

2017 Study of Oncor Electric Delivery Distribution Loss Factors

General Information on Distribution Loss Factor:

The Distribution Loss Factor is a percent that ERCOT will use to determine distribution losses for each Distribution Service Provider. See ERCOT Protocols Section 13: Transmission and Distribution Losses, which was updated on September 1, 2016. See following protocol link:
<http://www.ercot.com/mktrules/nprotocols/current>

According to this protocol, ERCOT will calculate Distribution Loss Factors for each Settlement Interval of the Operating Day for settlement purposes. Distribution Loss Factors will be calculated from the data provided by Distribution Service Providers using the following equation:

$$SILFi = F1 * (SIELi/AAL) + F2 + F3 / (SIELi / AAL)$$

Where:

i = interval (15 minutes)

SILFi = Settlement Interval Distribution Loss Factor

SIELi = Settlement Interval estimated ERCOT System Load

AAL = Annual Interval Average ERCOT System Load (15 minute basis)

F1, F2, F3 = Coefficients derived from regression analysis of the TDSP loss study results

AAL = Annual Total System MWh / (Number of settlement intervals in the year)

Typically = 365 days * 24 hours * 4 intervals

2015 ERCOT AAL VALUE FOR USE IN 2017 = 9,918 MWH

General Statements on Oncor's Energy and Demand Data:

1. Oncor system losses were calculated using 2015 calendar year energy and demand peak. See Attachment 1.
2. Assume AAL for Oncor corresponds to AAL for ERCOT.
3. Oncor peak is proportionately greater than the peak for ERCOT, relative to AAL.

RATIO OF PEAK TO AAL (Ratio of Peak to AAL for Oncor is not proportional to ERCOT)

<u>Oncor</u>	<u>ERCOT</u>
1.86656	1.76137

	2015 for use in 2017	
	<u>15 mins</u>	<u>1 hour</u>
Oncor Peak	5,669.68	22,679
Oncor AAL	3,037.50	12,150
ERCOT Peak	17,469.25	69,877
ERCOT AAL	9,918.00	39,672

Oncor peak is proportionately higher than Oncor AAL as compared to ERCOT peak vs. ERCOT AAL, so % losses (and DLF) above AAL are increased an amount that is consistent with this higher loading at peak, so that when ERCOT hits peak, % losses will correspond to Oncor peak.

Customer Coding and Distribution Loss Factor Coefficients:

Distribution customers that take service at secondary voltage are coded "A"

Distribution customers that take service at primary voltage are coded "B"

FOR "A" SECONDARY CUSTOMERS

F1 = 0.017000

F2 = -0.002000

F3 = 0.017780

FOR "B" PRIMARY CUSTOMERS

F1 = 0.011470

F2 = -0.000310

F3 = 0.005300

Methodology for calculating the Distribution Load Factor:

Oncor contracted Management Applications Consulting (MAC) to perform a distribution system loss analysis for the 2015 calendar year.

The MAC report, as detailed in Attachment 1, provides a breakdown of Oncor's distribution system losses by voltage level (primary and secondary), including "no-load" & "load" losses for substation and distribution transformers.

Equations for distribution substation transformer losses, distribution primary conductor losses, distribution transformer losses and secondary conductor losses were utilized to calculate the total losses on Oncor's distribution system for various load levels. See Page 6.

$$\begin{aligned}
 \text{Losses} &= AX^2 + B \\
 A &= \text{Constant} \\
 B &= \text{Constant (No-load losses)} \\
 X &= \text{Input to System (MW)}
 \end{aligned}$$

Constants A & B were then used to recalculate the loss equations by customer class (primary metered customers and secondary metered customers), and at different load levels. See Page 4.

The resulting losses were plotted by customer class, as a function of ERCOT AAL. See Pages 5 & 6.

DLF Coefficients (F1, F2 and F3):

For both primary and secondary customers, the F1, F2 and F3 coefficients were selected to provide a curve fit with the loss equations that were developed above. F1 impacts the right side of the curve, F2 impacts the middle/entire curve, and F3 impacts the left side of the curve. These coefficients were adjusted to get a curve that would fit in the most critical areas. See Pages 5 & 6.

The F1, F2, and F3 coefficients for "A" secondary customers and "B" primary metered customers for 2015 are shown above.

