REGULATED INDUSTRIES COMMISSION

Incentive Mechanisms for Managing Transmission & Distribution Losses

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Consultative Document

Table of Contents

Background

The Regulated Industries Commission (RIC), under Sections 47 and 48 of the Regulated Industries Commission Act No. 26, 1998, is responsible for setting maximum prices and/or principles for determining rates and charges every five years for service providers and services specified in Schedule 1 and 2 of the RIC Act. Accordingly, the Final Determination: Regulation of Electricity Transmission and Distribution 2006 – 2011 (**the Determination**), which was published in 2006, prescribed the rates and miscellaneous charges for the services provided by the Trinidad and Tobago Electricity Commission (T&TEC).

T&TEC, as the sole Service Provider (SP) in the Electricity Transmission and Distribution Sector, is not subject to competitive pressure to maintain or improve its service quality. Therefore, in setting the tariffs and/or principles for determining T&TEC's rates and charges, the RIC paid regard to a broad range of matters, including the criteria set out in Sections 6, and 67 of the RIC Act. These Sections emphasize the adoption of incentive/price cap regulation which allows for the provision of incentives to improve the efficiency of the SP's operations, which should result in better customer service especially in the absence of competition in the industry.

One of the ways of ensuring efficiency and reducing costs is for the SP to reduce the total system losses occurring on its network. The RIC incentivized this aspect by allowing T&TEC to be rewarded based on the efficient management of the level of losses on its network.

Purpose of Report

The objectives of this document are to:

- Review the rationale for the inclusion of an incentive mechanism for the management of total system losses in the first regulatory control period;
- Assess T&TEC's management of the total system losses and its fulfillment of the conditions established by the RIC in the first regulatory control period; and
- Propose recommendations for the improving the management of the total system losses for the second regulatory period.

Responding to this Document

All persons are invited to submit their comments on this document. Responses should be sent by post, fax or e-mail **February 28, 2018** to:

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All responses will normally be published on the RIC's website unless there are good reasons why they must remain confidential. Any requests for confidentiality must be indicated. A copy of this document is available from the RIC's website at **www.ric.org.tt.**

Introduction

One of the responsibilities of the RIC is to ensure that the service provider operates efficiently and that services are reliable, and as far as is practicable, provided at the lowest possible cost. Consequently, as part of the Determination, measures were instituted to incentivize T&TEC to manage the level of losses on its Transmission and Distribution network.

Ultimately, consumers pay for energy losses throughout the network via tariffs. Some of the losses can be reduced (but never completely eliminated) by utilizing suitable techniques and equipment. Other elements of the losses are avoidable and can be eliminated or minimized through accurate measurement of electricity consumption and good management of the network. Losses are generally divided into technical and non-technical losses.

Technical losses arise due to physical characteristics of the network, and are dependent on the energy flowing through the system, the materials used to construct transmission lines and transformers, and the way the network is configured and operated. Non-technical losses, at times called commercial losses, arise when energy is delivered to customers but no revenue is collected by the utility for the delivered energy. These losses are usually as a result of measurement errors, recording errors, and theft. **Table 1** below explains in detail how some of the contributing factors affect the total system losses.

Table 1. Contributing Factors affecting Total System Losses

Contributing Factor	Underlying Cause
Technical Losses • Resistive and Impedance Losses	The materials typically used in the construction of electrical conductors such as copper and aluminum have values of resistance, inductance and capacitance. As current flows through the conductor there is unavoidable heating and loss of energy due to resistance. Likewise, reactive power is also consumed and lost by the inductive and capacitive components of the materials.

Contributing Factor	Underlying Cause
• Power factor	The ratio of real power (transmitted to the load) to apparent power is the power factor. As reactive current increases, the reactive power increases and the power factor decreases. For systems with low power factors, losses are higher than for systems with high power factors.
• Transmission and Distribution line losses	The degree of dispersion of customers and the proportion of different types of customers across the network can uniquely affect the losses. Transmitting electricity to customers located further away from generating sources and at lower voltage levels increases the system losses.
• Transformers	Resistance and impedance losses are characteristic of transformers. However, improved designs and materials can reduce these losses.
• Impact of load profile differences	The load profile of electricity usage is important to the efficiency and reliability of power transmission. The factory specification of power transformers for the optimization of load losses versus no-load losses is dependent directly on the characteristics of the load profile that the transformer is expected to be subjected to during normal operations. Therefore, differences from the optimal load profile would result in greater losses.
• Meters	Meters consume small amounts of power whether or not there is any consumption to record.
• Metering Accuracy	Older analog/mechanical/manual metering systems typically develop a greater magnitude of errors than the newer digital/automated systems in use today. Typically, these errors usually result in readings that are lower measurements of the energy actually consumed by the customer.

