

ComEd Distribution System Loss Study

Commonwealth Edison Company

April 26, 2010

Summary

An engineering analysis of distribution system losses using 12 months ending December 31, 2009 (Study Period) customer hourly load data and distribution system equipment information was conducted to determine the Distribution Loss Factors. Distribution losses are determined by subtracting energy delivered to retail and wholesale customers plus transmission losses from the ComEd Zone Load. The ComEd Zone Load is the summation of the net output of all generators within the ComEd Zone plus net transmission interchange.

Study Approach

Distribution losses were calculated using a simplified resistance model of the elements that are used to deliver energy from the transmission system to consumers. The calculated losses are used to allocate total distribution losses to each customer class. All abbreviated terms used in the document are provided in the Abbreviated Terms section below.

Customer Classes

An hourly load profile for each customer class was developed using appropriate sample data, as described in a document with the title "E-7 Load Research Results and Supporting Materials", submitted in this docket pursuant to Section 285.5120 of 83 Illinois Administrative Code Part 285, the standard information requirements for public utilities. Each profile represents electricity deliveries to a class of customers during the Study Period. The classes represent those in Rate RDS – Retail Delivery Service (Rate RDS) and to wholesale resale municipalities. Electricity deliveries to all ComEd retail customers (i.e., those taking ComEd bundled service as well as those taking delivery service from ComEd and unbundled supply service either from a Retail Electric Supplier or from ComEd under the Power Purchase Option) are included in the load profiles by customer class. A description of the customer classes used for this distribution loss factor determination is listed in Appendix A. Hourly loads for each applicable customer class were increased to include service provided without charge (also known as free service) and ComEd company use in that customer class. The load for the high voltage customer class in this distribution loss factor determination is for the portion of the load receiving service at 69 kV or higher voltage. The portions of load receiving service at voltages below 69 kV to customers with up to 10,000 kW of load and to customers with Over 10,000 kW of load in the High Voltage Delivery Class are included with the Very Large Load (1,000 kW to 10,000 kW) and the Extra Large Load (Over 10,000 kW) customer classes, respectively. In addition, the load for the D-D Lighting in this study includes loads for both the Dusk to Dawn Lighting and the Fixture-Included Lighting Delivery Classes.

Loss Model

The simplified resistance model of the distribution system is used to account for load and no-load losses in loss causing elements. A diagram of the simplified resistance model is shown in Appendix B. An allocation factor for each element defines the portion of the energy for each customer class that flows through that element. Allocation factors were determined from review of the equipment configuration typically used to serve customers of that class. The allocation factors are listed in Appendix C. Utilizing these allocation factors and the customer class loads at the system peak hour for the Study Period (hour ending 3 p.m. on

June 25, 2009, which is the 2009 system peak hour), load dependent and non-load dependent losses are calculated for each element. Per unit load and no-load loss factors for each element are based on system average values and are listed in Appendix D. System peak hour losses are determined for each customer class and each element. Peak hour losses and losses as a percent of load for each element are listed in Appendix E.

Element Loss Calculation

Losses in the elements consist of both load losses and no-load losses. Load losses occur in each element and vary with the square of the load (I^2R).

Load Losses:

- Feeder and line load loss is calculated as the sum of the allocated class loads squared, multiplied by element percent load loss, all divided by the coincident load.
- Load loss for substation transformers that serve many customers in multiple customer classes (Appendix D, loss code = 1) is calculated as the sum of the loads for all classes squared, multiplied by the element percent load loss, divided by the nameplate MVA of the transformers in that class.
- Load loss for transformers used to serve customers of the same class (Appendix D, loss code = 2) is calculated as the sum for each load class of the class load squared, divided by the total class-coincident load, summation quantity multiplied by the element percent load loss.

No-Load (core) Losses:

- Transformer element no-load loss is calculated from installed MVA of transformer capacity multiplied by the percent core loss for that category of transformer.