Distribution Loss Factor:

FOR "A" SECONDARY CUSTOMERS

2015 for use in 2017

DLF at AAL **3.278%**

DLF at ERCOT Peak **3.804%**

FOR "B" PRIMARY CUSTOMERS

2015 for use in 2017

DLF at AAL **1.367%**

DLF at ERCOT Peak **2.011%**

2017 Study of Oncor Electric Delivery Distribution Loss Factors																With Scaling	Using F1, F2 & F3 Coefficients		With Scaling		Adjustment for % Losses	
ERCOT Load (15 min)	ERCOT Load (1 hr)		Oncor Load (15 min)	Oncor Input To Sub Trfs (MW)	Sub Trf Losses (MW)	Input to Dist Sys (MW)	Primary Conductor Losses (MW)	Total Primary Losses	Total Primary Loss %	Input to Dist Trfs (MW)	Dist Trf Losses (MW)	2015 Input To Secondary (MW)	Secondary Conductor Losses (MW)	2015 Total Losses (MW)	2015 Total Losses (%)	2015 Total Losses (%)	2015 DLF Secondary	2015 DLF Primary	Total Primary Loss %	2015 Primary Loss %		
SIEL																0.0000%			0.0000%			
			50		49.67	0.33	0.61	50.28	100.56%	-0.28	151.41	-151.69	12.05	213.74	427.473%	427.473%						
			135		49.67	85.33	0.61	50.29	37.25%	84.71	151.41	-66.70	12.04	213.74	158.326%	158.326%						
			500		49.72	450.28	0.73	50.45	10.09%	449.55	151.46	298.09	12.06	213.97	42.794%	42.794%						
816	3265		250	1000	49.85	950.15	1.16	51.01	5.10%	948.99	151.63	797.36	12.20	214.84	21.484%	21.484%						
1633	6530	1	500	2000	50.40	1949.60	2.93	53.33	2.67%	1946.67	152.32	1794.35	12.86	218.51	10.926%	10.926%	10.881%	3.099%	2.667%	2.667%		
3673	14693	2	1125	4500	53.36	4446.64	12.70	66.06	1.47%	4433.94	156.13	4277.81	16.68	238.87	5.308%	5.308%	5.230%	1.546%	1.468%	1.468%		
4204	16816	3	1287.5	5150	54.50	5095.50	16.48	70.98	1.38%	5079.02	157.61	4921.41	18.19	246.78	4.792%	4.792%	4.715%	1.427%	1.378%	1.378%		
4735	18938	4	1450	5800	55.80	5744.20	20.78	76.58	1.32%	5723.42	159.28	5564.14	19.90	255.76	4.410%	4.410%	4.336%	1.348%	1.320%	1.320%		
5265	21060	5	1612.5	6450	57.25	6392.75	25.59	82.84	1.28%	6367.16	161.15	6206.01	21.82	265.81	4.121%	4.121%	4.052%	1.297%	1.284%	1.284%		
5796	23183	6	1775	7100	58.86	7041.14	30.91	89.77	1.26%	7010.23	163.22	6847.01	23.94	276.93	3.900%	3.900%	3.836%	1.267%	1.264%	1.264%		
6326	25305	7	1937.5	7750	60.62	7689.38	36.75	97.37	1.26%	7652.63	165.48	7487.15	26.27	289.12	3.731%	3.731%	3.672%	1.253%	1.256%	1.256%		
6857	27428	8	2100	8400	62.53	8337.47	43.10	105.63	1.26%	8294.37	167.94	8126.43	28.80	302.37	3.600%	3.600%	3.547%	1.250%	1.258%	1.258%		
7387	29550	9	2262.5	9050	64.60	8985.40	49.96	114.56	1.27%	8935.44	170.59	8764.85	31.54	316.69	3.499%	3.499%	3.453%	1.256%	1.266%	1.266%		
7918	31672	10	2425	9700	66.82	9633.18	57.33	124.15	1.28%	9575.85	173.44	9402.41	34.48	332.07	3.423%	3.423%	3.384%	1.270%	1.280%	1.280%		
8449	33795	11	2587.5	10350	69.20	10280.80	65.21	134.41	1.30%	10215.59	176.48	10039.11	37.62	348.51	3.367%	3.367%	3.335%	1.289%	1.299%	1.299%		
8979	35917	12	2750	11000	71.73	10928.27	73.61	145.34	1.32%	10854.66	179.72	10674.95	40.96	366.01	3.327%	3.327%	3.303%	1.314%	1.321%	1.321%		
9510	38039	13	2912.5	11650	74.41	11575.59	82.51	156.92	1.35%	11493.08	183.14	11309.93	44.51	384.57	3.301%	3.301%	3.284%	1.343%	1.347%	1.347%		
10040	40162	14	3075	12300	77.25	12222.75	91.92	169.17	1.38%	12130.83	186.76	11944.06	48.25	404.19	3.286%	3.293%	3.277%	1.375%	1.375%	1.381%		
10571	42284	15	3237.5	12950	80.24	12869.76	101.85	182.09	1.41%	12767.91	190.57	12577.34	52.19	424.85	3.281%	3.295%	3.280%	1.410%	1.406%	1.418%		
