Zambia Electricity Cost of Service Study

Final Summary Consolidated Report

Prepared for

Energy Regulation Board

supported by the African Development Bank

Submitted by

Energy Market and Regulatory Consultants Limited (part of the MRC Group)

Draft Final Report

21st December 2021

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Acronyms

Acronym	Description
AfDB	African Development Bank
AVG	Average
BCN	Basic Consumption Needs
CAPEX	Capital Expenditure
CRT	Cost Reflective Tariff
COSS	Cost Of Service Study
ERB	Energy Regulation Board
FX	Foreign Exchange
GDP	Gross Domestic Product
HH	Household
ICT	Information and Communication Technology
IPP	Independent Power Project
KPI	Key Performance Indicator
LCGEP	Least Cost Generation Expansion Plan
LV	Low Voltage
MD	Maximum Demand
MV	Medium Voltage
NEP 2019	National Energy Policy
OPEX	Operating Expenditure
PPA	Power Purchase Agreement
PR	Public Relations
PV	Photovoltaic
REA	Rural Electrification Authority
SAPP	Southern Africa Power Pool
USD	US Dollar
ZMW	Zambia Kwacha

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1 Introduction

This is the final report of the Cost of Service Study (CoSS) carried out in 2020 and 2021 by the EMRC Group for ERB supported by the AfDB.

The overall objectives of the CoSS are summarised in the Terms of Reference (TOR) of the CoSS as:

"The objective of the study is to provide a basis for setting consumer electricity tariffs for all customer categories to promote efficiency of electricity supply, and consumption, and to ensure financial viability of the electricity sector, while taking into account social and equity considerations in the pricing of electricity to poor households."

The TOR require that the objective be delivered through ten tasks initiated by an inception visit and report. A separate report was prepared for each of the subsequent nine tasks with three reports prepared for Task 4 as shown in Table 1 below.

Table 1: CoSS Tasks and Deliverables

Task No	Summary Title	No pages
2	Review of Structure and Conduct of the Power Sector including the Legal and Regulatory Framework –	111
3	Electricity Load Forecast	282
4	Least Cost Expansion Plan Generation.	145
4	Least Cost Expansion Transmission	121
4	Least Cost Expansion Distribution	69
5	Determination of Economic Cost of Supply and Structure and Levels of Tariffs	152
6	Life-Line Tariff Mechanism	36
7	Review of Financial Performance of LEC and Preparation of Projections	123
8	Transmission Wheeling Charges	42
9	ERB Tariff Determination Methodology	57
9a	Model (Excel Spreadsheet)	
10	Tariff Adjustment Roll-Out Strategies	64

This report summarises the key data sources, assumptions, analyses/methodologies and results of these eleven deliverables. This final report executive summary, the individual eleven task reports, eleven summary reports of the reporats lsited above, the tariff model and the financial model are provided as the "CoSS package". All tables and figures in the remainder of this executive summary are provided in full in the respective Task reports.

2 Task 2 – Sector Appraisal

2.1 Conclusions - Based on the review of the structure, performance, and legal and institutional framework of the power sector

1. Positive elements have been identified in the pre-2020 framework, which create pre-conditions for the development of an adequate and reliable electricity sector, well-aligned with the regional context. Historically, Zambia is on its way to develop a multiple domestic plant generation portfolio and multiple resource bases involving IPPs.
2. The NEP 2019 proposes a direction of reform which is likely to be compatible with the country's orientation and the SAPP system. The NEP 2019 supports the sector's ability to move positively towards cost reflective tariffs.
3. The new Energy Laws (Electricity Act 11, 2019 and the Energy Regulation Act 12, 2019) clarify the underlying concept of the energy sector reform and the power market reform strategy in Zambia.
4. The changes introduced through the two Acts sharpen the regulatory tools for tariff setting by expressly conferring sufficient authority to ERB and empowering it to enforce and monitor the sector through suitable second level regulations.
5. Currently the Rural Electrification Authority has power to set tariffs. As it is, it unnecessarily overlaps with what is rightly ERB's function. Furthermore, it is necessary to put the legal status of the ERB tariff guidelines beyond any doubt, on and off-grid, by issuing them as a regulation under the new Acts to give them the force of secondary law. The Rural Electrification Act is also under revision.