Contributing Factor	Underlying Cause
• Lack of Embedded generation	Embedded generators are credited with supplying electricity closer to the locations of actual consumption. Their location results in lower transmission losses than the losses incurred in transporting electricity from traditional generators, which are usually located far away from the majority of end users.
Non-technical (Commercial) Losses	
• Meter reading/recording errors	Meters were traditionally read by personnel and the readings then passed to a billing department. Errors could occur either in the meter reading exercise or in the transcription of readings.[1]
• Unmetered supplies	Traditionally, utilities provided their facilities with unmetered supplies, thereby, not properly accounting for the energy used at these facilities. However, in recent times utilities are being required by regulators to measure and bill their energy consumption.
• Theft	Meters are sometimes tampered with by customers to report incorrectly or illegal unmetered connections are made to utility lines.

Impact of System Losses

Reduction in system losses is generally expected to have positive economic and environmental impacts. An improvement means that less electricity will have to be generated in supplying customers, thereby lowering the amount of natural gas consumed and the amount of greenhouse gases produced. In 2014, total system losses globally ranged from 73% for Togo to 2% for

[1] T&TEC has a small number of meters that are read manually that are subject to reading/recording errors.

Singapore[2]. By comparison, the total system losses for Trinidad and Tobago in 2014 was 6.9% of output[3]. Table 2 shows the figures for systems losses for selected countries for the years 2000 and 2014. T&TEC's system losses for those years were 7.9% and 6.9% respectively.

Table 2. Transmission and Distribution Losses in Selected Countries

Country	% Losses		Country	% Losses	
	2000	2014		2000	2014
Finland	3.7	4	Sweden	9.1	5
Netherlands	4.2	5	Australia	9.1	5
Belgium	4.8	5	U.K.	9.4	8
Germany	5.1	4	Portugal	9.4	10
Italy	7	7	Norway	9.8	6
Denmark	7.1	6	Ireland	9.9	8
USA	7.1	6	Canada	9.9	9
Switzerland	7.4	7	Botswana	10	11
France	7.8	6	Spain	10.6	10
Austria	7.8	5	New Zealand	11.5	7
Trinidad and Tobago	**7.9**	**6.9**	Jamaica	18.8	27

Sources: Incentive Mechanisms for Managing Transmission and Distribution Losses (RIC 2005), The World Bank Group, Electric Power Transmission and Distribution Losses (IEA Statistics 2014), and T&TEC's Annual Performance Indicator Report For The Year 2014 (RIC 2017).

[2] **Source: www.worldbank.org which compiled data from the IEA Statistics database**
[3] **Source: T&TEC's Annual Performance Indicator Report For The Year 2014 (RIC 2017)**

Incentive Mechanism implemented in the First Control Period

As part of the Determination for the first regulatory period 2006-2011, the RIC defined the formula for the calculation of system losses and the terms and conditions of the incentive mechanism.

The RIC chose the following formula for the calculation of the total system losses:

$$\textbf{Total System Losses} = 1 - \left\{ \frac{\textbf{Energy Units Billed}}{\textbf{Energy Units Purchased}} \times \frac{\textbf{Collection in \$}}{\textbf{Billing in \$}} \right\}$$

Utilizing this formula, the level of the transmission and distribution losses in Trinidad and Tobago was computed and the value obtained was then benchmarked against the system losses of other countries.

The RIC stipulated five conditions in the incentive mechanism:

- An initial level of total system losses of 7.9% for T&TEC was adopted by the RIC based on the average value computed over the period 1999-2003, which at the time compared favourably with that of some developed countries. A target for reduction in loss levels for the first regulatory control period was then set at 6.75%;

- T&TEC was allowed to keep 90% of the gains derived from savings if the realized total system losses fell below 6.75%, with the sharing of these gains set to occur at the end of the regulatory control period;

- The RIC supported the principle of taking into account the value of loss reduction measures into the asset base. These would be rolled forward into the succeeding regulatory control period, in order to encourage investment in loss reduction equipment;

- T&TEC was required to develop (in conjunction with the RIC) a framework for assessing the economic prudence of loss management investment during the first price control period; and

- T&TEC was required to install appropriate metering/monitoring equipment at strategic locations of its network during the first regulatory control period.