11102	44407	16	3400	13600	83.39	13516.61	112.28	195.67	1.44%	13404.33	194.57	13209.76	56.33	446.57	3.284%	3.304%	3.291%	1.447%	1.439%	1.456%		
11632	46529	17	3562.5	14250	86.69	14163.31	123.22	209.91	1.47%	14040.09	198.77	13841.32	60.67	469.34	3.294%	3.321%	3.310%	1.487%	1.473%	1.497%		
12163	48651	18	3725	14900	90.14	14809.86	134.67	224.81	1.51%	14675.19	203.15	14472.04	65.20	493.16	3.310%	3.344%	3.335%	1.529%	1.509%	1.538%		
12693	50774	19	3887.5	15550	93.75	15456.25	146.63	240.38	1.55%	15309.62	207.72	15101.90	69.93	518.03	3.331%	3.373%	3.365%	1.572%	1.546%	1.581%		
13224	52896	20	4050	16200	97.51	16102.49	159.10	256.61	1.58%	15943.39	212.48	15730.92	74.85	543.93	3.358%	3.406%	3.400%	1.617%	1.584%	1.625%		
13755	55018	21	4212.5	16850	101.43	16748.57	172.07	273.50	1.62%	16576.50	217.42	16359.08	79.97	570.89	3.388%	3.444%	3.440%	1.663%	1.623%	1.670%		
14285	57141	22	4375	17500	105.50	17394.50	185.55	291.05	1.66%	17208.95	222.55	16986.40	85.28	598.88	3.422%	3.485%	3.483%	1.710%	1.663%	1.716%		
14816	59263	23	4537.5	18150	109.72	18040.28	199.53	309.26	1.70%	17840.74	227.87	17612.87	90.78	627.91	3.460%	3.529%	3.530%	1.758%	1.704%	1.763%		
15346	61385	24	4700	18800	114.10	18685.90	214.03	328.13	1.75%	18471.87	233.38	18238.49	96.47	657.98	3.500%	3.576%	3.580%	1.807%	1.745%	1.810%		
15877	63508	25	4862.5	19450	118.63	19331.37	229.03	347.66	1.79%	19102.34	239.07	18863.27	102.36	689.09	3.543%	3.626%	3.632%	1.857%	1.787%	1.858%		
16408	65630	26	5025	20100	123.32	19976.68	244.53	367.85	1.83%	19732.15	244.95	19487.20	108.43	721.23	3.588%	3.678%	3.687%	1.908%	1.830%	1.906%		
16938	67753	27	5187.5	20750	128.16	20621.84	260.54	388.70	1.87%	20361.30	251.01	20110.29	114.69	754.40	3.636%	3.733%	3.744%	1.959%	1.873%	1.955%		
17469	69875	28	5350	21400	133.16	21266.84	277.05	410.21	1.92%	20989.79	257.25	20732.54	121.14	788.60	3.685%	3.789%	3.804%	2.011%	1.917%	2.005%		
17999	71997	29	5512.5	22050	138.30	21911.70	294.07	432.38	1.96%	21617.62	263.68	21353.95	127.78	823.84	3.736%	3.847%	3.865%	2.064%	1.961%	2.055%		
18530	74120	30	5675	22700	143.61	22556.39	311.60	455.20	2.01%	22244.80	270.28	21974.51	134.61	860.09	3.789%	3.907%	3.928%	2.117%	2.005%	2.105%		
19061	76242	31	5837.5	23350	149.06	23200.94	329.62	478.69	2.05%	22871.31	277.07	22594.24	141.62	897.38	3.843%	3.968%	3.992%	2.170%	2.050%	2.156%		
19591	78364	32	6000	24000	154.67	23845.33	348.15	502.83	2.10%	23497.17	284.05	23213.13	148.81	935.69	3.899%	4.030%	4.058%	2.224%	2.095%	2.207%		
20122	80487	33	6162.5	24650	160.44	24489.56	367.19	527.62	2.14%	24122.38	291.20	23831.18	156.19	975.02	3.955%	4.094%	4.125%	2.278%	2.140%	2.258%		
20652	82609	34	6325	25300	166.36	25133.64	386.72	553.08	2.19%	24746.92	298.53	24448.39	163.76	1015.37	4.013%	4.159%	4.194%	2.333%	2.186%	2.309%		
21183	84732	35	6487.5	25950	172.43	25777.57	406.76	579.19	2.23%	25370.81	306.04	25064.77	171.50	1056.74	4.072%	4.225%	4.263%	2.388%	2.232%	2.361%		
21713	86854	36	6650	26600	178.66	26421.34	427.30	605.96	2.28%	25994.04	313.73	25680.31	179.43	1099.12	4.132%	4.292%	4.334%	2.443%	2.278%	2.413%		
9918	39672		3037.5	12150																		
15 min	ERCOT		15 min	Oncor																		
9,918	39,672	AAL	3037.5	12150.00	76.58	12073.42	89.10	165.68	1.3636%	11984.32	185.91	11798.41	35.33	386.92	3.185%							
17,469.3	69,877	Peak	5669.675	22,679	143.43	22535.27	310.40	453.83	2.0011%	22224.87	270.07	21954.79	122.35	846.25	3.731%							

