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Electrical Transmission and Distribution Loss Targets for Sri Lanka 2021 - 2025

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Abstract

Losses in transmission and distribution network is not only a technical loss but also an economic loss. However, it is hard to eliminate these losses, but they could be minimized by network improvements and proper management. Therefore, it is important to encourage transmission and distribution licensees to minimize their respective losses. Declaring allowed loss or a loss target by the regulator is one way to encourage. This paper describes a scientific approach to establish electricity transmission and distribution loss targets for Sri Lanka during the period from 2021 to 2025. This study concludes that a target loss of 7.23% of net generation is feasible for year 2025 in Sri Lanka's transmission and distribution network.

Keywords

Loss targets, metering loss, electricity loss, transmission loss, distribution loss, technical loss

Introduction

Energy infrastructure plays a vital role in economic growth. Growth and security of any country depends on the adequacy of the electricity supply [1]. Electricity transmission and distribution systems incur power and energy losses. Such losses directly impact financial well-being and the overall efficiency of utilities [2]. Therefore, implementing various initiatives for loss reduction and imposing loss targets are essential to improve the performance of utilities.

Electricity losses in transmission and distribution occur in form of technical and commercial losses. Technical losses occur due to heating of electrical conductors and other equipment on the grid. These losses can be minimized by reducing currents that flow through conductors and by selecting conductors that could optimize the technical losses. Commercial losses are errors or inaccuracies in metering or straightforward theft of electricity by tampering with meters or through illegal connections. Technical losses can be calculated, measured and controlled. However, they cannot be eliminated [1].

Sri Lanka's Transmission and Distribution Losses

have been on a steady decline (as a percent of generation) since the year 2001. The Electricity Act of 2009 resulted in the establishment of separately licensed entities for transmission and distribution, functionally and technically separated from each other. The introduction of the tariff methodology in 2011, caused the transmission licensee and each of the five distribution licensees to be allocated an "allowed loss" in their networks. In determining allowed revenues for their respective business (for example, the allowed total annual cost of distribution of a distribution licensee), each licensee has an "allowed loss" which may also be termed as the "loss target". If a licensee violates the loss target, then the value of additional energy lost will erode the allowed revenue of that distribution licensee. On the other hand, if a distribution licensee's losses are less than the "allowed loss", then the value of such avoided energy loss can be retained by the distribution licensee and will eventually add on to its profits.

In 2016, SLEMA conducted a comprehensive study for Public Utilities Commission of Sri Lanka (PUCSL) to determine losses in the transmission and distribution networks of Sri Lanka. This study will be referred to as the SLEMA study 2016 [3]. In this study, technical losses were calculated separately for each one of the five distribution licensees and the transmission licensee, and for each specific segments of the network of each licensee.

Specific features, for example, the impacts on losses caused by seasonal power flows from mini-hydropower plants embedded in the distribution network back into the transmission network, were analysed. In summary, the 2016 study recommended that Sri Lanka's total transmission and distribution losses should achieve a target of 7.5% of net generation by 2020.

Subsequently, PUCSL adopted the targeted losses recommended in the SLEMA study 2016 to be the allowed losses, for determining the allowed revenues for each licensee from 2016 to 2020. Allowed profits of transmission and distribution licensees are a fixed percentage of their assets.

This means that if a licensee meets a targeted loss level, there will be no additional profit or loss, from the activity of purchasing electrical energy from generation and delivering to customers.

Similarly, if the actual losses turn out to be lower than the allowed loss, the value of energy saved will not be clawed back and would add to the profits of the licensee. If the actual loss turns out to be higher than the allowed loss, the value of such incremental energy loss would have to be borne by the licensee, thus reducing the profits of the licensee.

This paper presents an approach to evaluate electricity transmission and distribution loss targets for Sri Lanka during the period from 2021 to 2025. The study includes analyses of specific emerging concerns such as the impacts of distributed generation on LV network losses.

The paper is organized as follows. Section III describes the methodology. Section IV analyses the impact on LV line losses caused by the increasing deployment of rooftop solar photovoltaics. The approach for determining the transmission loss targets is given in section V and the approach for determining the distribution loss targets is given in section VI. Section VII gives the conclusions. Limitations, potential improvements, and further studies are stated in section VIII.

Literature Review

Loss targets recommended in the SLEMA study 2016 is given in Table 1 and Table 2.