Assessment of T&TEC's Performance over the Periods 2006-2011 and 2012-2016

T&TEC's total system losses fluctuated from year-to-year over the period 2006 to 2011, (the first regulatory period) as presented in Table 3.

Table 3. T&TEC's Transmission and Distribution Losses 2006-2011

Year	2006	2007	2008[4]	2009	2010	2011	Average
% Losses	7.73	8.45	7.84	9.40	6.46	6.50	7.73

T&TEC was not able to achieve any sustainable reduction of total transmission and distribution system losses during the period. The annual total system losses remained above the initial value of 7.73%, and was above the 6.75% target for all years except 2010 and 2011. Total system losses over that period averaged at 7.73%, with the highest annual loss of 9.40% occurring in the year 2009. Although the annual total systems losses showed improvement in the last two years of the period, in aggregate T&TEC did not achieve the set target of 6.75% for reduction in loss levels for the first regulatory control period.

In the period that followed, 2012 to 2016, system losses showed some improvement, with an average of 7.21%, as shown in Table 4. However, except for 2012, all annual values were above the 6.75% level.

Table 4. T&TEC's Transmission and Distribution Losses 2012-2016

Year	2012	2013	2014	2015	2016	Average
% Losses	6.67	7.08	6.93	7.40	7.99	**7.21**

The improvement observed for the period may have been influenced by the use of the higher transmission voltage of 220 kV on part of the network, which was introduced with the commissioning of the combined-cycle power plant in La Brea, as well as the upgrade from 66 kV to 132 kV of the transmission lines from the Bamboo substation in Valsayn to the Gateway substation in Port of Spain.

[4] All computations for 2008 were based on data from the first three quarters of that year. The data for the last quarter was not used due to the fact that T&TEC had conducted a retroactive billing exercise which resulted in the reporting of more **Energy Units Billed** than **Energy Units Purchased** for that quarter, thereby, resulting in a considerable and inaccurate decrease in the value of total system losses for the entire year of 2008.

The average variable cost of electricity per kWh for T&TEC for periods 2006-2011 and 2012-2016 were estimated to be TT$ 0.300 and TT$ 0.305 respectively. Using these figures, the average annual cost to T&TEC of exceeding the 6.75% target during these period was approximately TT$ 21.42 million and TT$ 18.43million, respectively.

Table 5. Estimated Cost of Total System Losses 2012-2016

YEAR	TOTAL SYSTEM LOSSES (MWh)	COST (TT$MILLION)	COST OF EXCEEDING 6.75% TARGET (TT$MILLION)
2006	557,422	167.23	21.20
2007	653,407	196.02	39.43
2008	459,084	137.73	19.15
2009	741,073	222.32	62.68
2010	546,134	163.84	(7.36)
2011	570,912	171.27	(6.59)
2012	602,096	252.499	(3.03)
2013	667,755	280.041	13.05
2014	652,800	273.768	7.11
2015	707,350	296.643	26.06
2016	752,124	315.421	48.95
Total	**6,910,157**	**2,476.79**	**220.66**
Annual Average	628,196	225.16	20.06

It is estimated that, if the set target of 6.75% was achieved and maintained throughout the entire period of 2006 to 2016, the reduction in total system losses would have saved T&TEC at least **TT$ 220 million**, or approximately TT$ 20 million per annum (Table 5). It should also be noted that the full cost of technical losses on a network consists of not only the value of the electricity lost, but also the cost of providing the additional power line capacity and the cost of the environmental impacts associated with the additional generation that is needed to cover losses.

Despite the mechanism that was introduced in the Determination, T&TEC did not undertake any significant capital projects or activities to reduce total system losses. The company also did not report on the status of the installation of appropriate metering /monitoring equipment at strategic locations of its network for the first regulatory period.

Overall, the incentive mechanism did not stimulate T&TEC to reduce the total system losses either through the benefit derived from cost savings, or the additional incentive to keep gains that could have been realized by surpassing the target set by the RIC for the first regulatory period.

RIC's Proposals for the Second Regulatory Period

T&TEC's transmission and distribution system losses translate into higher prices for all customers, as it represents an amount of electricity that the service provider has to purchase that is not delivered but which is paid for by customers. Hence, the RIC will continue to implement measures to improve system losses, given its mandate to ensure that the costs passed on to customers are efficient. Therefore, mechanisms to incentivize the reduction in system losses will be included in the second regulatory control period to encourage T&TEC to minimize these losses.

