Smart Grid Advanced Metering Annual Implementation Progress Report

ATTACHMENT 1

(SUPPLEMENTAL RESPONSE)

Metrics and Milestones

Metric: 9 *(Supplemental Response)*

Metric Description: Reduction in Greenhouse Gas Emissions enabled by smart grid and the success of AMI deployment in enabling consumer benefits from the smart grid.

ComEd has worked with the Citizen's Utility Board *("CUB")* and Environmental Defense Fund *("EDF")* to develop a practical measure of changes in Greenhouse Gas *("GHG")* emissions attributable to smart grid functions enabled by Advanced Metering Infrastructure *("AMI")* deployment and AMI related investments by exploring the capability of calculating GHG emission changes realized through items such as the following:

A. Enabling Energy Efficiency and conservation
B. Reducing peak load and creating a flatter load profile
C. Creating a more predictable load profile
D. Enabling customer Demand-side management and Demand Response
E. Enabling the integration of clean, renewable generation sources
F. Reducing technical electricity losses

In its 2015 AMI Annual Implementation Progress Report *("AIPR")*, ComEd proposed modifications to Metric 9. The reporting of the revised and updated metric began with the 2016 AIPR. ComEd, CUB and EDF have continued to work together to identify and define certain details of the methodology to implement the revised GHG emission metric, including as reflected in the Stipulation to Dismiss Proceeding as to Commonwealth Edison Company filed on March 14, 2016 in ICC Docket No. 14-0555.

Vehicle GHG Emissions

Meter Reading Vehicles

ComEd refined this calculation in its 2015 AIPR to be the difference between (i) the previous year's GHG emissions associated with meter reading vehicles at each operating center that had AMI meter deployment during that year or in a prior year and (ii) a baseline defined as the three (3) year average GHG vehicle emissions associated with meter reading vehicles at each such operating center. GHG emissions are calculated based on fuel consumption and the emission factors from the Climate Registry used by Exelon Corporation.

The vehicle GHG emissions metric methodology includes all vehicles that are used to read meters because a significant number of non-fleet vehicles are utilized to read electric meters. When a ComEd-owned vehicle is no longer needed in one operating center, it is commonly redeployed to another operating center, offsetting the use of non-fleet vehicles *(which are not in the fleet data)*.

2016 Meter Reading Vehicle GHG Emissions Calculation

Operating Center	2014 (a)	2015 (b)	2016 (c)	Average (d)	2016 Emissions *(MT CO_2)* (f)=(c)*(e)	Avg Emissions *(MT CO_2)* (g)=(d)*(e)	Emissions *(MT $CO_2\Delta$)* (f)-(g)
Chicago North	22,569	20,574	15,089	19,411	138	177	-39
Chicago South	27,853	12,177	7,638	15,889	70	145	-75
Mt Prospect	6,998	8,239	5,861	7,032	54	64	-11
Northbrook	6,987	6,216	9,732	7,645	89	70	19
Libertyville	18,048	18,254	16,430	17,577	150	160	-10
Maywood	2,645	2,611	3,082	2,779	28	25	3
Glenbard	6,678	6,151	4,016	5,615	37	51	-15
Joliet	14,319	10,659	12,653	12,543	116	115	1
University Park	4,668	7,694	6,643	6,335	61	58	3
Crestwood	6,864	9,004	7,993	7,954	73	73	0
Bolingbrook	6,295	5,961	6,736	6,331	62	58	4
Dekalb	11,086	9,774	10,026	10,295	92	94	-2
Dixon/Freeport	24,602	20,898	20,239	21,913	185	200	-15
Rockford	13,817	14,489	11,986	13,431	109	123	-13

Operating Center	2014 (a)	2015 (b)	2016 (c)	Average (d)	2016 Emissions *(MT CO_2)* (f)=(c)*(e)	Avg Emissions *(MT CO_2)* (g)=(d)*(e)	Emissions *(MT $CO_2\Delta$)* (f)-(g)
Aurora	4,739	4,600	4,727	4,689	43	43	0
Elgin	6,378	5,417	5,570	5,788	51	53	-2
						Total	**-153**

Emission Factor[1] *(MT CO_2/gal)* (e)
0.00913

The overall results show a reduction in GHG emissions for meter reading functions due to AMI deployment for nine operating centers, while seven operating centers show an increase. ComEd notes that certain meters in operating centers where AMI is being deployed are not exchanged to AMI either because they are "Unable to Complete" *("UTC")* or are customers who requested service under Rider NAM – Non AMI Metering *("Rider NAM")*. Reading these meters increases the miles driven on a per-meter basis and increases related fuel consumption due to the inefficient meter reading routes needed to read these meters. This impact may be why those seven operating centers show an increase in GHG emissions during deployment.

Outage and Maintenance Vehicles

This new calculation for the 2016 AIPR measures reduction in GHG emissions due to dispatching fewer outage and maintenance related vehicles. When a customer calls to report an outage, ComEd utilizes AMI technology by pinging the AMI meter and determines if the outage is taking place on the ComEd system. If the reported outage is the customer's responsibility, a ComEd vehicle can avoid being dispatched. GHG emissions are calculated based on fuel consumption and the emission factors from the Climate Registry used by Exelon Corporation.