2.2 Recommendations relevant to tariff adjustment roll-out:

1. A key step is to eliminate any possible overlapping and conflicting roles. A solid and clear institutional design in the power sector is important for the determination and setting of tariffs, in particular between the Ministry of Energy and ERB, and between REA and ERB. The crucial step is to implement those necessary clarifications to mandates.
2. An ERB with arms-length separation from the Government is important. It is therefore desirable to ensure an autonomous ERB free from undue political and market influences, that can set parameters for contracts and monitor their implementation and have the discretion to respond to rapidly changing market conditions.
3. With respect to tariff regulation, there is need to establish a transparent and clear Cost Reflective Multi Year tariff regime, through an incentive-based approach. The transition from financial to economic based tariffs must be implemented as soon as possible, considering four pillars:
    - Tariff revenues should promote productive efficiency, through adequate incentives for the most electricity supply at least cost
    - At the same time, tariff revenues must allow financial sustainability of utilities in the long term
    - Price signals must promote allocative efficiency of final consumption, reflecting costs responsibility of the different tariff categories
    - Suitable automatic pass-through rules that automatically change final tariffs for cost items not manageable by ZESCO and other regulated companies (fuel costs, PPA prices, local inflation, exchange rate).

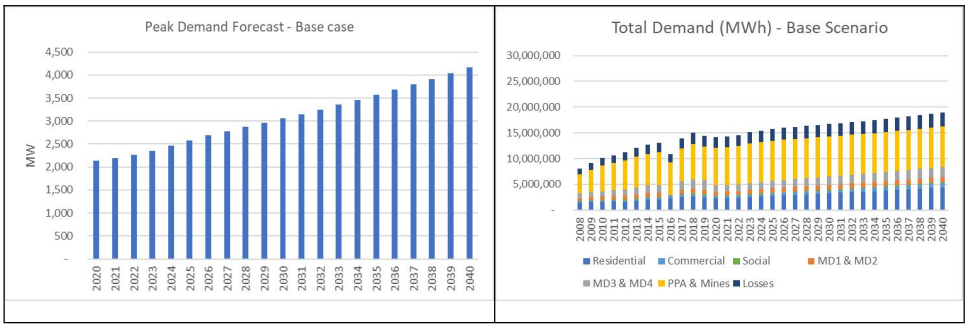
3 Task 3 – Electricity Load Forecast

With the growth in Zambia's GDP, the demand for electricity is expected to increase. Task 3 forecast the demand for electricity (peak demand and energy consumption) in Zambia which is a key input needed for the COSS and in particular the system expansion plan. Peak demand forecasting is particularly important for the determination of the required generation and transmission system capacities that will be required to guarantee security of supply in the future, considering the necessary security margin above system maximum load.

The electricity consumption and peak demand in Zambia were forecasted for the period of 2020–2040 using linear regression modelling for the residential, commercial, social, MD1/2, and MD3/4, a linear regression with GDP for the peak demand and a deterministic methodology for the Mining/PPA customers.

Three levels of growth were presented: low growth, base case and high growth and the resulting results for both capacity and energy demand for each customer category were determined and used in the proceeding analyses for the system expansion and economic tariff determination.

The resulting forecasts for the base case projection for peak demand and energy concumption are shown in the following figures:



4 Task 4 – System Development Programme

4.1 Generation

The Least Cost Generation Expansion Plan (LCGEP) indicates that 4,418 MW are required to be integrated to the system (USD 9,078 Million) to comply with security supply criteria in the most efficient way. The Least Cost Long-Term Generation Expansion Plan for 2020 - 2040 comprises 3,538 MW of hydro power capacity, 720 MW of PV capacity and 280 MW of wind capacity.

4.2 Transmission

During the next two decades it is expected that Zambia security of supply problems will predominantly be related to peak demand problems. To serve all demand during peak hours a reliable transmission system will be required. With decreasing load factor (i.e. higher peak demand) the stress on the national transmission system will increase. Therefore, for planning purposes, it is crucial to guarantee that transmission network can serve peak demand by 2040 (last year of the study horizon when maximum demand is achieved).