Figure *1:* gives a comparison between the national targets for losses as recommended in the SLEMA study 2016 and the actual values, for the period between 2016 and 2020. During the last five years, the electrical power system loss percentages (on net generation) of Sri Lanka showed a gradually reducing trend.

At a national level, transmission and distribution licensees comfortably met the targeted losses in years 2016, 2017, and 2018.

In 2019, the losses continued in a the downward trend but missed the targeted value by 0.82% (targeted 8.02% vs 8.84% achieved). However, in 2020, for the first time since the year 2001, Sri Lanka's transmission and distribution losses increased. It rose by 1.95%, recording a total loss of 9.45% vs the targeted loss of 7.50%. This incident should be analysed separately as it goes beyond the objective of this paper.

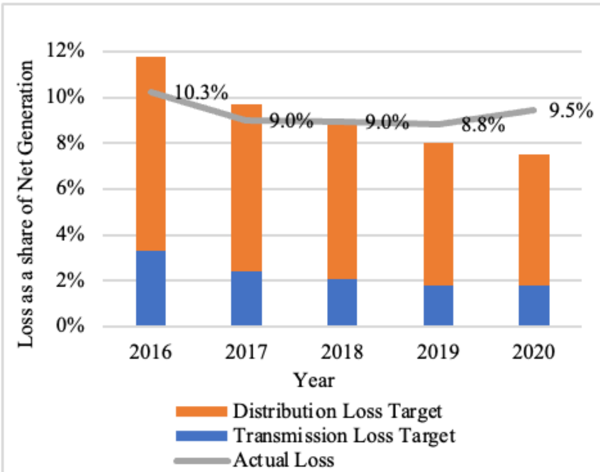
Table 1: Transmission Loss Targets and Total (Transmission and Distribution) Loss Targets

Year	Transmission Loss Target (%)	Transmission & Distribution Loss Target (%)
2016	3.26	11.46
2017	2.41	9.84
2018	2.08	8.94
2019	1.80	8.09
2020	1.71	7.50

Table 2: Distribution Loss Targets by Licensee

Year	Distribution Loss Target (%)				
	Distribution Licensee				
	1	2	3	4	5
2016	8.20	10.00	8.20	8.60	5.00
2017	7.41	8.57	7.64	7.92	4.81
2018	6.75	7.58	7.30	7.67	4.54
2019	6.18	6.74	6.78	7.17	4.23
2020	5.60	5.94	6.54	6.80	4.02

Figure 1: National Targets for Losses 2016-2025 Compared with Actual Valuesa



[a] Targets for 2016-2020 are from the Loss Targets 2016-2020 study. Targets for 2021-2025 are from this study. Actual losses calculated based on CEB and LECO sales to end users, divided by net generation inclusive of purchases from rooftop solar PV by both CEB and LECO

The performance of Sri Lanka's power system loss reduction policies should be appreciated. These policies have outperformed compared with some other South Asian countries.

The transmission and distribution losses recorded in power system statistics, 45th edition (March 2021), published by National Transmission and Dispatch Company (NTDC) of Pakistan [4] and the Ministry of Power, Energy and Mineral Resources of Bangladesh [5] are summarized in Table 3.

Table 3: Transmission and Distribution Losses Recorded in Pakistan and Bangladesh

Year	Transmission Losses (%)		Distribution Losses (%)		Transmission and Distribution Losses (%)	
	Pakistan	Bangladesh	Pakistan	Bangladesh	Pakistan	Bangladesh
2016	2.6	2.67	17.06	9.98	19.7	12.19
2017	2.3	2.75	17.09	9.60	19.4	11.87
2018	2.4	3.10	17.59	9.35	20.0	11.96
2019	2.8	2.91	17.71	8.73	19.28	11.23
2020	3.3	na	17.82	na	19.75	na

na: not available

Transmission and distribution losses of Pakistan have increased over the period. By 2020, the total losses have reached 19.75% while Sri Lanka reported 9.45%. In Bangladesh, distribution losses have decreased while transmission network losses were increasing. In 2019, all losses (total, transmission, distribution) have decreased. However, the total losses as a percentage are still higher than Sri Lanka. This may be due to the large network and lower customer density in both countries. Commercial losses are a large share of distribution losses.