Some transformers are located at 138-69, 138-34, 138-12, 69-12, 34-12, 34-4 and 12-4 kV substations. Other transformers are used to reduce primary feeder voltages to the customer delivery voltage. No-load losses are constant at all load levels. The distribution loss model does not model transmission system losses. Electricity used for operation of ComEd office and operational centers has been accounted for in the class load profiles and is not considered as a part of energy losses.

Non-coincident Class Peak Loads

For customer classes with a non-coincident peak significantly different from the load at the system peak hour, the peak load and no-load losses are based on losses for an hour representative of that class. For the dusk to dawn lighting class, the non-coincident peak hour (hour ending 10 p.m. on June 25, 2009) was used. For both the residential single family and multi family electric space heat classes, the average of the load at the 2009 system peak hour and the load at the respective class 2009 winter peak hour, the hour ending 8 a.m. on January 16, 2009 was used. The class-to-element allocation factors are used to allocate element losses to class loads to determine the peak hour losses by customer class.

Annual Energy Losses

Hourly load losses for each class for each hour are then calculated using the square of the ratio of the hourly class load for the hour to the class load at the peak hour multiplied by the load loss at the peak hour.

$$\text{Hourly Load Loss} = \text{Peak Load Loss} * (\text{Hourly Load}/\text{Peak Load}) ^2$$

No-load losses determined for the peak hour remain constant for all hours. The annual loss factor for each class is determined by the ratio of total load and no-load losses for the class to the annual deliveries for that class. A summary of losses on an annual basis for each class is listed in Appendix G.

Transmission Losses

Annual transmission losses were separately determined to be 1.6% of load at the interface between the transmission and distribution systems. Transmission system losses range from about 1.3% at low load levels to about 1.9% at peak load levels. Transmission Planning confirmed that these values are appropriate for a loss determination.

Changes From the Previous (Year 2006) Loss Study

- The Winnetka and Rock Falls municipal utility loads were added to the ComEd Zone in 2008.
- Substation and distribution transformer quantities were updated.

Reconciliation of Peak Hour Losses

The sum of the calculated transmission and distribution losses for all delivery system users plus total energy delivered was compared to the ComEd Zone load at the system coincident peak hour. The ComEd Zone load is a measurement of the net output of generating stations within ComEd service territory plus net interchange into the ComEd transmission system. The calculated load plus losses was 216.4 MW (1.0% of the load) less than the ComEd Zone load. The load losses for each class were proportionally increased by this amount to fully allocate peak hour losses. Peak hour load (I²R) and no-load (core) losses and loads by class following this adjustment are listed in Appendix F.

Reconciliation with ComEd Zone Energy for the Study Period

Total distribution energy loss for each class is determined by summing the load and non-load losses for all hours by class. As a final check, class energy deliveries, distribution losses by class and transmission losses were totaled for comparison to the ComEd Zone energy for the Study Period. The ComEd Zone energy was approximately 0.9992 of the deliveries plus losses. A final adjustment to losses was applied so that load plus losses equals the ComEd Zone Load. Appendix G contains the total energy delivered and calculated annual distribution energy losses by class.

Abbreviated Terms

AC	Alternating Current
ACNW	Alternating Current Network
DC	Distribution Center
DRYTR	Dry Type Transformer
ESS	Electric Service Station
FDR	Feeder
HV	High Voltage
kV	Kilovolt
kVA	Kilovolt Ampere
kW	Kilowatt
MVA	Megavolt Ampere
SEC	Secondary
TDC	Transmission Distribution Center
TR, TRANF	Transformer
TSS	Transmission Substation