Detailed load flow studies were carried out (using load flow software) to guarantee the long – term reliability of the transmission network during the study period (2020 – 2040), identifying network constraints and suitable mitigation measures.

After concluding the load studies a detailed expansion and investment plan was defined. The proposed investment plan takes into consideration the ZESCO transmission plan with planned investments up to 2030.

4.3 Distribution

During the next two decades it is expected that Zambia electricity demand growth will come mainly from higher domestic and commercial consumption. These types of customers present a low load factor (i.e., high peak load) and consequently system peak demand will increase at a higher rate than energy consumption. Currently, more than 50% of Zambia electricity demand comes from the mining sector and most of the loads are connected directly to the transmission network. The share increase of low voltage and medium voltage consumption will lead to increased stress on the distribution network serving them. Therefore, ZESCO needs to invest sufficient CAPEX to guarantee that the distribution system can serve increasing peak load that will come from LV and MV levels in a reliable and safe manner.

ZESCO CAPEX requirements for 2020 – 2040 have been estimated using a Parametric CAPEX Model (PCM). The PCM includes three different types of investments: Expansion CAPEX to meet increasing demand and number of customers, renewal CAPEX and ICT investments devoted to enhancing ZESCO operations. The modelling determines the type and value of investments per year over the planning period to 2040.

The proposed CAPEX schedule has three distinct development phases: 1) 2020-2021: contained levels of investment due to stagnation or moderate demand growth; 2) 2022-2023: rapid CAPEX growth to cope with accelerated demand growth after a period of low demand and low CAPEX and 3) 2024-2039: stabilization and sustained growth.

These results were key inputs to the COSS analysis and in particular to the modelling of tariffs by customer category in Task 5 and the modelling of the financial performance of ZESCO in Task 7.

4.4 Summary of Least Cost Expansion

Least Cost Expansion Plan

The total CapEx costs to support the growth in demand is estimated at US$14.03 billion.

Details	Estimated cost in US$ millions
Generation projects (inclusive of refurbishments to existing plants)	9,446
Transmission projects (inclusive of network reinforcements)	2,663
Distribution projects	1,921
Total	**14,030**

- The **generation projects** in the Least cost expansion plan were selected from candidate projects obtained from DoE, OPPPI, IDC and ZESCO and went through a **dynamic optimisation process to arrive at a least cost**
- The transmission expansion plans will comprise new lines for **power evacuation** from new generation plans, network **reinforcements** and construction of **regional interconnectors**
- The **distribution expansion** plan and its associated CapEx is estimated on the basis of **projected demand growth**

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5 Task 5 – Economic Cost of Supply, and Structure and Levels of Tariffs

The task develops a proposal for cost-reflective tariffs for each customer category and these are tabulated in detail and compared with the current tariff charges (ERB 2020) in USD 2019 and ZMW 2019.

Major findings and interpretation

ZESCO	Customer Tariffs				
2020 CRT US$c9.04/kWh Revenue requirement US$1.23 billion	Special customers	Average PPA and other mining reduce	Residential increase significantly:	Social and commercial increase significantly	MD and other PPA customer reduce
2025 CRT US$c10.44 Revenue requirement US$1.39 billion	range from US$c6.9/kWh to US$c 5.12/kWh.	US$c8.83 to US$c6.32/kWh	by up to 145%	by up to 80%.	up to 30%

17% increase
With legacy debt the rise is 38% (US$c12.41)

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It is important to point out that our tariff proposal recognises that most of the revenue is demand/capacity driven. Capacity driven revenues are recovered via demand charges. Therefore, our demand driven charges for maximum demand customers are higher than ERB current tariffs. The difference between ERB and EMRC demand charges is considerable mainly in the peak ToU charges. Higher peak demand charges in relative terms aim to give the adequate price signals to MD customers to incentivise peak shaving and capacity optimization.

The counterpart of higher demand charges is lower energy charges for MD customers. Since most of revenues are recovered via demand charges, EMRC energy charges for all ToU customers are below current tariffs levels. Moreover, energy charges are more equalized between time blocks than demand charges. This is because energy driven costs are barely affected by the hour of consumption while demand costs are heavily driven by the capacity demand at system peak hours.