Figure 2: Transmission and Distribution Loss Percentages of Pakistan and Bangladesh

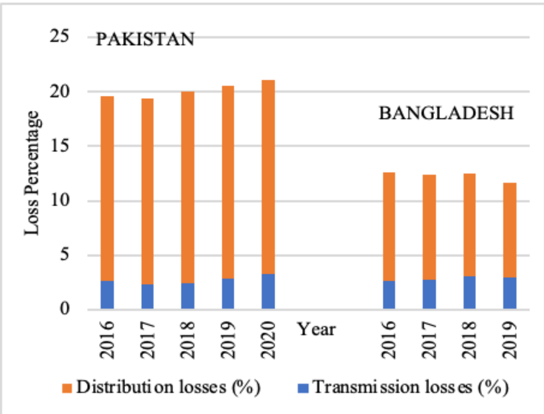
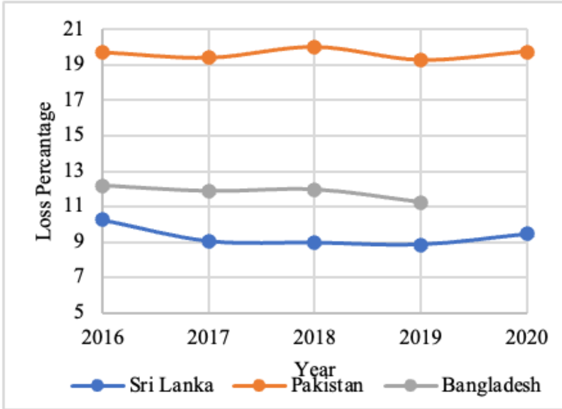


Figure 3: Percent Transmission and Distribution Losses of Sri Lanka, Bangladesh, and Pakistan



The Figure compares the historic losses of Sri Lanka, Pakistan, and Bangladesh. Performance of the Sri Lanka power system has outperformed both Pakistan and Bangladesh. However, Sri Lanka has the potential to reduce losses further, and achieve the target of 7.5%, which the country missed in 2020. Compared with the SLEMA 2016 study, several improvements were introduced to the methodology for loss assessment.

Losses in LV Metering

Energy delivered to a customer is measured with an energy meter installed at the customer premises. Customers are categorised according to their contract demand and type, such as domestic, industrial, hotel, and general-purpose. Different types of energy meters are used to measure the energy delivered to each customer category. Both electromechanical (EM) meters and electronic (EL) meters are used in Sri Lanka. Table shows the type of energy meter used for each customer category.

Table 4: Types of Energy Meter Used for Each Customer Category

Customer Contract Demand	No. of Phases	Current (A)	Type of Customer	Energy Meter Type
Up to 7 kVA	1	30	Retail	2-wire direct connected (1 phase meter)
Between 7 kVA & 21 kVA	3	30	Retail	3 x 2-wire direct connected, or 1 x 4 wire direct connected (3 phase meter)
Between 21 kVA & 42 kVA	3	60	Retail	3 x 2-wire direct connected, or 1 x 4 wire direct connected (3

				phase meter)
Above 42 kVA	3	more than 60	Bulk	Current transformer (CT) connected 4 wire or 3 wire

Meters require energy when they are powered-up.

The number of customers grow rapidly, and energy used in energy meters will also increase.

The number of LV customers served by each distribution licensee and energy sales to LV customers were forecast on the same basis as in the SLEMA study 2016.

The number of three-phase customers were obtained by multiplying the total number of customers by the percentage of three-phase customers, provided by each distribution licensee.

It was assumed that 1% of EM meters presently in use will be replaced by EL meters every year. It was assumed that all 3-phase customers of all licensees are served through EL meters.

There are two types of losses incurred in measuring energy delivered by a distribution licensee to a customer. These are technical losses and non-technical losses.

Calculation of Technical Losses (Standby Losses)

Energy meters consume electrical energy to remain active. The energy consumed by the meter is not accounted as energy delivered to the customer. The cumulative technical losses of all meters will be significant and cannot be neglected, especially since the transmission and distribution losses and their targets are below 10% of net generation. Energy consumption by the meters (which has been classified as a technical loss) changes with the technology used in metering. Electromechanical meters that operate on induction theory with magnetic coils consume more energy than electronic meters that operate on digital technology.

Energy meters remain energised throughout resulting in energy use and termed as 'standby energy loss in meters'. This is a type of technical loss. Distribution licensees should be allowed to incur this loss, without being penalised. As given in IEC 62052, the standard for electricity metering equipment, the power consumption of energy meters should be less than 2 W [10].

