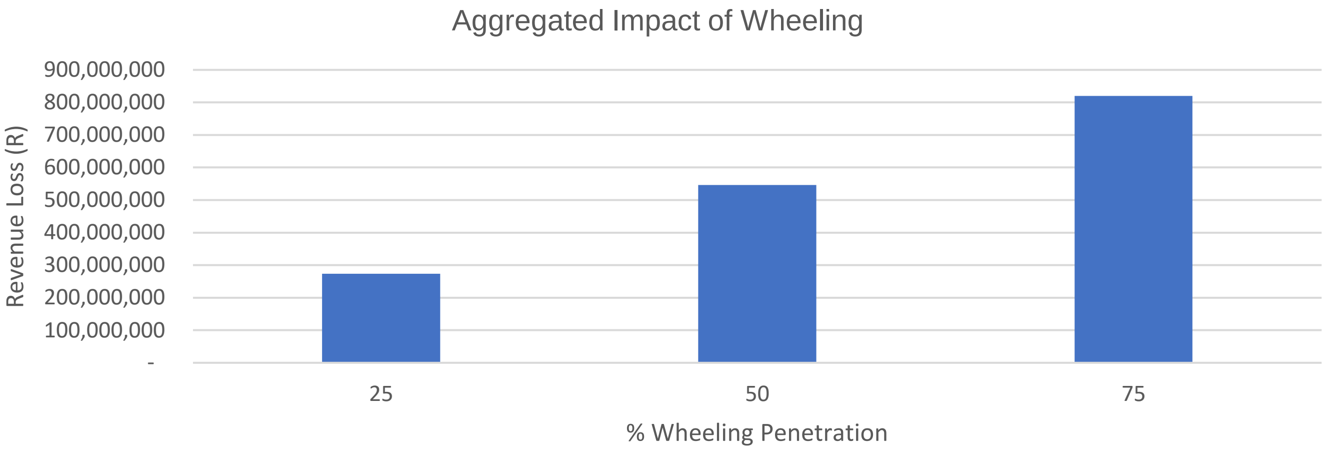


Figure 11 Cumulative revenue impact at varied rates of wheeling penetration

As the prevalence of wheeling increases, municipal revenue losses increase proportionally. While it seems unlikely that wheeling will penetrate this sector in the short term, the significant revenue losses indicate the difficulty of incorporating wheeling into the current tariff structures and revenue models.

2.3 INTERPRETATION OF THE LOSSES

The energy rates included in the ITOU tariff structure are based on the Eskom Megaflex. As a result, a decrease in energy sales will not affect the municipality, as the cost is passed through. Ultimately, Eskom will bear the brunt of the decreased energy sales. Nonetheless, the municipality continues to incur losses because some tariff components recover network-related charges based on the amount of energy sold.

The ITOU tariff structure recovers network-related charges via the tariff components as shown below:

Table 3: Tariff components that contribute to the recovery of network costs

No.	Network recovery tariff component	Method of charge	% Contribution to the recovery of total network costs
1	Network Access Charge (NAC)	kVA	69%
2	Network Demand Charge (NDC)	kVA	
3	Voltage Surcharge (VS)	% Levied on kWh & kVA	31%

The NAC and NDC are not dependent on the flow of energy and, therefore, are not affected when energy is wheeled across the network. However, the voltage surcharge depends on the quantity of electricity sold. Therefore, any attempt to reduce the amount of energy sold will reduce the revenue to the municipality. The UOS charge philosophy embedded in the wheeling literature assumes that the recovery of network charges is independent of energy flow. For many municipalities in South Africa, this is not the case. As a result, any attempt to wheel electricity across the network will attract a loss of network recovery charges to the municipality. Historically the tariff structure took advantage of high growth rates in energy to share network costs and drive down the overall cost of electricity. Customers on the ITOU tariff structure pay, on average, 191 c/kWh; this is 82 c/kWh above the Eskom Megaflex tariff. The total of the recovered charges helps fund the Unit's operations and contributes to the city. Due to cost pooling and the bundled nature of tariffs, the actual flow of the revenue verse costs is difficult to track. Structural cross recovery is not a flaw, and it was a strategic hold position in the move to cost-reflective tariffs to keep prices lower for the broader customer base.

