

# LP&L 2023 Distribution Loss Factor Calculations and Methodology

**Conclusion:** 17.8% of total system losses calculated included both primary and secondary system losses.

Code A: Primary Customers = 5.8% loss

Code B: Secondary Customers = 12% loss

Code T: Transmission Customers

## Assumptions:

1. Inputs are measured from substation high side breakers and feeder breakers
2. Outputs are measured from customers' meters
3. Component Losses are represented by the following equation:

$$Losses = AX^2 + B$$

Where  $X$  = Power into Component

$A$  = Power Loss Coefficient

$B$  = No Load Loss Coefficient

## Approximate Simplified Circuit Model

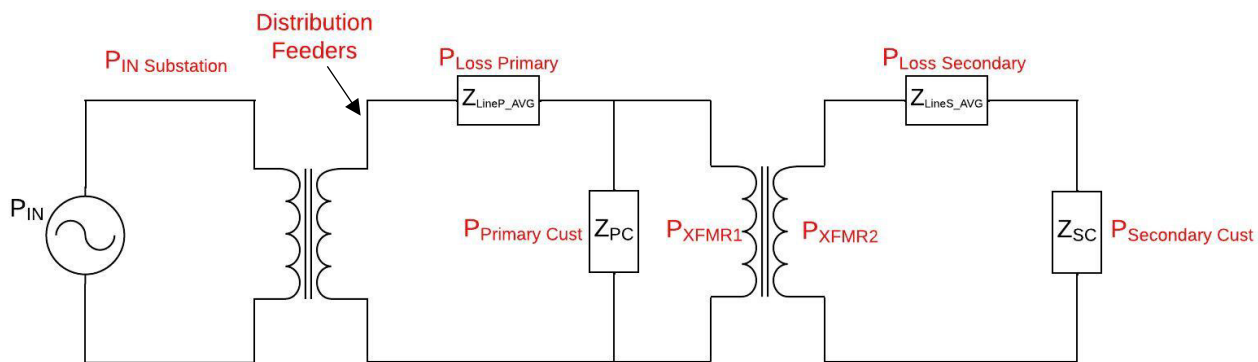


Figure 1: Approximate and Simplified Distribution System Circuit Model

## Primary Conductor Loop

Figure 1 above shows the simplified model of LP&L's distribution system. The power source represents the high side of a representative substation. The metered data LP&L has is the real and reactive power from the substation, the power factor, and the 3 main phase currents. Based on this information, we know the total power being delivered to the distribution system as well as the injection currents at various points in the system. Using substation data from the high side breakers and the feeder breakers, the substation transformer losses can be found with the following equation:

$$\text{Substation Losses} = A_{Sub}X_{Sub}^2 + B_{Sub}$$

Losses can also be represented by the difference in input and output powers of a component.

$$(1) X_{Sub} - Y_{Sub} = A_{Sub}X_{Sub}^2 + B_{Sub}$$

Where  $X_{Sub}$  = Substation Power Input,

$Y_{Sub}$  = Substation Power Output

### Primary Conductor and Secondary Loop Equations

Losses in the distribution system were found by creating a mathematical model of the distribution system and fitting the available feeder and customer consumption data to it. The losses of the primary conductor can be represented by the following equation:

$$(2) X_P - X_T - Y_P = A_P X_P^2 + B_P$$

Where  $X_P$  = Primary Conductor Input,

$X_T$  = Distribution Transformer Input,

$Y_P$  = Primary Customer Consumption

The secondary conductor losses are tied in with the transformer losses as one loss calculation. The secondary losses of the system are calculated by first determining the injection power into the transformer (using equation 2) and then subtracting the customer output data. These losses are represented by the following equation:

$$(3) X_T - Y_S = A_T X_T^2 + B_T$$

Where  $Y_S$  = Secondary Customer Consumption

Combining equations 2 and 3 will give an overall mathematical model of the distribution system from the feeder breaker to the customer meters. This will represent secondary customer consumption as a function of primary conductor input and primary customer consumption as seen below:

$$Y_S = X_P - A_P X_P^2 - B_P - Y_P - A_T (X_P - A_P X_P^2 - B_P - Y_P)^2 - B_T$$

Customer and substation meter data can then be regressed to this model to provide the A and B coefficients for each loss equation. These loss equations can then be used to calculate the percent loss across the system.