Table 5: Meter Power Loss Stated by Manufacturers

Meter type	Meter 1	Meter 2	Meter 3
Single-Phase Electromechanical (EM)	1 W	1 W	1 W
Single-Phase Electric (EL)	0.65 W	0.65 W	0.62 W
Three-Phase Electronic (EL)	0.7 W	0.7 W	0.7 W

Note: Meter 1, Mater 2 and Meter 3 represent three samples

Table 5 summarizes the results from several Type Test reports (available with distribution licensees) of energy meter manufacturers related to power consumption of energy meters.

The standby energy losses in meters for the selected period were calculated by multiplying the estimated number of customers under each category by the standby power required for each type of meter. The standby power requirement for three-phase meters (all of EL type) was assumed to be 0.7 W. For single-phase meters, the standby power requirement was assumed to be 0.8W for EM type meters and 0.4 W for EL type meters.

Calculation non-Technical Losses

Meter commercial losses occur owing to errors in meter readings caused by limitations in meter accuracy. Typically, each meter is calibrated accurately to read the calibrated load current with no error.

Table 6: Accuracy Error in Meter Commercial Loss Calculation [6]

Consumption Category	Accuracy Error (%)	
	Electro-magnetic	Electronic
Less than 60 kWh/month	0.46	0.1
Between 60 and 90 kWh/month	0.61	0.07
Between 90 and 120 kWh/month	0.77	0.07
Between 120 and 180 kWh/month	1.02	0.05
Greater than 180 kWh/month	0.99	0.06

Energy consumption of each type of meter (EM & EL) for a given consumption category was calculated. The consumption values were multiplied by the respective accuracy errors of each meter and the resulting values were added together to obtain the commercial losses in metering. The forecast commercial losses during the period from 2021 to 2025 are presented in Table .

Table 7: Forecast Commercial Losses in LV Metering

Distribution Licensee	Forecast Energy Loss (GWh)				
	2021	2022	2023	2024	2025
DL1	1.095	1.12	1.146	1.172	1.199
DL2	0.67	0.794	0.818	0.843	0.869
DL3	0.505	0.514	0.523	0.532	0.542
DL4	0.484	0.495	0.505	0.516	0.528
DL5(LECO)	0.305	0.312	0.32	0.328	0.335
Total	3.059	3.235	3.312	3.391	3.473

Note: Energy supplied includes sales, technical loss in meters and commercial loss in meters.; DL: distribution licensee; Sri Lanka has five distribution licensees.

Energy Supply

The total electrical energy supplied to the LV customers represents the addition of both LV sales and metering losses for each distribution licensee. This was calculated for the period from 2021 to 2025, as follows:

$$Forecast\ energy\ supply = Sales\ forecast + technical\ losses\ in\ metering + commercial\ losses\ in\ metering \quad (1)$$

Energy Loss

The total energy loss from energy meters is the summation of technical (standby) losses and commercial losses. Percentage technical and commercial energy loss is the ratio between the metering energy loss and input to the LV supply.

$$Energy\ Loss\ \% = \frac{(Standby + Commercial\ Loss)}{Input\ to\ LV\ \ Supply} \times 100$$

Table 8: Forecast Percent Energy Loss in LV Metering

Distribution Licensee	Technical and commercial loss (percent of energy supplied)				
	2021	2022	2023	2024	2025
DL1	0.53%	0.51%	0.48%	0.46%	0.44%
DL2	0.60%	0.58%	0.55%	0.53%	0.51%
DL3	0.65%	0.62%	0.59%	0.57%	0.54%
DL4	0.58%	0.55%	0.53%	0.51%	0.48%
DL5(LECO)	0.35%	0.33%	0.31%	0.30%	0.29%

Effect of Solar PV Generation on Network Losses

Distributed generation is expected to reduce distribution losses, because a portion of customer demand is generated in the distribution network itself. However, when generation exceeds the demand in a particular distribution network, surplus electricity has to flow through the transmission network to another distribution network in which demand exceeds supply.

An analysis of network losses in the LV network caused by grid-connected solar PV systems was carried out for different case definitions based on different solar penetration levels on the LV network. The analysis used a distribution network with 225 customers, comprising four LV feeders served by one distribution transformer rated at 100 kVA. The maximum customer demand on the distribution system (occurring at night) was 38 kW. Four separate cases were defined for the analysis of losses in distribution.