3.0 PROPOSALS TO INCORPORATE WHEELING WITHIN ETHEKWINI

3.1 Option 1: Recover Network Charges Independent of Energy Usage

Option 1 is to shift the revenue recovery mechanism of network charges away from the voltage surcharge. Shifting the network charge recovery away from the voltage surcharge would make the network recovery costs independent of the amount of energy that flows within the network. Enabling such a shift means that an additional 31% of network costs must be collected through kVA charges rather than kWh charges. This shift would significantly increase customer demand charges and exceed the NERSA benchmarks. The increase per customer would be highly dependent on the load factor of operation. On average, an increase of 141% would be required in the NAC. The increased kVA amount would prevent the loss to municipalities and should not be interpreted as a wheeling charge.

3.1.1 The rationality of implementing option 1:

Implementing option 1 would result in high customer increases, as their kVA component would rise sharply, especially for low load factor customers. However, considering the high electricity costs experienced in South Africa, such a move may not gain popularity amongst customers or the National Energy Regulator of South Africa (NERSA) at this time.

3.2 Option 2: Municipalities remain agnostic to wheeling

Considering the cross recovery of network charges via energy rates, any form of wheeling will lead to an under-recovery. A simple yet effective means to avoid this scenario and implement wheeling speedily is to retain the voltage surcharge on the pre-wheeled consumption. The voltage surcharge varies per voltage, inherently by design, and the wheeling contribution will also vary based on the operational voltage. This variation will allow for a self-calculating mechanism to prevent municipal losses as wheelers are introduced into the network. However, wheeling will introduce many administrative processes that must be carefully managed via an automated billing system. Therefore, incorporating wheeling tariffs would require additional design, development, and maintenance of the billing system. As a result, it would be prudent to introduce a monthly administration charge to cater for this additional administration.

In essence, all energy wheeled will be quantified based on the energy value of the ITOU tariff structure, which is equivalent to the purchasing tariff. The quantified value will be decreased by the voltage surcharge percentage of the receiving party. Subsequently, the receiving party will be credited. Adopting this method will result in the municipality being revenue neutral to wheeling transactions.

3.2.1 The rationality of implementing option 2:

Considering the need for wheeling tariffs urgently, Option 2 aims to achieve a balance between introducing wheeling tariffs and maintaining the sustainability of the distribution grid. In this case, the wheeler helps the municipality preserve revenue neutrality by paying the wheeling tariff. However, the wheeler is not surcharged for their activity. Furthermore, with alternate generating technology producing electricity at rates considerably cheaper than Eskom, the opportunity to wheel electricity is likely still lucrative even while contributing to the loss in network charges.

3.2.2 A typical pricing approach based on principles of option 2:

Table 4: Wheeling tariff rates to maintain revenue neutrality

Based on 21/22 tariff rates

	Winter Season - Energy Wheeled (c/kWh)			Summer Season - Energy Wheeled (c/kWh)			All Seasons (R/pm)	All Seasons
Voltage	Peak	Standard	Off-Peak	Peak	Standard	Off-Peak	Admin Charge R	Annual Average 24 hrs (c/kWh)
0.4kV	92	30	17	32	23	15	5105	40
6.6kV	52	17	10	18	13	9	5105	23
11kV	43	14	8	15	11	7	5105	19
33kV	12	4	2	4	3	2	5105	5
132kV	9	3	2	3	2	2	5105	4

Note:

1. *The above rates only augment revenue loss due to how costs are recovered amongst tariff components.*
2. *The above rates do not lead to additional revenue but maintain the current status quo.*
3. *The above rates are not adjusted for the state of cost of supply/cost reflectiveness.*