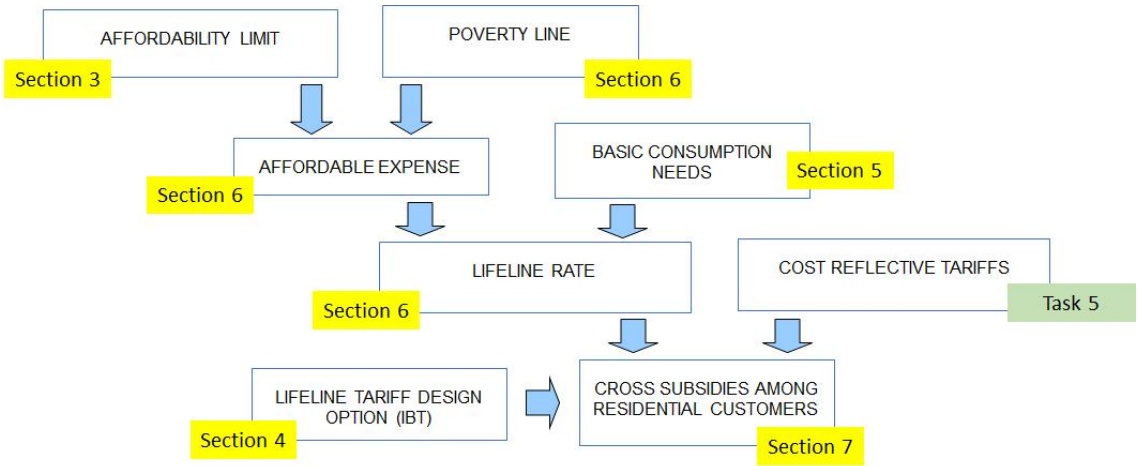
On average, for the whole system, the final tariff proposal includes a tariff increase of 14.2% with respect to current 2020 tariffs as shown in Table 2 below.

Table 2 - Final Tariff Proposal vs current ERB tariffs

	Total Average Tariff (US Cent/kWh)
Cross Reflective Tariff (CRT)	10.20
Current tariffs (ERB 2020)	8.93
Variance (CRT - ERB 2020)	1.27
% Variance (CRT - ERB 2020)	14.2%

6 Task 6 – Life-Line Tariff

The following diagram represents the general approach for Task 6 and how it is addressed in the Task 6 report:



Our analysis based on the Living Conditions Monitoring Survey of the Zambia Statistical Agency shows that 54% of the households in the country are not able to afford the Basic Consumption Needs (BCN) of 50 kWh/HH/month, under the current tariff rate and under a cost reflective one.

A lifeline tariff for households that consume less than 50 kWh would adequately address the basic energy necessities of poor households in Zambia and lead to an improvement in the standard of living.

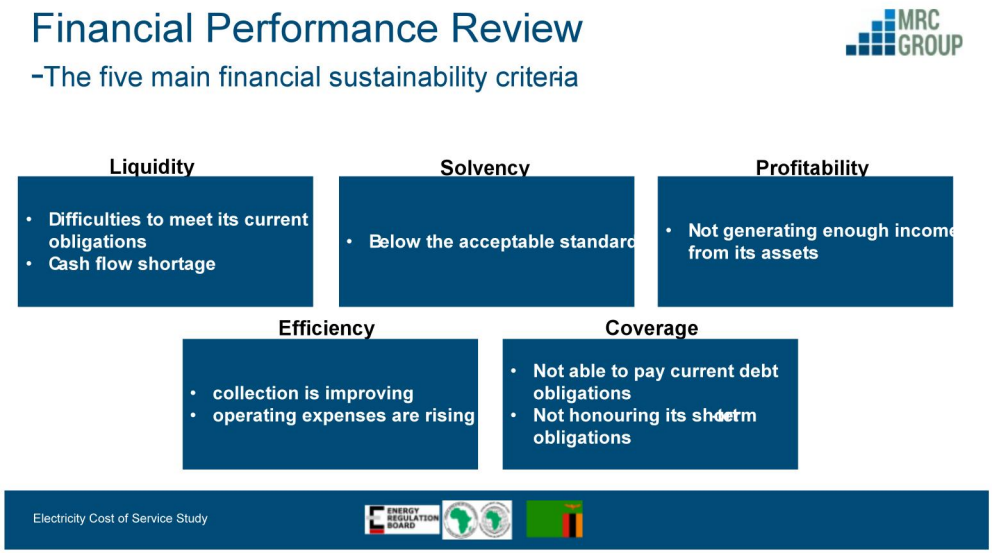
A lifeline tariff of 0.57 ZMW/kWh would allow customers under the poverty line to reasonably afford to pay for electricity and we therefore propose such a lifeline tariff for the lower consumption block below 50 kWh/month under the increasing blocks regime (IBT) already in place.