The base case was defined to be the network without any rooftop solar PV installations. The other three cases were defined to reflect a situation where the number of customers with rooftop solar PV installations increase gradually. The network was modelled using DigSILENT PowerFactory software. Customer daily load profiles for each customer category used in the SLEMA 2016 study were also used in the model. The typical daily generation curve for solar PV was developed using the System Advisory Model (SAM).

Results of 15-minute modelling of power flows were multiplied by 0.25 hours to convert power losses into energy losses. Simulation results showed that the transformer energy loss decreases with the increase in the number of solar PV installations, owing to the reduction in transformer loading level during the day. Cases 1 and 2 show a reduction in LV feeder energy loss as solar PV installations increase. Case 3 on the other hand, with a maximum capacity of solar PV installations, shows an increase in LV feeder energy loss.

Table 9: Case Definitions – Case 1

Tariff Category	GP – 3P > 300	HH-1P > 181
Number of Solar PV installations	2	1
Capacity of a solar PV unit (kW)	2.5	2.5
Energy requirement of the customer (kWh/month)	332	310
Electricity generation from Solar PV (kWh/month)	334	334

Net electricity generation (kWh/month)	2	25

Table 10: Case Definitions – Case 2

Tariff Category	GP-3P<300	GP-3P>300	HH-1P>181	HH-1P-121-180
Number of Solar PV installations	2	4	1	1
Capacity of a solar PV unit (kW)	1	2.5	2.5	1.5
Energy requirement of the customer (kWh/month)	125	332	310	152
Electricity generation from Solar PV (kWh/month)	147	334	334	206
Net electricity generation (kWh/month)	22	2	25	54

Table 11: Case Definitions – Case 3

Tariff Category	GP-3P<300	GP-3P>300	HH-1P-121-	HH-1P>181	HH-3P-121-180	HH-1P-91-120	HH-3P-91-120
Number of Solar PV installations	11	4	2	1	1	1	1
Capacity of a solar PV unit (kW)	1	1	1.5	2.5	1.5	1	1
Energy requirement of the customer (kWh/month)	125	125	152	310	152	104	104
Electricity generation from Solar PV (kWh/month)	147	147	206	334	206	147	147
Net electricity generation (kWh/month)	22	22	54	25	54	43	43

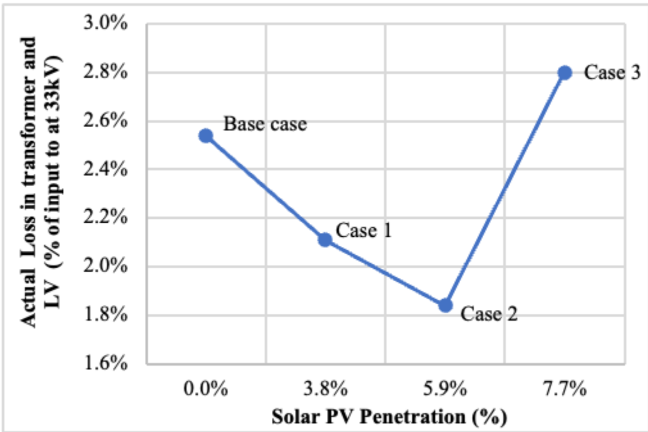
Note: HH = Household, GP = General Purpose, GP-1P->300 = General Purpose Three Phase with consumption higher than 300 kWh/month, HH-1P->181 = Household Single phase with consumption higher than 181 kWh/month, HH-1P-121-180 = Household Single phase with consumption higher than 121 kWh/month and lower than 180kWh/month

Solar PV penetration is defined as the ratio between peak PV generation and peak daytime demand, stated in terms of apparent power. Figure 4 shows how the calculated percentage loss varies with solar PV penetration.