### DLF Calculation

The A and B coefficients are used to determine the loss percentages at varying loads into the LP&L distribution system. These loss percentages are then used to find the Settlement Interval Distribution Loss Factor (SILF<sub>i</sub>) for each class of customer. These loss factors are then fit to the following equation to find F1, F2, and F3:

$$SILF_i = F1 \cdot \left( \frac{SIEL_i}{AAL} \right) + F2 + \frac{F3}{\left( \frac{SIEL_i}{AAL} \right)}$$

Figures 2 through 7 show the DLF calculation and graphs for the primary and secondary customers. Coefficients for each are below:

LP&L Peak = 616.19		AAL = 12450 Peak = 85579		DLF Coefficients										Substation Transformers		Loss Coefficients		Distribution Transformer			
				A- Primary					B- Secondary					Primary Conductors		Distribution Transformer					
				F1 = 3.22E-02					F1 = 3.61E-02					A = 8.40E-05		A = 7.16E-06		A = 1.35E-05			
				F2 = 3.02E-04					F2 = 9.26E-04					B = 9.15E+00		B = 0		B = 20.798979			
				F3 = 2.54E-02					F3 = 0.083277644												
ERCOT Load (15 Min)	ERCOT Load (1hr)	LP&L Load (15 Min)	LP&L Input to Sub XFMRs (MW)	Sub XFMR Losses (MW)	Input to Dist Sys (MW)	Primary Conductor Losses (MW)	Total Primary Losses	Total Primary Loss %	Input to Dist XFMRs (MW)	Dist XFMR & Secondary Losses (MW)	Total Losses	Total Loss %	DLF Primary	DLF Secondary	SIEL/AAL	sec(SIEL/AAL)	prim(SIEL/AAL)				
668.6	2674.3	1	4.8	19.3	9.2	10.1	0.0	9.2	47.69%	10.1	20.8	30.0	155.71%	47.57%	155.36%	0.0537017	0.083617558	2.56E-02			
1337.2	5348.7	2	9.6	38.5	9.3	29.2	0.0	9.3	24.10%	29.2	20.8	30.1	78.14%	24.06%	78.02%	0.1074034	0.083921897	2.59E-02			
2005.8	8023.0	3	14.4	57.8	9.4	48.3	0.0	9.4	16.35%	48.3	20.8	30.3	52.41%	16.34%	52.37%	0.161105	0.084441631	2.63E-02			
2674.3	10697.4	4	19.3	77.0	9.6	67.4	0.0	9.7	12.57%	67.3	20.9	30.5	39.65%	12.56%	39.64%	0.2148067	0.085176926	2.70E-02			
3342.9	13371.7	5	24.1	96.3	9.9	86.4	0.1	10.0	10.37%	86.3	20.9	30.9	32.08%	10.37%	32.08%	0.2685084	0.086127149	2.78E-02			
4011.5	16046.1	6	28.9	115.5	10.3	105.3	0.1	10.4	8.96%	105.2	20.9	31.3	27.09%	8.96%	27.10%	0.3222101	0.08729187	2.89E-02			