The revised mechanism will take cognizance of the fact that T&TEC has substantially reduced meter reading/recording errors on the network with the implementation of a full scale Advanced Metering Infrastructure. Consequently, less emphasis can be placed on non-technical (commercial) losses. Additionally, T&TEC encountered specific difficulties in tabulating the "collections" component of the formula. RIC has noted this as well in its review of its original formula for calculating total system losses.

The establishment of an overall performance target for the entire regulatory control period did not result in the improvement intended. Consequently, the RIC will seek to incentivize progress throughout the regulatory control period in a manner that would encourage incremental improvement by establishing annual targets and assessing the performance of the utility, and

corresponding penalties or rewards, on an annual basis. **Non achievement of the annual reduction target will incur a penalty, the value of which will be predetermined and applied as necessary.**

The proposed incentive mechanism for the second regulatory control period will consist of the revised formula for the calculation of system losses and the initial conditions listed below, whereby the RIC will:

- Set Total System Losses at $1 - \left\{ \frac{\textbf{Energy Units Billed}}{\textbf{Energy Units Purchased}} \right\}$

- Set the base value of total system losses for the next regulatory control period as the average monthly value computed over the year preceding the commencement of the period, and set a target for annual reduction in loss levels for the control period at 0.25% down to an overall target of 6.75% for the control period. Accordingly, for a base value of 8%, the first year's target would be 7.75%, the second year's target would be 7.5%, etc;

- Allow T&TEC to keep 90% of the annual gains if actual total system losses fall below the target set for that year, the sharing of the gains to occur at the end of the regulatory control period;

- Impose a penalty on the service provider for years where system losses exceed the target, with the penalty set at a fixed amount or as a percentage of the cost of exceeding the target as determined by the RIC.

- Require T&TEC to include in the capital expenditure programme, projects which entail:

    - The installation of appropriate metering/monitoring equipment at strategic locations of its network; and

    - Network modification to reduce the level of total system losses which include but are not limited to shortening the lengths of long distribution lines and the

installation of capacitors on feeders. The execution of these projects is to be given high priority during the second regulatory control period; and

- Require T&TEC to report on the implementation of capital expenditure plans to reduce system losses. Failure to implement key projects may result in the imposition of penalties;
- Take into account the value of loss reduction equipment into the asset base when it is rolled forward to encourage investment in loss reduction equipment. The full cost incurred would be incorporated into the asset base if the annual target for actual total system losses is achieved and the cost will be prorated for partial achievement of the target.

A comparative summary of the current versus the proposed formula and the terms and conditions of the incentive mechanism is presented in Table 6.

Table 6. Differences between the Incentive Mechanism for the First Regulatory Control Period and Proposed Incentive Mechanisms

First Regulatory Control Period	Proposed Terms
• Total System Losses was calculated using RIC's formula, which included the ratio of "collections" to "billings" in addition to electricity sold and electricity purchased.	• The formula is based only on the ratio of electricity sold to electricity purchased.
• The base value of total system losses was set at 7.9%, with a target of 6.75% to be achieved by the end of the control period.	• The base value of total system losses for the next regulatory control period will be set at the average value computed over the year preceding the commencement of the period, with an overall target of 6.75%, and annual reduction target of 0.25%.
• Retention of 90% of saving gains once system losses fell below the target.	• Retention of 90% of saving gains once system losses fall below the target.

First Regulatory Control Period	Proposed Terms
• Installation of metering/monitoring equipment.	• Installation of metering/monitoring equipment and execution of specific network modification capital expenditure projects.
• Inclusion of the cost of loss reduction measures into the asset base.	• Inclusion of the cost of loss reduction measures into the asset base once targets are achieved. If targets are not achieved these costs would not be included into the asset base and similar measures will be undertaken in the following regulatory control period at no cost to the customer.
• No penalty on the service provider for exceeding the target set for system losses.	• A penalty of a fixed amount or a percentage of the cost of exceeding the target where the service provider fails to maintain levels below the stipulated target.
• Assess and apply gains at the end of the regulatory control period.	• Assess gains/penalties at the end of each year during the regulatory control period, and apply at the end of the regulatory control period.
• No specific reporting requirement on system losses specific capital expenditure.	• Require T&TEC to report on the implementation of capital expenditure plans to reduce system losses. Failure to implement key projects may result in the imposition of penalties.

The RIC welcomes responses and comments of interested parties.