The analysis has demonstrated the impact on other tariffs and provided an indication of the order of magnitude of increases in the highest consumption block of the Residential tariff (above 300 kWh/month) if the cross subsidy is to be recovered through over charges on this sub-group of customers, asuming the subsidy is not recovered from customers in the mid block (100-300kWh).

On the basis of the NEP 2019 and the new ERB Act, a lifeline tariff can be introduced by an appropriate regulation.

7 Task 7 – Financial Performance of ZESCO and Other Companies in the Sector

7.1 Review of Historical Financial Performance of ZESCO



The financial performance of ZESCO was assessed through a set of financial indicators, considering five main financial sustainability criteria: liquidity, solvency, profitability, coverage and efficiency. We also included an operational analysis, taking into account the recent tariff evolution.

The overriding conclusion was that ZESCO has not been performing well financially and that to improve its financial indicators it needs to improve its efficiency and increase its revenue by having a cost-reflective tariff. To improve its efficiency ZESCO will need to look at reducing its cost of sales and administration expenses, which are mainly staff costs. We also provided reasonable glidepaths for improvements which are typically 5 years

7.2 Financial Projections of ZESCO.

The financial analysis of ZESCO is the representation of the outputs of tasks 3 (load forecast), 4 (development programme), and 5 (economic cost of supply) as financial transactions in the accounts of ZESCO. The analysis translates the principal outputs of the investment programme and future revenues as targets to be achieved over time.

The outputs of earlier deliverables are considered ideal outcomes with optimum efficiency whereas, in reality, such efficiency levels are considered unrealistic in the short term and a glidepath to efficiency is to be expected.

The financial analysis produces projected financial statements on an annual basis for 20 years. Results show ZESCO returning to profitability and also demonstrate the financing requirements over the period.

7.3 Financial Performance of Other Companies in the Sector

Financial Overview of the other Electricity Companies in Zambia

1. CEC:	- Strong balance sheet - KPIs good - Operational efficiency is key
2. KNBE:	- 2016 to 2019 income doubled (208 million ZMW to 475 million ZMW) - Profitability is negative and below acceptable levels
3. NDOLA:	- Strong balance sheet and capital structure - Good financial health: based on current debt assets ratio and DSCR
4. Lunsemfwa	- Improving financial performance & steady improvement in the absolute net profit - Strong balance sheet
5. Itezhi Tezhi	- Profitable since 2015 (except 2019) - Significant increase in administrative costs and uncontrolled increase in 3rd party receivables.
6. Maamba Collieries:	- Substantial improvements in net worth over the last three years - Ratios: Of concern to lenders
7. NWEC	- Sustained improvement: Acceptable and solid profitability and liquidity - Working capital increase sustainably, should be monitored

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8 Task 8 – Transmission and Wheeling Charges

Key findings and conclusions

Recommended Postage Stamp Method

- **Zambian system is being centrally planned and locational problems are not critical**
- In the medium term with the perspective of locational signals postage stamp can be complemented applying deep connection costs to new connections
- Compatible with the current point-to-point concept recognizing national borders as the points of entry and exit (MW.km).
- **Transmission system planned developments by ZESCO can be covered through the proposed postage stamp methodology.** For private initiatives of agents >> separate wheeling charges computation can be carried out under a "beneficiary pays" principle

Total Wheeling Costs (MUSD)

	2021	2022	2023	2024	2025
Trans. Network	190.5	254.7	262.7	265.1	353.1
Anc. Services	53.0	52.7	52.7	52.5	53.2
TOTAL Cost	243.5	307.4	315.4	317.7	406.3