Appendix A

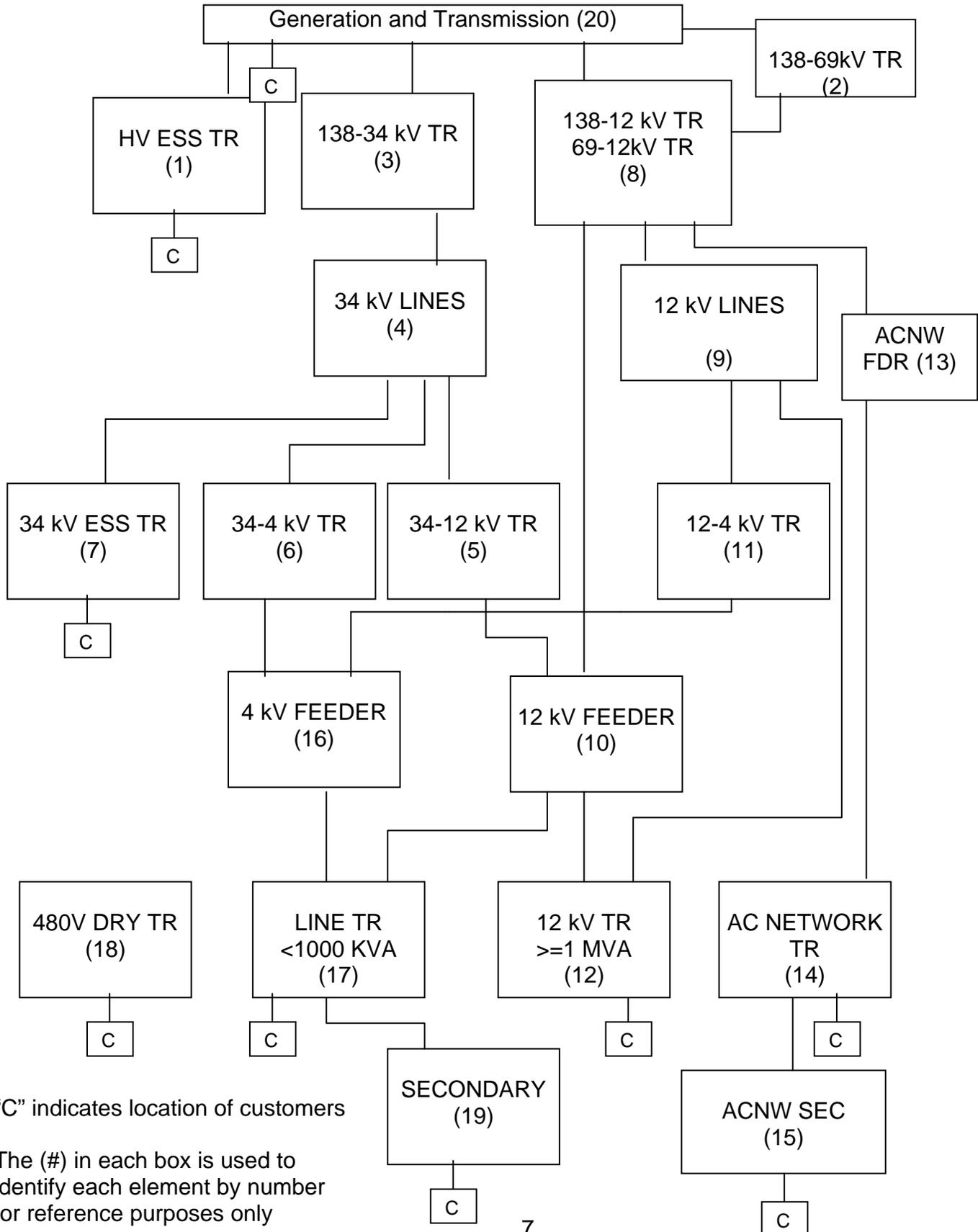
2009 Distribution System Loss Factors - Customer Classes