A plausible wheeling framework based on revenue neutrality for eThekwini Municipality is highlighted in Table 4 above. The rates would be adjusted yearly following relevant tariff increases. Another dynamic area for the municipality is the percentages levied per voltage level. In an ideal case, this would depend on the cost of the supply study. The cost of supply study is highly dependent, among other things, on the loading of the network, maintenance, and growth factors. The tariff will be adjusted following NERSA-approved cost of supply studies. Unfortunately, as the sector changes, the wheeling costs will also change. Varying costs are the sector's reality under these circumstances. All parties must be able to share such volatility. Signing into long-term agreements without fully understanding and appreciating the costs is not in the municipality's best interest.

Option 2 could serve as a revenue-neutral transitionary wheeling framework for eThekwini Municipality until the actual cost of supply tariffs has been implemented. At such time, a new wheeling approach can be devised. The implementation of option 2 bears no advantage directly for the municipality. The municipality is only enabling transactions that allow other parties to engage in the sector. Notwithstanding the policy and regulatory requirements and the potential for overall economic benefits, there is no direct business case for the municipality to promote wheeling in its current form. [18]

3.3 Option 3: Municipalities participate in the wheeling arrangement to enhance revenue generation

A more innovative strategy would be to establish a mutually beneficial relationship around wheeling, which would contribute to a more substantial business case for the municipality. For example, a situation in which a wheeling entity could provide a scenario in which the wheeling of electricity would increase the municipality's revenue. This arrangement would be a "win" – "win" scenario that would encourage municipalities to implement wheeling as a diversified revenue stream instead of the conventional value-neutral virtual transaction.

3.3.1 The rationality of implementing option 3:

Due to the current state of the economy, municipal revenue models fail to meet their projections. No growth and rising input cost further hamper the revenue model's rationality. Municipalities will benefit from an opportunity to diversify revenue streams, and wheeling could serve as a pilot case. Electricity consumption has steadily decreased in eThekwini. As a result of a rapidly dwindling consumption base and a rising cost structure, the electricity price would escalate beyond inflationary expectations. A death spiral is a reality with rising electricity costs and continuous negative electricity growth.

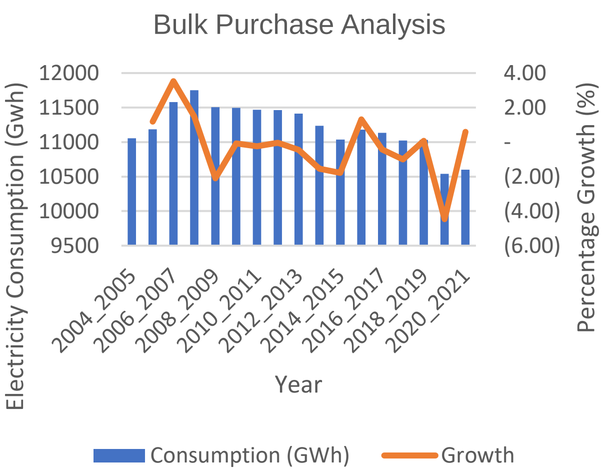


Figure 12 Bulk consumption analysis

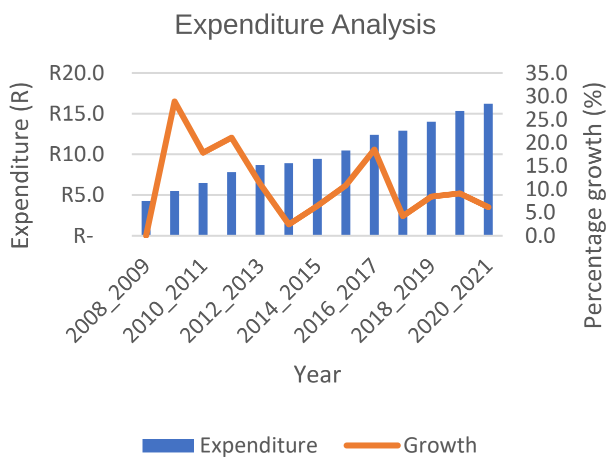


Figure 13 Expenditure analysis

4.0 MECHANICS OF THE WHEELING TRANSACTION

The mechanics of option two and option three are illustrated below. In addition, allowing Municipalities to provide a backup service to the wheeling transaction allows municipalities to enhance their revenue generation through the transaction.