Wheeling Charges – HV Extraction (USD mils./kWh)

Time Block	2021	2022	2023	2024	2025
Peak	71.0	88.1	87.2	86.2	108.0
STD	8.9	11.0	10.9	10.8	13.5
Off	3.9	4.8	4.7	4.7	5.9
Average	18.7	23.3	23.0	22.8	28.5

- The future Entry-Exit approach being tested since 2016 will require the identification of the nodes and lines of the said Horizontal Network inside Zambia and apply the future SAPP tariff methodology to this Zambian horizontal regional network, consistently with the internal wheeling methodology

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This Task set out the criteria and methodologies for transmission tariffs setting, and their pros and cons. The process comprises firstly the establishment of the revenue requirements of the transmission network, followed by the allocation of those requirements amongst users of the network: both suppliers and users of power.

9 Task 9 – Tariff Adjustment Methodology

Based on the assessment of the current tariff adjustment methodology in Zambia and its comparison with international experience, we have elaborated a recommended approach for tariff setting in the Zambian power system.

9.1 From Financial Cost Based Tariffs to an Incentive Based Regime

The current tariff setting scenario in Zambia is that ERB does not fully follow a Cost Plus approach. It does scrutinize ZESCO costs, but it does not reflect the total exploitation costs in the electricity tariffs it approves, and consequently ZESCO has not achieved financial sustainability. Furthermore, the financial approach for tariff setting in recent years has not been able to follow the evolution of operational costs, with consequent negative financial consequences. As a result, ZESCO is today in financial stress.

In parallel, there is a recognized need to transit from this pure Financial Approach to a Cost Reflective Economic approach on an Incentive Based Regime. This economic approach will require an estimation of the efficient cost of service for each tariff category, which will be reflected in the tariff structure, and with average tariff levels set to guarantee long term financial sustainability of ZESCO.

However, for an initial transitional period, it is necessary to consolidate ZESCO financial situation before shifting towards an Incentive Based Regime (IBR). The analysis carried out in Task 2 and Task 7 reports reflect that ZESCO is not covering its costs with the current tariff levels, which is leading the utility to a gradually worsening financial situation. This issue requires a time-limited and focused action on ZESCO actual cost structures and a transition glide path on electricity tariffs.

9.2 Multi-year Tariffs

The implementation of an Incentive Based Regime is based on multi-year tariffs over a predefined period, of 5 years.

At the end of each tariff period, major tariff reviews are carried out under the guidance of the regulator (ERB) to establish the rules and tariffs for the next period. During each tariff period, automatic adjustments are implemented to update tariff charges as a result of changes to non-manageable factors: inflation, exchange rate, hydrology (fuel expenses), etc.

9.3 Productive Efficiency and Cost Reflectivity

The pure financial approach applied for ZESCO tariff reviews, does not include specific efficiency incentives for ZESCO (included in revenue computation or through penalties).

Allocative Efficiency, usually referred as Cost Reflectivity, requires the identification of clear responsibility factors for allocating allowed revenues among the different tariff categories with forward looking criteria. With respect to this, in the specific case of ERB, efficient cost allocation will require:

- The tariff structure to reflect the cost responsibility of the different tariff categories, in particular differentiating tariff charges per voltage level.
- Tariff charges for the different categories to reflect responsibility factors of each tariff category derived from typical load profile estimations, that shall be ruled and mandated by ERB based on international best practice.

9.4 Tariff Model

The Excel spreadsheet used to analyse tariffs for Tasks 5, 6, 8 and 10 is presented as part of this deliverable.

10 Task 10 – Roll-Out Strategies

10.1 Pass-Through and Automatic Adjustment

Currently, there is lack of a transparent pass-through mechanism that automatically reflects changes in cost items that are not manageable by ZESCO (hydrology and fuel costs, PPA prices, local inflation, exchange rate). For all those elements that are beyond the control of ZESCO, an adjustment or pass-through formula is needed.

This aspect is currently being addressed by ERB that is developing a Multi-Year Tariff framework that would include pass-through mechanisms. In task 10 of the COSS we make specific proposals based on our experience.