When ERCOT is at peak, Oncor is 2 intervals below peak, so % losses at ERCOT peak are scaled up to match % losses at Oncor peak.

Scaling for % Losses	
Secondary	Primary
0.1040%	0.0880%

AAL for ERCOT (15 mins) = 9,918
DLF = F1 * (SIEL/AAL) + F2 + F3 / (SIEL/AAL)

Substation Transformers		Primary Conductor	
B Constant	A Constant	B Constant	A Constant
49.67	1.8230E-07	0.61	6.11227E-07

Distribution Transformers		Secondary Conductor	
B Constant	A Constant	B Constant	A Constant
151.41	2.40232E-07	12.04	2.53826E-07

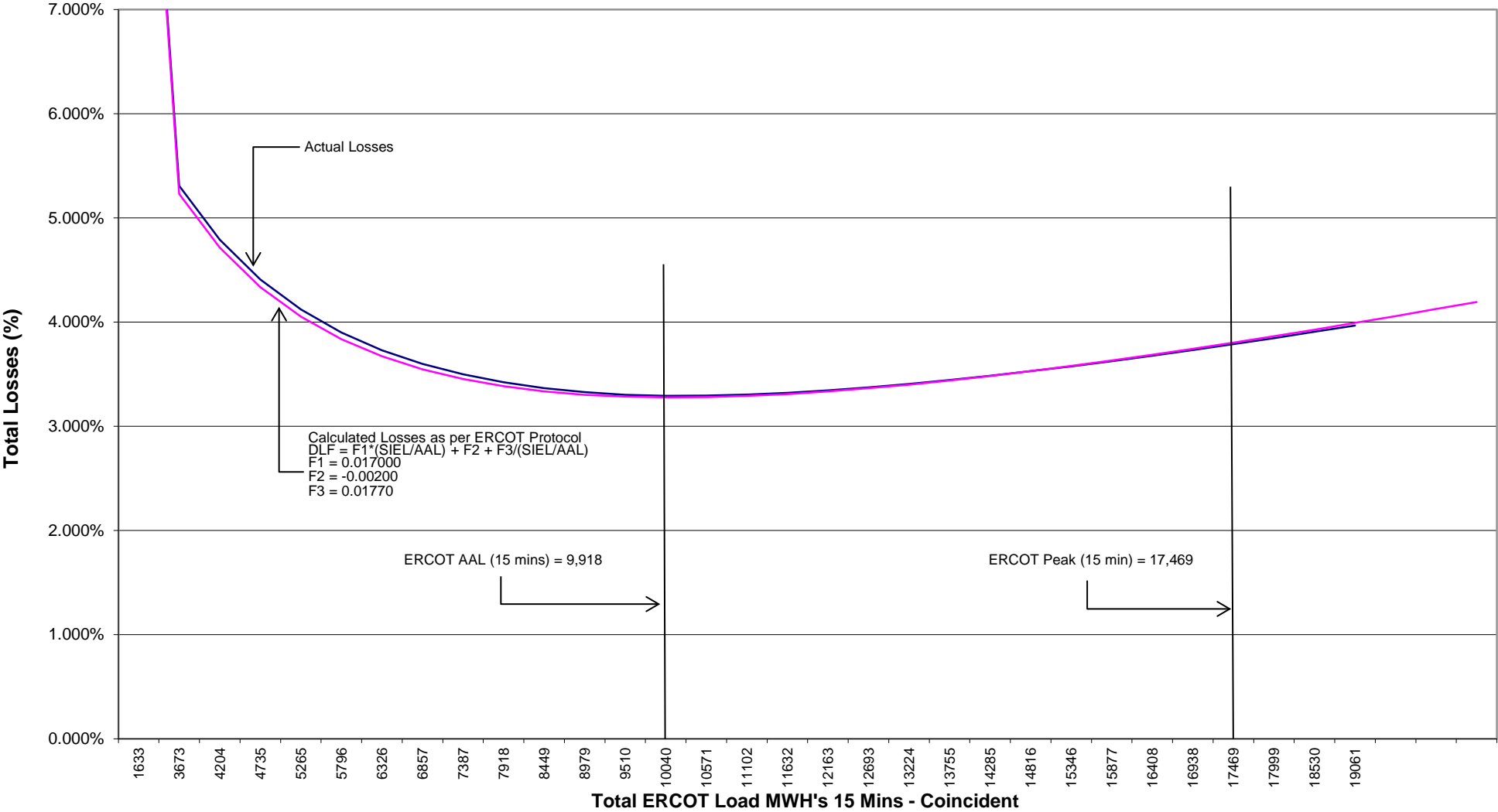
----- 2015 Values

For Secondary Distribution Customers "A"