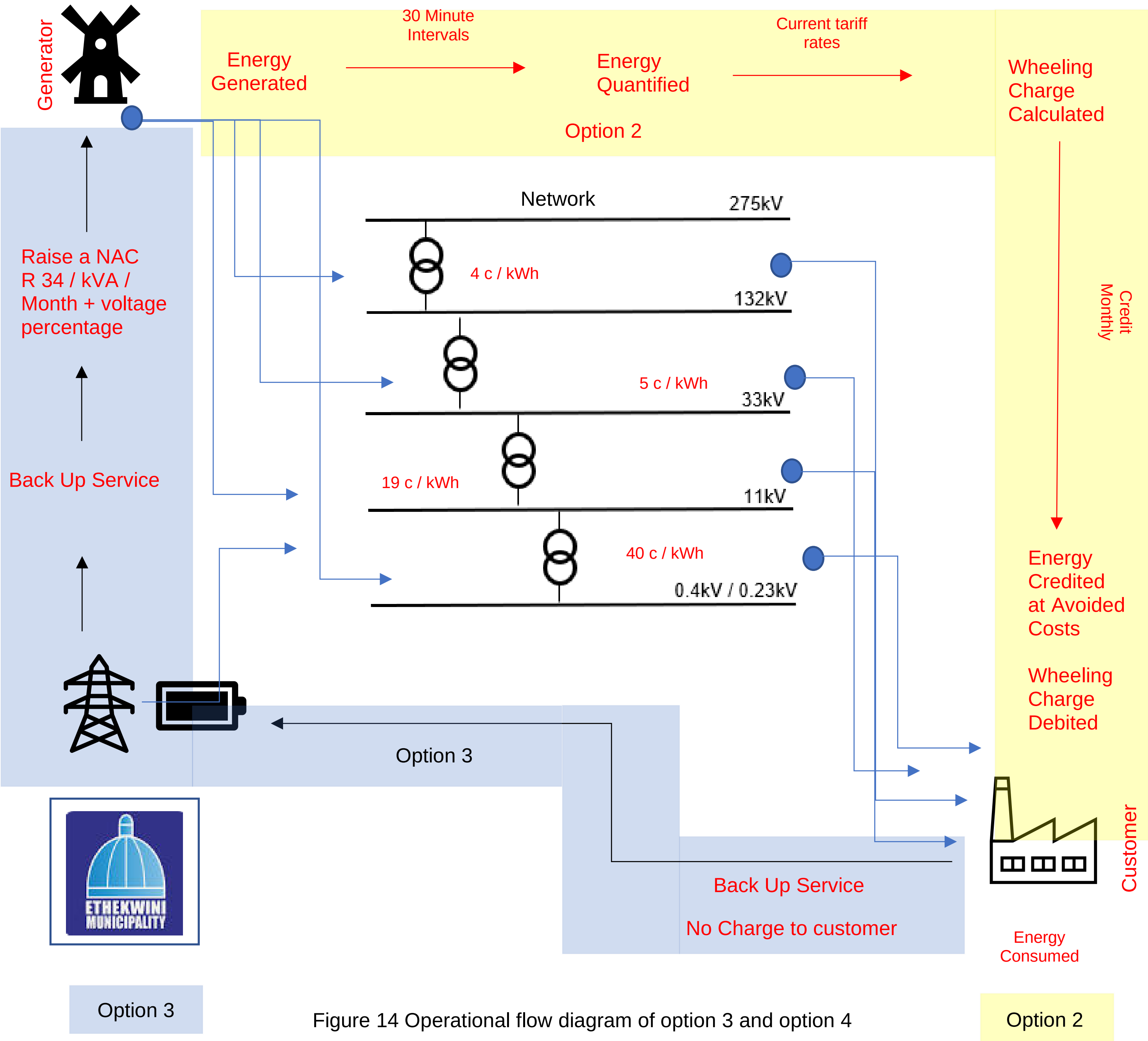


Figure 14 Operational flow diagram of option 3 and option 4

Localised renewable energy generators are variable since they are intermittent by nature. Failures and malfunctions are also a reality. Uncertainty exists as to who will provide backup functionality in the developing South African market; nevertheless, municipalities can provide this capability through their existing grids and contractual agreements with Eskom. Therefore, it would be prudent to contract with municipalities for this service. By contracting this service to municipalities, they can engage in the market for auxiliary services.

5.0 THE FUTURE OF WHEELING

The world has experienced restructuring in the energy supply industry (ESI). This restructuring's primary goal is to create competition in the electricity supply sector to improve service quality and efficiency [8]. Although many countries worldwide have engaged in some deregulation, the concept does not adhere to a standard model and is frequently viewed and executed based on each country's unique conditions and needs [19]. Therefore, some significant adjustments must be made in the municipal sector to meet the challenge and fully use the potential presented by the continuous deregulation. In addition, each party's rights and obligations must be clear in a competitive setting. As a result, municipalities will be encouraged to make better investments, enhancing system performance [6].

In South Africa, wheeling has been progressively liberated through the ongoing amendments to regulations, acts, and policy, primarily driven by the notion of creating a competitive generation sector. However, costs and unpinning tariff structures must be fully unbundled to appreciate and utilise wheeling fully. Such unbundling must be classified into energy costs, wires costs (network), and retail costs (commercial). Unfortunately, this is not the case in many distribution utilities within South Africa. Further, as wheeling gets more pronounced, the would be a need to control network congestion management, and a range of pricing methodologies apply, each with its pros and cons.

The rush to a competitive market must be balanced with the coordination of the market as the cost of incoordination is expensive and leads to inefficiencies [20]. As the country moves away from vertical integration, structured coordination falls away, which must be replaced by market coordination amongst the various role-players. Market coordination must be implemented through stringent policy and regulatory instruments, minimising misalignment of incentives and improving the market's overall efficiency. Market coordination is an iterative and challenging task. The integrative wheeling framework and current regulatory protocols are inadequate, leading to an uncoordinated approach to wheeling amongst municipalities.