2009 Loss Factors – Customer Classes ⁽¹⁾	
Abbreviation	Description
SF	Single Family Without Electric Space Heat
MF	Multi Family Without Electric Space Heat
SF_SH	Single Family With Electric Space Heat
MF_SH	Multi Family With Electric Space Heat
WH	Watt-Hour
0-100 kW	Small Load (0 to 100 kW)
100-400 kW	Medium Load (100 to 400 kW)
400-1,000 kW	Large Load (400 to 1,000 kW)
1-10 MW	Very Large Load (1,000 to 10,000 kW) ⁽²⁾
>10 MW	Extra Large Load (Over 10,000 kW) ⁽²⁾
HV > = 69 kV	Receiving service at 69 kV and higher voltage ⁽²⁾
Railroad	Railroad (using electric traction power)
D-D Lighting	Dusk to Dawn Lighting and Fixture-Included Lighting
Gen Lighting	General Lighting
Muni	Wholesale Municipal ⁽³⁾

Notes:

- (1) Hourly loads for comparable classes have been increased to account for electricity delivered for:
 - Service provided without charge
 - ComEd company use
- (2) For the determination of distribution losses, the portions of load that are receiving service at voltages below 69 kV to customers with up to 10,000 kW of load and to customers with over 10,000 kW of load in the High Voltage Delivery Class are included in the Very Large Load (1,000 kW to 10,000 kW) and the Extra Large Load customer classes, respectively. The portion that is receiving service at 69 kV and higher voltage to customers in the High Voltage Delivery Class is included in the “HV >= 69 kV” customer class.
- (3) Wholesale municipal load include all deliveries to Naperville, St. Charles, Batavia, Geneva, Winnetka, Rock Falls, and Rochelle.

2009 Loss Factors - Simplified System Resistance Model



“C” indicates location of customers

The (#) in each box is used to identify each element by number for reference purposes only

2009 Loss Factors - Percent of Class Load Through Elements

Element		SF	MF	SF_SH	MF_SH	WH	0-100 kW	100-400 kW	400- 1,000 kW	1-10 MW	>10 MW	HV >= 69 kV	Railroad	D-D Lighting	Gen Lighting	Muni
(#)	Description															
1	HV ESS	0	0	0	0	0	0	0	0	0	0	100	0	0	0	13
2	138-69 TSS	4	4	4	4	4	4	4	4	4	4	6	5	4	4	0
3	138-34 TSS	17	16	17	16	17	17	20	20	25	25	0	3	17	17	34
4	34KV LINES	17	16	17	16	17	17	20	20	25	25	0	3	17	17	34
5	34-12KV DC	13	13	12	13	13	13	10	6	0	0	0	3	13	13	0
6	34-4KV DC	4	3	5	3	4	4	5	1	0	0	0	0	4	4	0
7	34KV ESS	0	0	0	0	0	0	5	13	25	25	0	0	0	0	5
8	138/69-12 TDC	83	84	83	84	83	83	80	80	75	75	0	97	83	83	0
9	12KV LINES	5	5	5	5	5	7	8	11	35	35	0	85	10	10	0
10	12KV FDR	78	77	78	77	73	71	67	64	40	40	0	12	71	71	0
11	12-4KV DC	5	5	5	5	5	5	3	0	0	0	0	0	5	5	0
12	12KV ESS	0	0	0	0	0	0	10	25	75	75	0	0	0	0	0
13	ACNW FDR	0	2	0	2	5	5	5	5	0	0	0	0	2	2	0
14	ACNW TRANF	0	2	0	2	5	5	5	5	0	0	0	0	2	2	0
15	ACNW SEC	0	2	0	2	5	5	5	5	0	0	0	0	2	2	0
16	4KV FDR	9	8	10	8	9	9	8	1	0	0	0	0	9	9	0
17	LINE TRANF	100	98	100	98	95	95	80	57	0	0	0	0	98	98	0
18	480V DRYTR	0	10	0	10	5	2	0	0	0	0	0	0	0	0	0
19	SEC / SERVICE	95	95	95	95	80	70	0	0	0	0	0	0	90	90	0
20	Transmission	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Appendix D