Secondary Coefficients

F1 = 0.017000 right
F2 = -0.002000 middle
F3 = 0.017780 left

2017 Study of Oncor Electric Delivery Distribution Loss Factors (%) For Secondary Distribution Customers "A"

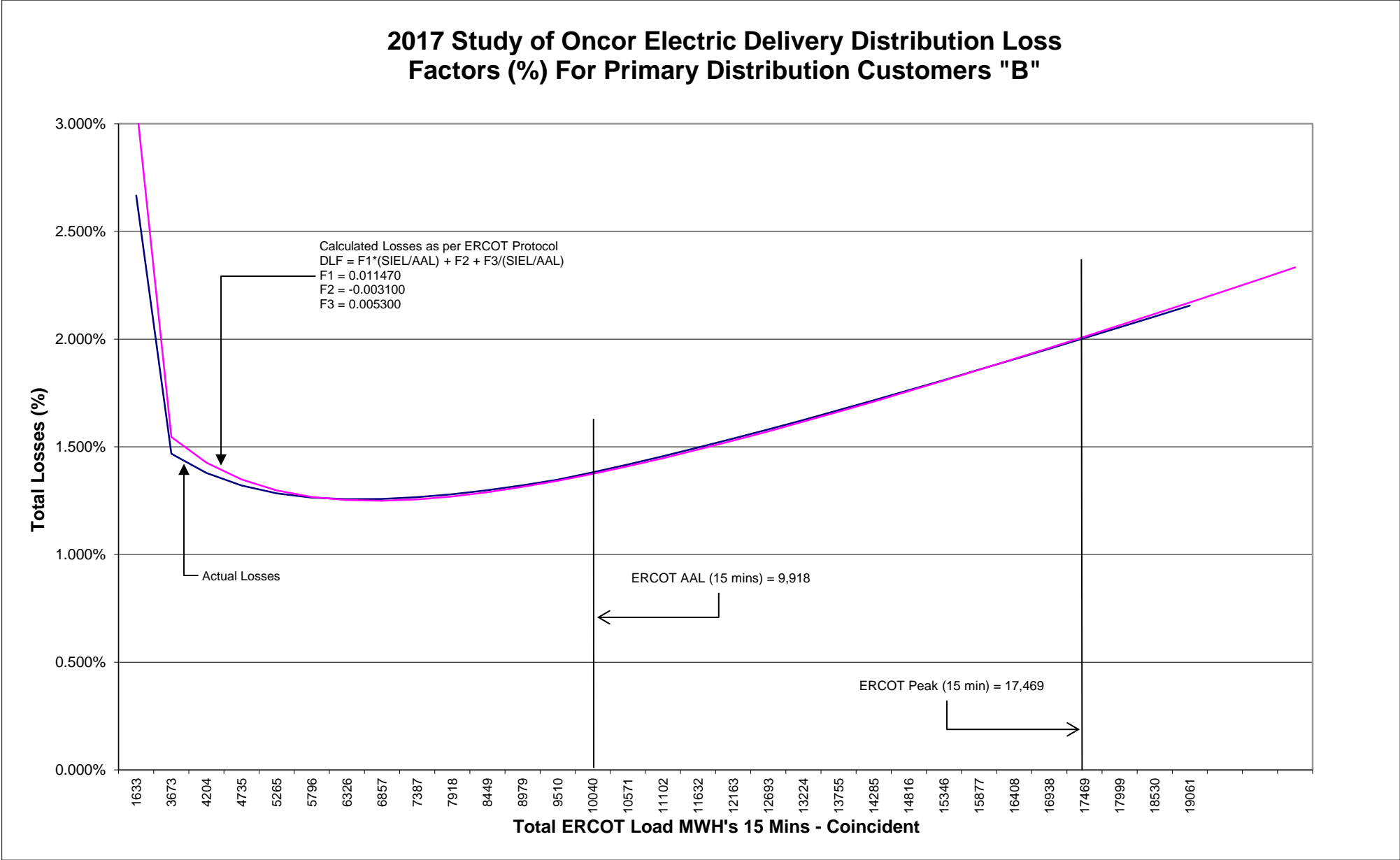


For Primary Distribution Customers "B"

Primary Coefficients

F1 =	0.011470	right
F2 =	-0.003100	middle
F3 =	0.005300	left

2017 Study of Oncor Electric Delivery Distribution Loss Factors (%) For Primary Distribution Customers "B"



System Loss Equations - Using Oncor's peak data and losses, at ERCOT peak:

$$\text{Losses} = AX^2 + B$$

A = Constant

B = Constant (No-load losses)

X = Input to System (MW)

SUBSTATION TRANSFORMERS

$$143.43 = A * (22,678.7 * 22,678.7) + 49.67$$

$$A = 1.82298E-07$$

$$B = 4.96700E+01$$

Total No-Load Losses for Substation Transformers = 49.67 MW

Total Load Losses = 93.76 MW at 22,678.7 MW load level

2015

No Load Losses	49.670
Load Losses	<u>93.760</u>
Total	143.430

PRIMARY CONDUCTOR