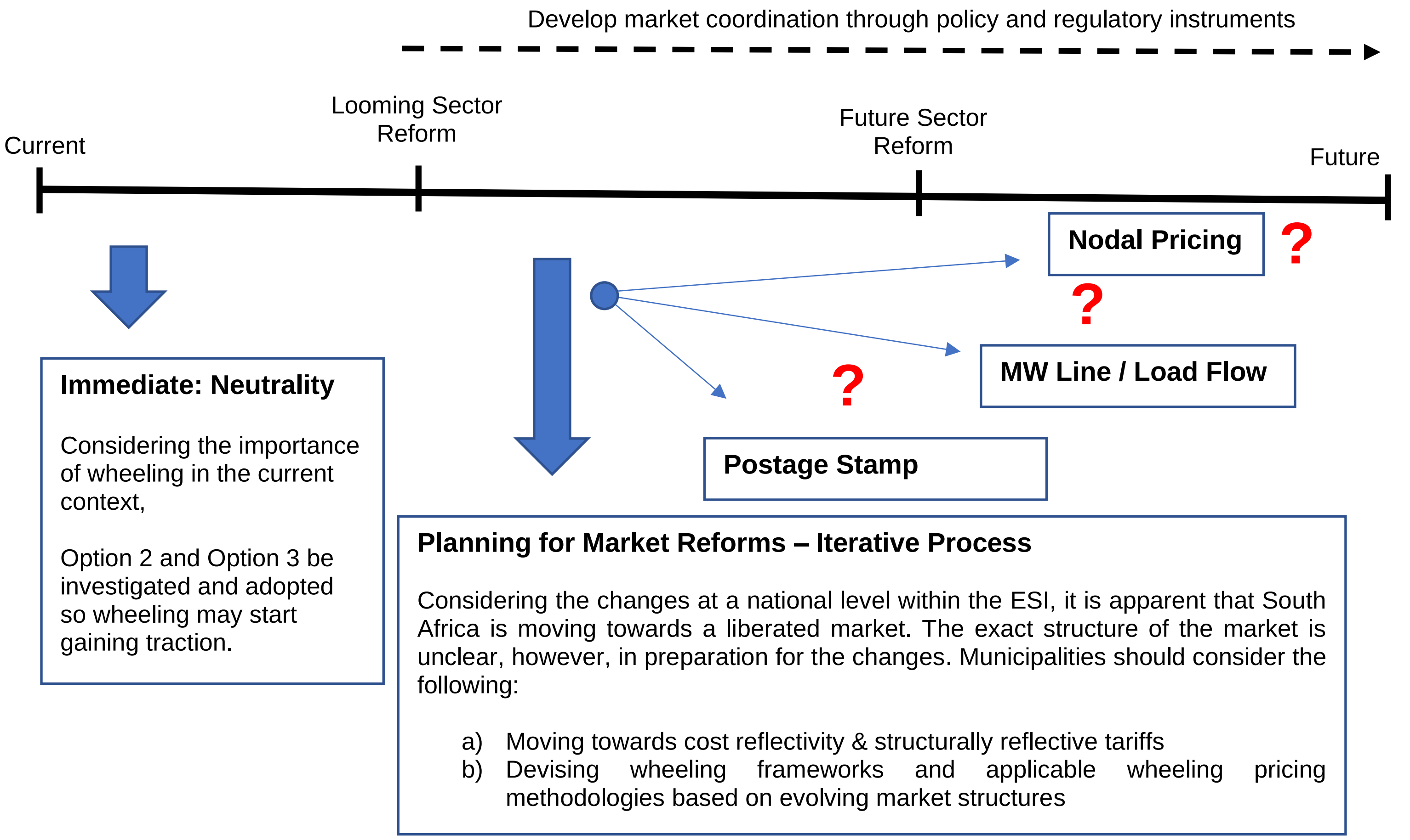


Figure 15 Probable roadmap to respond to wheeling as the sector reforms

6.0 CONCLUSION

Should wheeling be permitted under the current tariff structures, eThekwini Municipality will experience revenue shortfalls threatening its viability. Shortfalls in revenue are caused by the use of energy-related tariff components to recover non-energy-related revenue. Therefore, any attempt to reduce or eliminate energy sales will affect the bottom line.

The current framework that enables the concept of wheeling is incapable of harmonising and integrating wheeling within the existing operational spheres. This discord leads to circular arguments that frequently lack a conclusion. The significance of wheeling today cannot be denied, nor can the concept of wheeling. However, to reach amicable solutions, parties must find common ground and prioritise a discussion that strikes a balance between the wheeling entity's interests and the municipalities sustainability if wheeling is to gain traction in the near future. This type of discussion will contribute to the advancement of the industry as a whole.

Following the principles of a just energy transition, wheeling should neither be restricted nor ignored but instead incorporated to enable sector growth. However, transitioning from a monopolised structure to a liberalised market is neither simple nor instantaneous. Consequently, the revenue-neutral wheeling framework should be adopted immediately but adapted gradually over time as the market develops, ensuring that all parties acclimate to this process in a JUST manner.

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