2009 Loss Factors - Element Loss Parameters

Element losses at nameplate load for transformers or at system peak for lines

#	Element	Core loss%	I ² R loss%	Base MVA	Loss Code (See Note 1)
	Description				
1	HV ESS	0.2	0.8	3,575	2
2	138-69 TSS	0.2	0.6	2,122	1
3	138-34 TSS	0.2	0.7	6,123	1
4	34KV LINES	0	3	3,637	1
5	34-12KV DC	0.2	0.8	3,915	1
6	34-4KV DC	0.3	0.8	1,167	1
7	34KV ESS	0.3	0.8	2,619	2
8	138/69-12 TDC	0.2	1	22,733	1
9	12KV LINES	0	1.8	2,257	1
10	12KV FDR	0	4	11,755	1
11	12-4KV DC	0.3	0.8	1,085	1
12	12KV ESS	0.3	0.8	16,344	2
13	ACNW FDR	0	0.8	359	1
14	ACNW TRANF	0.3	1	2,143	1
15	ACNW SEC	0	0.5	359	1
16	4KV FDR	0	5	1,093	1
17	LINE TRANF	0.4	1.4	33,024	2
18	480V DRYTR	0.7	1.4	528	2
19	SECONDARY	0	2	9,061	1
20	Transmission	0.2	1.9	27,950	1

Note 1: Loss Code – I² R loss proportional to:

1. square of the sum of the load
2. sum of the squares of the load

2009 Peak Hour Distribution Model Losses (in MWs, unless otherwise indicated)

Element		I ² R Loss	Core Losses	Total Losses	Allocated Class load	% Loss (load)
(#)	Description					
1	HV ESS	5.0	7.2	12.2	720.4	1.69
2	138-69 TSS	1.6	4.2	5.9	756.4	0.77
3	138-34 TSS	16.4	12.2	28.6	3,637.1	0.79
4	34KV LINES	111.3	0.0	111.3	3,637.1	3.06
5	34-12KV DC	5.5	7.8	13.4	1,646.9	0.81
6	34-4KV DC	1.8	3.5	5.3	518.3	1.03
7	34KV ESS	9.9	7.9	17.8	1,270.3	1.40
8	138/69-12 TDC	105.5	45.5	150.9	14,371.1	1.05
9	12KV LINES	40.8	0.0	40.8	2,257.1	1.81
10	12KV FDR	494.3	0.0	494.3	11,755.3	4.21
11	12-4KV DC	2.4	3.3	5.7	574.4	0.99
12	12KV ESS	26.2	49.0	75.3	3,354.3	2.24
13	ACNW FDR	3.0	0.0	3.0	358.7	0.84
14	ACNW TRANF	0.6	6.4	7.0	358.7	1.96
15	ACNW SEC	1.8	0.0	1.8	358.7	0.50
16	4KV FDR	54.6	0.0	54.6	1,092.7	5.00
17	LINE TRANF	165.6	132.1	297.6	12,750.6	2.33
18	480V DRYTR	2.5	3.7	6.2	198.9	3.11
19	SECONDARY	181.2	0.0	181.2	9,060.8	2.00
20	Transmission	335.7	55.9	391.6	19,096.8	1.90
Total		1,565.9	338.7	1,904.6	19,096.8	9.97

Losses By Element, unadjusted for difference between ComEd Zone Load and load plus losses. Upstream element loads increased to include losses in downstream elements.