4680.1	18720.4	7	33.7	134.8	10.7	124.1	0.1	10.8	8.00%	124.0	21.0	31.8	23.59%	8.01%	23.60%	0.3759118	0.088670659	3.01E-02			
5348.7	21394.8	8	38.5	154.0	11.1	142.9	0.1	11.3	7.33%	142.8	21.1	32.4	21.01%	7.33%	21.03%	0.4296135	0.090263088	3.15E-02			
6017.3	24069.1	9	43.3	173.3	11.7	161.6	0.1	11.9	6.84%	161.4	21.2	33.0	19.05%	6.85%	19.07%	0.4833151	0.092068733	3.31E-02			
6685.9	26743.4	10	48.1	192.6	12.3	180.3	0.2	12.5	6.49%	180.1	21.2	33.7	17.52%	6.50%	17.54%	0.5370168	0.094087168	3.49E-02			
7354.4	29417.8	11	53.0	211.8	12.9	198.9	0.3	13.2	6.23%	198.6	21.3	34.5	16.31%	6.24%	16.32%	0.5907185	0.096137973	3.68E-02			
8023.0	32092.1	12	57.8	231.1	13.6	217.4	0.3	14.0	6.05%	217.1	21.4	35.4	15.33%	6.05%	15.34%	0.6444202	0.098760727	3.90E-02			
8691.6	34766.5	13	62.6	250.3	14.4	235.9	0.4	14.8	5.92%	235.5	21.6	36.4	14.53%	5.92%	14.54%	0.6981219	0.101415011	4.13E-02			
9360.2	37440.8	14	67.4	269.6	15.3	254.3	0.5	15.7	5.83%	253.9	21.7	37.4	13.87%	5.84%	13.88%	0.7518235	0.104280408	4.38E-02			
10028.8	40115.2	15	72.2	288.8	16.2	272.7	0.5	16.7	5.78%	272.1	21.8	38.5	13.33%	5.78%	13.34%	0.8055252	0.107356504	4.66E-02			
10697.4	42789.5	16	77.0	308.1	17.1	291.0	0.6	17.7	5.76%	290.4	21.9	39.7	12.88%	5.76%	12.88%	0.8592269	0.110642885	4.95E-02			
11366.0	45463.8	17	81.8	327.4	18.2	309.2	0.7	18.8	5.75%	308.5	22.1	40.9	12.50%	5.76%	12.51%	0.9129286	0.114139139	5.25E-02			
12034.5	48138.2	18	86.7	346.6	19.2	327.4	0.8	20.0	5.77%	326.6	22.2	42.3	12.19%	5.77%	12.20%	0.9666303	0.117844857	5.58E-02			
12703.1	50812.5	19	91.5	365.9	20.4	345.5	0.9	21.3	5.81%	344.6	22.4	43.7	11.93%	5.81%	11.94%	1.0203932	0.121759631	5.99E-02			
13371.7	53486.9	20	96.3	385.1	21.6	363.5	0.9	22.6	5.86%	362.6	22.6	45.1	11.72%	5.86%	11.72%	1.0740336	0.125883055	6.29E-02			
14040.3	56161.2	21	101.1	404.4	22.9	381.5	1.0	23.9	5.92%	380.4	22.8	46.7	11.55%	5.92%	11.55%	1.1277353	0.130214723	6.67E-02			
14708.9	58835.6	22	105.9	423.6	24.2	399.4	1.1	25.4	5.99%	398.3	22.9	48.3	11.41%	5.99%	11.40%	1.181437	0.134754233	7.08E-02			
15377.5	61509.9	23	110.7	442.9	25.6	417.3	1.2	26.9	6.07%	416.0	23.1	50.0	11.29%	6.07%	11.29%	1.2351387	0.139501184	7.50E-02			