Table 12: Calculated LV Losses

	Base Case	Case 1	Case 2	Case 3
External in feed at 33 kV from grid [i.e., input to distribution transformer] (kWh/day)	596	560	519	457
Energy from rooftop solar PV (kWh/day)	0	33	72	140
Total energy supplied to the distribution network (kWh/day)	596	593	591	597
Total energy demand by customers (kWh/day)	580	580	580	580
Calculated transformer and LV loss (as a percent of input at 33 kV)	2.5%	2.1%	1.8%	2.8%
Calculated transformer and LV loss (as a percent of total energy supplied)	3.3%	3.2%	3.1%	3.2%

Figure 4: Percent loss variation with solar PV penetration



In 2020, generation from rooftop solar PV across all customer categories by all five distribution licensees were reported to be 335 GWh, whereas total sales to LV customers was 8,394 GWh. Therefore, in energy terms, solar PV rooftop generation was about 4.0% of LV sales, and 2.3% of total sales. Hence, in average terms, Sri Lanka's status concerning rooftop solar PV penetration has not reached the scenario in Case 1 yet. Therefore, at present, the impact of losses due to rooftop solar PV generation may be approximated to the losses in the Base case.

Loss Target for the Transmission System

Transmission losses, in principle, contains only technical losses. The technical loss of the transmission system depends on the evolving configuration of the network, parameters of network elements such as lines and transformers, dispatch of power plants, and features of demand served to distribution lines at each grid substation. Generation dispatch is determined by dispatch policies, causing the generation mix to vary from time to time.

Power flows in the transmission network vary over time. In the wet season, hydropower is a dominant source. In the dry season, when thermal generation dominates, the power flow will be significantly different. There will also be differences in the power flow patterns during weekdays and weekends. Different dispatch scenarios were assessed based on the amount of energy to be supplied by hydropower and thermal generation, considering different days of the week.

This study uses data from the latest available Long-Term Transmission Development Plan of CEB (2020-2039) [7], where the demand losses at different combinations of demand and power plant dispatch scenarios are presented. The demand losses at peak as reported by the CEB were converted into energy losses. Annual energy losses were calculated considering the number of days in the year, where each dispatch-demand scenario is expected to occur. Therefore, technical losses in the transmission system were estimated using the following procedure:

Step 1: Generation data from the forecast data set for the period from 2021 to 2025 was analysed to select typical days for the four dispatch scenarios such as hydro power with maximum thermal balance on a weekday, maximum hydro with thermal balance in the weekend, maximum thermal with hydro on a weekday, and maximum thermal with a hydro balance in the weekend, based on "Loss Target Final Report 2016-2020" [3]. Two days per scenario were selected.

Step 2: From the forecast dataset; peak demands, and daily energy for the selected days were calculated. Daily energy was estimated using half-hourly generation data from the forecast dataset.
To estimate the daily load factor (LF) daily energy and peak demand was used as given equation 2. The daily oss load factor (LLF), Equation (3) was used, where the parameter p was taken as 0, 0.1, and 0.2 based on Loss Targets Report 2016-2020 [3].

$$Daily\ Load\ Factor\ (LF) = \frac{Daily\ Energy}{Peak\ Demand * 24} \quad (2)$$

$$LLF = p * LF + (1 - p) * LF^2 \quad (3)$$

Step 3: The weekday night peak-time loss was taken from the long-term transmission development plan 2018-2027. The night peak-time loss during the weekend was estimated using the ratio, between weekend night peak-time loss and weekday night peak-time loss [8]. The day peak-time loss was estimated using the ratio between day peak-time loss and night peak-time loss, which could be obtained from the loss data. The maximum peak-time loss was taken from the available night peak-time loss and day peak-time loss for the selected day.
Step 4: The technical loss was calculated using the following equation:

$$Energy\ Loss = 24[Z_1 * LLF_1 * X_1 + Z_2 * LLF_2 * X_2 + Z_3 * LLF_3 * X_3 + Z_4 * LLF_4 * X_4] \quad (4)$$

where, Z_i is the peak-time loss for dispatch scenario i, X_i is the fraction of the days for dispatch scenario i, LLF is loss load factor for different dispatch scenarios.

Step 5: Percentage loss in the transmission was calculated using the formula:

$$Perecentage\ loss\ in\ transmission\ (\%) = \frac{Energy\ loss}{Net\ generation} * 100$$

5)

Impact of Energy used for GSS Auxiliary Requirements

Energy used at grid substations (GSS) is not accounted for either in the transmission planning model or in distribution planning models. A case study was conducted, by assessing the energy used at Jayewardenepura GSS. The following were observed.

- Peak demand on the auxiliary transformer = 27.0 kW
- Energy used in the GSS = 598 kWh/day (average of 9 days)
- Number of GSSs in the transmission system = 69 (in 2021)

Therefore, 15.1 GWh/year (in 2021) is the estimated energy used for auxiliary power requirements at all GSSs in the system. Net generation used for the transmission loss study was 19,370 GWh in the year 2021. Accordingly, auxiliary power consumption (i.e., technical losses) at grid substations amount to 0.08% of net generation.