2009 Peak Hour Losses By Class, Adjusted to Allocate Zone Peak (MWs)

Class	SF	MF	SF_S H	MF_S H	WH	0-100 kW	100- 400 kW	400- 1,000 kW	1-10 MW	>10 MW	HV >= 69 kV	Railroad	D-D Lighting	Gen Lighting	Muni	Total
I**2 R Loss D	554.1	118.2	10.1	16.2	10.5	221.1	141.2	108.5	153.0	33.0	5.1	2.4	15.2	1.4	10.5	1400.3
Core Losses D	87.6	21.1	1.6	2.9	1.9	40.2	32.0	26.7	47.2	10.2	6.5	0.3	2.5	0.2	1.9	282.8
Total Losses D	641.7	139.3	11.6	19.0	12.4	261.3	173.2	135.2	200.2	43.2	11.5	2.6	17.8	1.6	12.4	1683.1
I**2 R Loss T	119.5	25.5	2.2	3.5	2.4	51.9	41.5	35.1	58.2	12.5	11.8	1.4	3.4	0.3	13.0	382.1
Core Losses T																55.9
Total Losses T																438.0
Load	5856.0	1248.0	105.7	170.6	117.2	2559.2	2082.6	1773.8	2964.5	638.9	630.1	72.8	167.1	15.5	694.9	19096.8
% Loss T (load)																2.3
% Loss D (load)	11.0	11.2	11.0	11.2	10.6	10.2	8.3	7.6	6.8	6.8	1.8	3.6	10.6	10.6	1.8	8.8

Residual Losses	Zone Load	Class Load	I ² R Loss	Core Loss
0.0	21217.9	19096.8	1782.4	338.7

2009 Adjusted loads and losses for space heating classes (MWs)

Class	SF_SH ⁽²⁾	MF_SH ⁽²⁾
I**2 R Loss D	19.0	39.2
Core Losses D	3.0	7.0
Total Losses D		
Load	199.9	413.9

Notes:

- (1) Loads and losses for the D-D Lighting class are based on the noncoincident peak of the customer class.
- (2) Loads and losses for the Space Heating classes are based on the average of the coincident and noncoincident peaks of the customer classes.

Appendix G

2009 Annual Energy Loss By Customer Class⁽¹⁾

Class	Class Peak (MW)	Load Factor	Energy Delivered (MWh)	D Losses (MWh)	2009 Loss Factor
SF	6,525	0.35	20,219,292	1,562,856	7.73%
MF	1,342	0.37	4,385,512	360,618	8.22%
SF_SH	294	0.31	801,026	70,716	8.83%
MF_SH	657	0.28	1,635,261	153,141	9.36%
WH	123	0.51	552,118	44,977	8.15%
0-100 kW	2,559	0.52	11,583,071	892,135	7.70%
100-400 kW	2,119	0.57	10,652,636	717,225	6.73%
400-1,000 kW	1,799	0.61	9,683,246	611,913	6.32%
>1-10 MW ⁽²⁾⁽³⁾	3,034	0.68	17,959,848	1,061,749	5.91%
>10 MW ⁽²⁾⁽³⁾	656	0.67	3,877,660	227,435	5.87%
HV >= 69 kV ⁽²⁾⁽³⁾	739	0.75	4,859,278	90,218	1.86%
Railroad	135	0.43	511,790	17,782	3.47%
D-D Lighting	167	0.47	692,343	82,330	11.89%
Gen Lighting	15	1.00	135,491	14,225	10.50%
Muni	712	0.51	3,191,050	42,351	1.33%
Total	18,930	0.55	90,739,622	5,949,671	6.56%

Notes:

- (1) As explained in the Customer Classes section of this document, customer classes are not identical to the Delivery Classes in Rate RDS. Hourly loads for comparable classes have been increased to account for energy delivered for:
- Service provided without charge
 - ComEd company use
- (2) The Very Large (1,000 to 10,000 kW) and Extra Large (Over 10,000 kW) customer classes include the portion of load receiving service at voltages below 69 kV to customers in the High Voltage Delivery Class. The "HV>=69 kV" customer class includes the portion of load receiving service at 69 kV or higher voltage to customers in the High Voltage Delivery Class.
- (3) The Distribution Loss Factors for the Up to 10,000 kW and the Over 10,000 kW subclasses of the High Voltage Delivery Class shown in ComEd Exhibit 16.21, 2.33% and 1.93%, respectively, are higher than the 1.86% Distribution Loss Factor for the "HV>=69 kV" customer class shown here because a portion of the loads delivered to customers in these two subclasses of the High Voltage Delivery Class is at voltages below 69 kV.