$$299.55 = A * (22,115 * 22,115) + 0.61$$

$$A = 6.11227E-07$$

$$B = 6.10000E-01$$

Total No-Load Losses for Primary Lines = 0.61 MW

(auto-transformers no-load losses)

Total Load Losses = 298.94 MW at 22,115.2 MW load level

2015

No Load Losses	0.610
Load Losses	<u>298.940</u>
Total	299.550

DISTRIBUTION TRANSFORMERS

$$249.89 = A * (20,247 * 20,247) + 151.41$$

$$A = 2.40232E-07$$

$$B = 1.51410E+02$$

Total No-Load Losses for Distribution Transformers = 151.41 MW

Total Load Losses = 98.48 MW at 20,246.9 MW input to Distribution Transformers

2015

No Load Losses	151.410
Load Losses	<u>98.480</u>
Total	249.890

SECONDARY CONDUCTOR

$$113.54 = A * (19,997 * 19,997) + 12.04$$

$$A = 2.53826E-07$$

$$B = 1.20400E+01$$

Total No-Load Losses for Services = 12.04 MW (meter losses)

Total Load Losses for Secondary Conductor/Services = 101.5 MW at 19,997 MW load level

2015

No Load Losses	12.040
Load Losses	<u>101.500</u>
Total	113.540



MANAGEMENT APPLICATIONS CONSULTING, INC.