16046.1	64184.3	24	115.5	462.1	27.1	435.0	1.4	28.5	6.16%	433.7	23.3	51.8	11.21%	6.15%	11.20%	1.2888404	0.144455176	7.99E-02			
16714.6	66858.6	25	120.3	481.4	28.6	452.8	1.5	30.1	6.25%	451.3	23.6	53.6	11.14%	6.25%	11.14%	1.342542	0.149615811	8.39E-02			
17383.2	69532.9	26	125.2	500.7	30.2	470.4	1.6	31.8	6.35%	468.9	23.8	55.6	11.10%	6.35%	11.09%	1.3962437	0.154982695	8.87E-02			
18051.8	72207.3	27	130.0	519.9	31.9	488.0	1.7	33.6	6.46%	486.3	24.0	57.6	11.07%	6.45%	11.07%	1.4499454	0.160555431	9.36E-02			
18720.4	74881.6	28	134.8	539.2	33.6	505.6	1.8	35.4	6.57%	503.8	24.2	59.6	11.06%	6.56%	11.06%	1.5036471	0.166333629	9.87E-02			
19389.0	77556.0	29	139.6	558.4	35.4	523.1	2.0	37.3	6.68%	521.1	24.5	61.8	11.06%	6.68%	11.06%	1.5573488	0.172316896	1.04E-01			
20057.6	80230.3	30	144.4	577.7	37.2	540.5	2.1	39.3	6.80%	538.4	24.7	64.0	11.08%	6.80%	11.07%	1.6112055	0.178504844	1.10E-01			
20726.2	82904.7	31	149.2	596.9	39.1	557.8	2.2	41.3	6.92%	555.6	25.0	66.3	11.11%	6.92%	11.10%	1.6647521	0.184897085	1.15E-01			
21394.8	85579.0	32	154.0	616.2	41.1	575.1	2.4	43.4	7.05%	572.8	25.2	68.7	11.14%	7.05%	11.14%	1.7184538	0.191493233	1.21E-01			
22063.3	88253.3	33	158.9	635.4	43.1	592.4	2.5	45.6	7.17%	589.9	25.5	71.1	11.19%	7.17%	11.19%	1.7721555	0.198292905	1.27E-01			
22731.9	90927.7	34	163.7	654.7	45.2	609.5	2.7	47.8	7.30%	606.9	25.8	73.6	11.24%	7.30%	11.24%	1.8236572	0.205295718	1.33E-01			
23400.5	93602.0	35	168.5	674.0	47.3	626.6	2.8	50.1	7.44%	623.8	26.1	76.2	11.31%	7.44%	11.30%	1.8795589	0.212501291	1.40E-01			
24069.1	96276.4	36	173.3	693.2	49.5	643.7	3.0	52.5	7.57%	640.7	26.4	78.9	11.38%	7.57%	11.38%	1.9332605	0.219909245	1.46E-01			
24737.7	98950.7	37	178.1	712.5	51.8	660.7	3.1	54.9	7.71%	657.5	26.7	81.6	11.45%	7.71%	11.45%	1.9869622	0.227519203	1.53E-01			
25406.3	101625.1	38	182.9	731.7	54.1	677.6	3.3	57.4	7.85%	674.3	27.0	84.4	11.53%	7.85%	11.54%	2.0406639	0.235330789	1.60E-01			
26074.9	104299.4	39	187.7	751.0	56.5	694.4	3.5	60.0	7.99%	691.0	27.3	87.3	11.62%	7.99%	11.63%	2.0943656	0.243343629	1.67E-01			
26743.4	106973.8	40	192.6	770.2	59.0	711.2	3.6	62.6	8.13%	707.6	27.6	90.2	11.71%	8.13%	11.72%	2.1480673	0.251557351	1.75E-01			