Transmission losses were calculated based on the Long-Term Transmission Development Plan 2020-2039 based on p being 0.0 after including adjustments for auxiliary energy requirements at GSSs. It is observed that transmission losses as a percent as well as in absolute energy terms, would be increasing throughout the period of 2021-2025.

Table 13 Forecast loss as a percent of input to transmission for years 2021 - 2025

Year	Percent of input to transmission		
	P = 0	P = 0.1	P = 0.2
2021	1.252	1.293	1.334
2022	1.301	1.345	1.388
2023	1.339	1.382	1.426
2024	1.540	1.540	1.640
2025	1.992	2.056	2.119

Table 14: Transmission Losses

Year	2021	2022	2023	2024	2025
Net generation to transmission (GWh)	19,370	20,331	21,342	22,037	23,522
Transmission loss (GWh) at p= 0.0	242.6	264.5	299.4	345.0	420.2
Auxiliary consumption at each GSS (GWh)	0.2	0.2	0.2	0.2	0.2
Number of GSSs	69	76	98	99	100
Auxiliary consumption at GSSs (GWh)	15.1	16.6	21.4	21.6	21.8
Total technical loss in transmission network (GWh)	257.7	281.1	320.8	366.7	442.0
Transmission technical loss (% of net generation)	1.33%	1.38%	1.50%	1.66%	1.88%

Note: Generation energy forecast shown above does not match with the forecast used for this study since the forecast reflects conditions in 2018.

Distribution Loss Targets

The distribution losses comprise transformer loss from LV bulk customers, LV network losses from LV customers, losses in distribution transformers and in medium voltage (MV) lines. The distribution losses for each distribution licensee were calculated separately, as technical losses and non-technical losses. In calculating technical losses, the network model assumed that the customers were uniformly distributed along the LV lines. Different load profiles were used for each customer category (e.g., for each block in the block tariffs for households). Distribution transformer losses were calculated using losses and parameters stated in typical transformer test data, on which typical load profiles were applied to calculate the energy losses.

Transformer losses for LV bulk customers were calculated using customer load profiles used in the SLEMA study 2016 and loss data available from transformer test reports. In the MV line loss calculation, metering losses were fixed at 0.02% of the energy supplied. Line losses were based on the latest distribution planning reports available from each distribution licensee. Non-technical losses for 2021 were computed by considering the difference between the actual losses and the technical losses [8][9].

Conclusions

Based on the methodology described in earlier sections, recommended distribution loss targets are given in Table and recommended transmission loss targets are given in

Table for the period between 2021 and 2025.

Table 15: Distribution Loss Targets

Distribution Licensee	Year	Loss Target (as a % of Purchase by each DL)		
		Technical	Technical	Technical
DL1	2021	5.18%	0.89%	6.07%
	2022	5.09%	0.69%	5.79%
	2023	5.08%	0.50%	5.58%
	2024	5.08%	0.30%	5.38%
	2025	5.02%	0.11%	5.13%
DL2	2021	6.34%	0.99%	7.33%
	2022	5.96%	0.77%	6.73%
	2023	5.81%	0.55%	6.36%
	2024	5.87%	0.33%	6.20%
	2025	5.85%	0.11%	5.95%
DL3	2021	6.40%	0.62%	7.03%
	2022	6.20%	0.49%	6.69%
	2023	6.18%	0.36%	6.55%
	2024	6.17%	0.24%	6.41%
	2025	6.13%	0.11%	6.24%
DL4	2021	6.00%	1.03%	7.03%
	2022	5.94%	0.80%	6.74%
	2023	5.70%	0.58%	6.28%
	2024	5.63%	0.35%	5.98%
	2025	5.50%	0.12%	5.62%
DL5 (LECO)	2021	3.52%	0.45%	3.96%
	2022	3.56%	0.37%	3.92%
	2023	3.54%	0.29%	3.83%
	2024	3.49%	0.21%	3.69%
	2025	3.52%	0.13%	3.65%

Table 16: Transmission Loss Targets

Year	Transmission Technical Loss (% of net generation)
2021	1.33%
2022	1.38%
2023	1.50%
2024	1.66%
2025	1.88%

Although distribution loss targets show a gradually decreasing trend, transmission loss targets increase over time. However, all the loss targets will be kept below 2% throughout the study period.