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January 27, 2017

Mr. J. Michael Sherburne
Sr. Director, Rates and Financial Analysis
Oncor Electric Delivery Company LLC
1616 Woodall Rodgers Freeway, Suite 6D-007
Dallas, TX 75202

RE: 2015 LOSS ANALYSIS

Dear Mr. Sherburne:

Transmitted herewith are the results of the 2015 Analysis of System Losses for the Oncor Electric Delivery System's (Oncor) power system. Our analysis develops cumulative expansion factors (loss factors) for both demand (peak/MW) and energy (average/MWh) losses by discrete voltage levels applicable to metered sales data. Table 1 of the Executive Summary presents the results and appropriate loss factors to apply to metered load research or sales data for adjustment to system input.

On behalf of MAC, we appreciate the opportunity to assist you in performing the loss analysis contained herein. The level of detailed load research and sales data by voltage level, coupled with a summary of power flow data and power system model, forms the foundation for determining reasonable and representative power losses on the Oncor system. Our review of these data and calculated loss results support the proposed loss factors as presented herein for your use in various cost of service, rate studies, and demand analyses.

Should you require any additional information, please let us know at your earliest convenience.

Sincerely,

Paul M. Normand
Principal

Enclosure
PMN/rjp

ATTACHMENT 1 PAGE 2 OF 2

ONCOR 2015 LOSS ANALYSIS

SUMMARY of SALES and CALCULATED LOSSES

EXHIBIT 5

LOSS # AND LEVEL	MW LOAD	NO LOAD	+	LOAD	=	TOT LOSS	EXP FACTOR	CUM EXP FAC	MWH LOAD	NO LOAD	+	LOAD	=	TOT LOSS	EXP FACTOR	CUM EXP FAC
1 BULK XFMMR	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0	0
2 BULK LINES	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
3 TRANS1 XFMR	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
4 TRANS1 LINES	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
5 TRANS2TR1 SD	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
6 TRANS2BLK SD	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
7 TRANS2 LINES	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
TOTAL TRAN	0.0	0.00		0.00		0.00	1.000000	1.000000	0	0		0		0	1.0000000	1.0000000
8 STR1BLK SD																
9 STR1T1 SD	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
10 SRT1T2 SD	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
11 SUBTRANS1 LINES	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
12 STR2T1 SD	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
13 STR2T2 SD	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
14 STR2S1 SD	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
15 SUBTRANS2 LINES	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
16 STR3T1 SD	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
17 STR3T2 SD	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
18 STR3S1 SD	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
19 STR3S2 SD	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
20 SUBTRANS3 LINES	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
21 SUBTRANS TOTAL	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
DISTRIBUTION SUBST																
TRANS1	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
TRANS2	22,678.7	49.67		93.76		143.43	1.006364	1.006364	106,435,666	341,427		265,963		607,390	1.0057394	1.0057394
SUBTR1	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
SUBTR2	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
SUBTR3	0.0	0.00		0.00		0.00	0.000000	0.000000	0	0		0		0	0.0000000	0.0000000
WEIGHTED AVERAGE	22,678.7	49.67		93.76		143.43	1.006364	1.006364	106,435,666	341,427		265,963		607,390	1.0057394	1.0057394
PRIMARY INTRCHNGE	0.0						0.000000		0						0.0000000	
PRIMARY LINES	22,115.2	0.61		298.94		299.56	1.013731	1.020183	102,610,160	5,350		936,888		942,238	1.0092678	1.0150604
LINE TRANSF	20,246.9	151.41		98.48		249.89	1.012496	1.032932	89,713,392	1,326,342		222,724		1,549,066	1.0175702	1.0328952
SECONDARY	19,997.0	0.00		37.76		37.76	1.001892	1.034886	88,164,325	0		87,940		87,940	1.0009984	1.0339265
SERVICES	19,959.2	12.04		63.74		75.78	1.003811	1.038830	88,076,386	105,458		170,703		276,161	1.0031453	1.0371785
TOTAL SYSTEM		=====		=====		=====				=====		=====		=====		
		213.72		592.68		806.40				1,778,576		1,684,217		3,462,794		