Figure 2: DLF Calculation Table

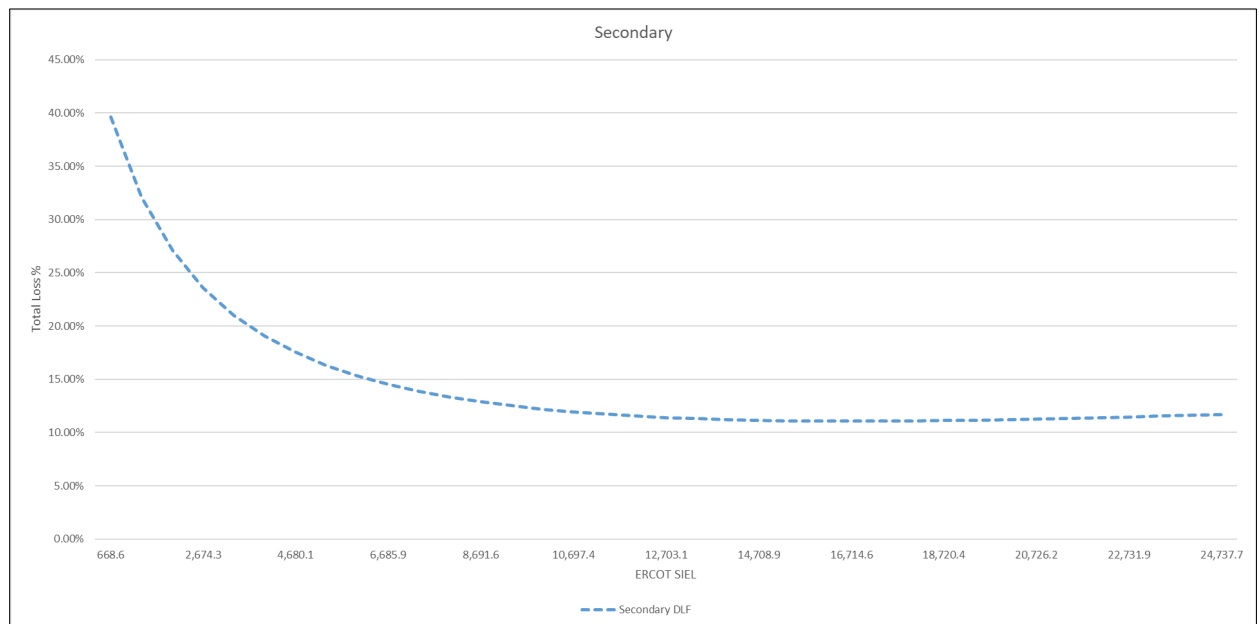


Figure 3: 15 kV Secondary DLF Calculated

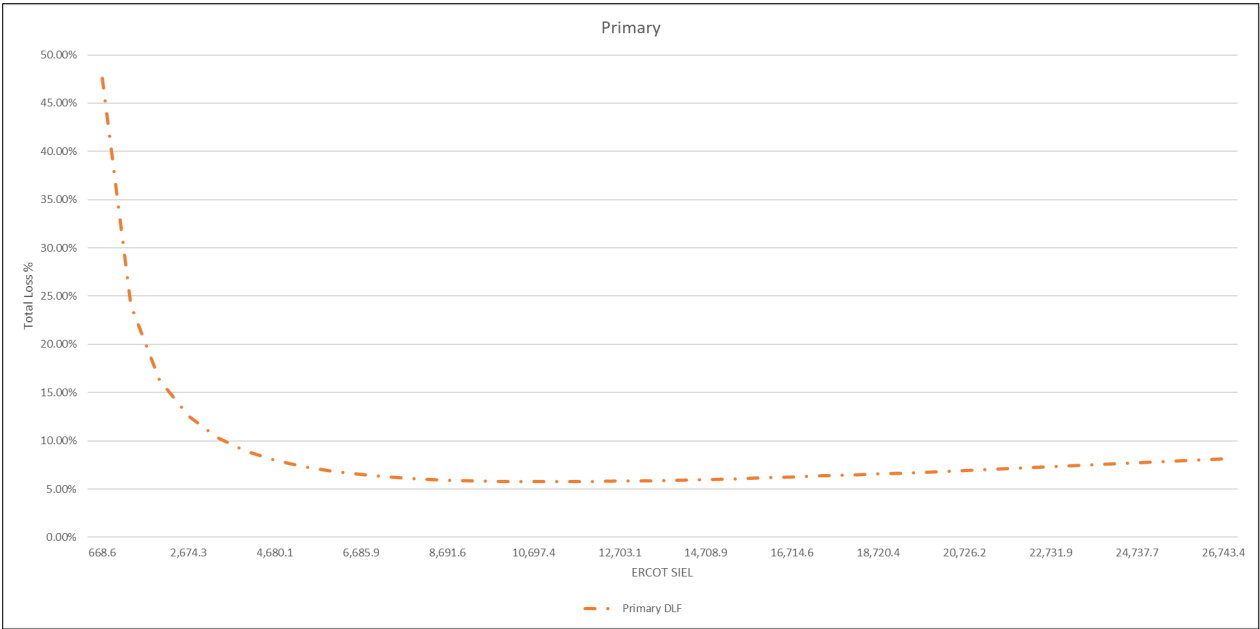


Figure 4: Primary DLF Calculated

A- Primary		B- Secondary	
F1 =	3.22E-02	F1 =	3.61E-02
F2 =	3.02E-04	F2 =	9.26E-04
F3 =	2.54E-02	F3 =	0.083277644