Based on the summarized results, targets for the total loss of the Sri Lankan transmission and distribution system could be given in

Table 17: . If the network could achieve the recommended loss targets, it will save energy at the

Year	Sales to end-use customers (GWh)	Total Sales to Distribution Licensees (GWh)	Net Purchases by the Transmission License (GWh)	Sri Lanka Total T&D Loss (as a share of net generation)		
				Technical	Commercial	Total
	Forecast	Forecast	Forecast	Target	Target	Target
2021	15,515	16,595	16,819	6.92%	0.83%	7.75%
2022	16,741	17,836	18,087	6.79%	0.65%	7.44%
2023	17,705	18,809	19,096	6.82%	0.47%	7.29%
2024	18,725	19,854	20,184	6.94%	0.29%	7.23%
2025	21,036	22,251	22,677	7.12%	0.11%	7.23%

generation levels as shown in Table .

Table 17: Recommended Total Loss Targets for 2021-2025

Year	Sales to end-use customers (GWh)	Total Sales to Distribution Licensees (GWh)	Net Purchases by the Transmission License (GWh)	Sri Lanka Total T&D Loss (as a share of net generation)		
				Technical	Commercial	Total
	Forecast	Forecast	Forecast	Target	Target	Target
2021	15,515	16,595	16,819	6.92%	0.83%	7.75%
2022	16,741	17,836	18,087	6.79%	0.65%	7.44%
2023	17,705	18,809	19,096	6.82%	0.47%	7.29%
2024	18,725	19,854	20,184	6.94%	0.29%	7.23%
2025	21,036	22,251	22,677	7.12%	0.11%	7.23%

Table 18: Saving in Generation with Loss Targets Implemented for 2021-2025

Year	Sales to end-use customers (GWh)	Input to Transmission Network (net generation) GWh		Energy saving at net generation level (GWh)
		Losses remain the same in % terms as in 2020	With loss targets implemented	
	Forecast	Forecast	Forecast	Forecast
2021	15,515	17,134	16,819	316
2022	16,741	18,488	18,087	402
2023	17,705	19,553	19,096	457
2024	18,725	20,680	20,184	495
2025	21,036	23,232	22,677	555

The results of this study could be summarized as follows.

(a) A loss level of 7.75% inclusive of a non-technical loss of 0.83% will be achievable in 2021.

(b) A loss level of 7.23% inclusive of a non-technical loss of 0.11% will be achievable in 2025.

(c) The unusual loss of 9.45% in 2020 requires a deeper investigation, examining metering records.

(d) Reducing losses to target levels will save 316 GWh in 2021. The value of 316 GWh of marginal energy, estimated at a conservative cost of LKR 20 per kWh is estimated to be about SLRs 6500 million per year.

Study Limitations and Potential Improvements

Transmission loss calculations were done based on the long-term transmission development plan for 2018-2027 which was based on a demand forecast higher than the demand forecast used for the rest of the study. This is unlikely to affect the percentage losses in transmission. However, it would be most likely to reduce losses in energy terms and percentage values.

Distribution loss calculations were based on the sales forecast that prevailed in the year 2020. Reduced sales in 2020 and 2021 would cause a reduction in sales in the near future affecting the losses. However, if the actual sales are less than the forecast sales, the percentage loss values will be lower than the estimated values.

The load profiles used for different customer categories are from the SLEMA study of 2016-2020.. The profiles used in this study were from the period between 2014 and 2015. Therefore, it may require to re-assess these profiles using field surveys for proper representation of maximum demand on LV networks and transformers.

a. Reverse power flow from embedded power plants to the transmission network does not cause a significant change in transmission losses.

b. Initially, the power flow from rooftop solar PV to the LV network causes a reduction in LV network losses and distribution transformer losses. With increased penetration, the LV network losses will also increase. However, the countrywide penetration of rooftop solar PV is not significant to consider these losses as a feature in assessing the target losses.

c. Electronic meters will reduce both technical and commercial losses in metering. A moderate meter replacement program to replace electromagnetic meters with electronic meters was assumed in this study. If the replacement program is accelerated, the assessments should be revised.

d. Auxiliary power at grid substations was obtained by measuring the requirements of only one grid substation. A broader database from several grid substations, preferably of different capacities, would provide a more representative estimate.

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