10.2 Roll-Out Plan

In this deliverable we present analyses to bring tariffs to cost reflective levels through a roll out plan that details the specific tariff changes required in each year of the plan. The following criteria have been applied in developing the plan:

i. A re-alignment of current tariffs to take into account inflation since the December 2019 tariff increase that established the current tariffs

ii. The selection of the number of years required – the glide path – to reach cost reflective tariffs is dependent on the revenue gap with respect to cost reflective that GRZ have to fund. The longer the glide path, the smoother impact on customers, but the higher revenue gap to fund. by GRZ.

iii. A period of 5 years is considered to be a minimum for achieving cost-reflectivity given the significant tariff changes that are required. Given the high tariff increases required for some customers, particularly the domestic customers (residential, social, commercial and MD1) customers, we also consider a longer period of eight years.

iv. The impact of the introduction of the lifeline tariff proposed in Task 6 is considered separately.

v. The rebalancing of the energy and capacity charges for MD customers is also considered separately.

vi. We also include an analysis of the ZESCO legacy debt and analysis of how this could be addressed directly through tariff adjustments.

vii. Tariff changes are to be adjusted where possible to be as equal year on year as possible to minimise tariff shock for customers.

viii. Front load the tariff changes starting with 70% adjustment of the CRT gap determined by EMRC in 2022 and the rest spread over 2023, 2024, 2025 and 2026

10.3 Roll-Out Communication Plan

One of the Government's principal objectives in establishing cost reflective tariffs is to enable the sector to tap into private sector resources by ensuring that it recovers its costs from customers.

There are also significant consequences for a failure to implement cost-reflective tariffs, with the risk that the debt burden of ZESCO will continue to grow.

Good communications and good Public Relations (PR) are therefore critical to the success of this project.

The objectives of the PR campaign are as follows:

- To make the tariff rises acceptable and desirable to all target audiences;
- To communicate that the COSS process is striking a balance between social and commercial objectives;
- To create a strategy that is consistent and cohesive with the plans of the public relations teams of both ZESCO and ERB.

Target audiences include: General public, Industrial and commercial customers, the mines, media, ZESCO employees and Government /public sector entities.

A detailed programme will need to be developed jointly by the communications teams of ZESCO, ERB and the Ministry. The plan will need to take into account any decision on the actual tariff adjustment timing proposed by ERB. It will need to set realistic time targets for:

- Formation of a communications team and secretariat
- A kick-off workshop
- Preparation of materials – targetted flyers, fact sheets, case studies, press releases, training materials,
- Development of a structured plan to roll-out the communications to the various stakeholders as defined above.

11 Conclusions

1. The roll-out plan described in this report draws on the results of the previous tasks of the COSS and in particular the economic tariffs derived under Task 5 and the Lifeline Tariff arrangements designed under Task 6.
2. The Roll-Out Plan proposes two glide path periods of 5 years and 8 years respectively and provides detailed tariff paths for each. It also considers a front-loaded 5-year glide path in which tariffs are increased towards the cost reflective level by 70% in the first year with the remaining 30% spread over the remaining 4 years.
3. tariffs to special customers will see a significant drop in capacity and energy charges.
4. Maximum demand category requires signifcant rebalancing between demand and energy tariffs
5. The roll-out plan also details the revenues that ZESCO can expect from the roll out showing how the delay in achieving cost-reflectivity delays ZESCO recovering its full cost of service after the glide-path period. For the various roll-out options the analysis details the gap between the revenue required and the projected income. Government, ERB and ZESCO will need to develop a clear plan for the financing of this gap in addition to resolving the existing legacy debt. Options may include direct Government funding, international development assistance, additional commercial borrowing, or even a form of asset-value realization through selling a share of part of the generation assets. A further option is increasing tariffs beyond the nominal CRT level in order to recover the accumulated shortfall in revenue.
6. For larger maximum demand customers (MD2, MD3 and MD4) cost reflective tariffs can be reached in two years with relatively modest tariff increases.
7. The life-line introduces extra increase in R3 that bears the burden

8. Significant tariff increases are required to reach cost reflectivity even without the recovery of legacy debt so a conclusion of this analysis is that sources other than the future customers of ZESCO should be considered to fund the repayment of legacy debts.