[1] CO_2 emission factors from the Climate Registry

2016 Outage and Maintenance Vehicle GHG Emissions Calculation

Operating Center	Fuel Qty *(lbs/gal)* (a)	# of Trips (b)	# of Reduced Truck Rolls (c)	2016 Emissions *(MT CO_2)* (e)=((a)/(b)*(c))*(d)
Chicago North	44,540	10,575	9,675	372
Chicago South	51,351	13,986	9,444	317
Mt Prospect	38,349	5,019	2,926	204
Northbrook	27,578	4,233	2,119	126
Libertyville	42,996	4,332	1,252	113
Maywood	23,313	4,363	3,819	186
Glenbard	30,700	4,662	3,392	204
Joliet/Streator	40,067	6,346	124	7
University Park	36,259	4,854	647	44
Crestwood	28,230	5,537	2,768	129
Bolingbrook	32,627	3,349	221	20
Dekalb	21,841	1,935	11	1
Dixon/Freeport	40,384	3,778	9	1
Rockford	41,444	4,229	256	23
Aurora	18,884	2,168	53	4
Elgin	24,776	2,350	17	2
			Total	**1,753**

Emission Factor[1] *(MT CO_2/gal)* (d)
0.00913

The overall results show a reduction in GHG emissions for outage and maintenance functions due to AMI deployment for each operating center.

Bottom-Up Approach

For this approach, ComEd calculated the estimated load differences between those customers with AMI and with IDR meters by operating center where deployment has taken place. These load differences will include total load reduction, and to the extent data availability and reliability permits, load shifting and conservation effects. Based on these differences in load by geographic area or customer program, the associated change in GHG emissions was estimated.

Peak Time Savings Program

Load impacts were estimated based on a difference-in-differences calculation between participants and a control group of non-participants with AMI meters that have similar load shapes during peak time savings event hours *(as described in Rider PTR – Peak Time Rebate ("Rider PTR"))*. The results for this calculation did not take into effect pre-event or post-event changes in load *(e.g. pre-cooling, changes due to notification of event, and post-event bounce back)*.

2016 Peak Time Savings Calculations

Delivery Service Classes	Date	Hour Ending	Non-Participant Load *(kW)* (a)	Participant Load *(kW)* (b)	Event Impact *(kW)* (c)=(a)-(b)	MER[2] *(MT CO_2/MWh)* (d)	MER[3] *(MT CO_2/MWh)* (e)	# of Participants[4] (f)	Emissions[5] *(MT $CO_2\Delta$)* (g)=(c)*(d)*(f)	Emissions[6] *(MT $CO_2\Delta$)* (h)=(c)*(e)*(f)
Single Family without Electric Space Heat	7/12/2016	13	1.67	1.51	-0.16	0.776	0.358	93,201	-11.573	-5.333
		14	1.67	1.51	-0.16	0.776	0.443	93,201	-11.573	-6.613
		15	1.67	1.51	-0.16	0.776	0.375	93,201	-11.573	-5.588
		16	1.67	1.51	-0.16	0.776	0.503	93,201	-11.573	-7.501

[2] Method 1 Marginal Emission Rates (MER) as described on page 19.

[3] Method 2 Marginal Emission Rates (MER) as described on pages 19-20

[4] Based on the number of customers who participated in the Peak Time Savings program in 2016.

[5] Final results based on Method 1 of Marginal Emission Rates.

[6] Final results based on Method 2 of Marginal Emission Rates.

Delivery Service Classes	Date	Hour Ending	Non-Participant Load *(kW)* (a)	Participant Load *(kW)* (b)	Event Impact *(kW)* (c)=(a)-(b)	MER[2] *(MT CO_2/MWh)* (d)	MER[3] *(MT CO_2/MWh)* (e)	# of Participants[4] (f)	Emissions[5] *(MT $CO_2\Delta$)* (g)=(c)*(d)*(f)	Emissions[6] *(MT $CO_2\Delta$)* (h)=(c)*(e)*(f)
	8/4/2016	14	1.67	1.51	-0.16	0.816	0.733	93,201	-12.169	-10.923
		15	1.67	1.51	-0.16	0.816	0.743	93,201	-12.169	-11.084
		16	1.67	1.51	-0.16	0.816	0.807	93,201	-12.169	-12.029
		17	1.67	1.51	-0.16	0.816	0.799	93,201	-12.169	-11.910
	8/19/2016	13	1.67	1.51	-0.16	0.816	0.706	93,201	-12.169	-10.534
		14	1.67	1.51	-0.16	0.816	0.633	93,201	-12.169	-9.432
		15	1.67	1.51	-0.16	0.816	0.694	93,201	-12.169	-10.350
Multi Family without Electric Space Heat	7/12/2016	13	1.37	1.24	-0.06	0.776	0.358	51,789	-2.412	-1.111
		14	1.37	1.24	-0.06	0.776	0.443	51,789	-2.412	-1.378
		15	1.37	1.24	-0.06	0.776	0.375	51,789	-2.412	-1.165
		16	1.37	1.24	-0.06	0.776	0.503	51,789	-2.412	-1.563
	8/4/2016	14	1.37	1.24	-0.06	0.816	0.733	51,789	-2.536	-2.276
		15	1.37	1.24	-0.06	0.816	0.743	51,789	-2.536	-2.310
		16	1.37	1.24	-0.06	0.816	0.807	51,789	-2.536	-2.506
		17	1.37	1.24	-0.06	0.816	0.799	51,789	-2.536	-2.482
	8/19/2016	13	1.37	1.24	-0.06	0.816	0.706	51,789	-2.536	-2.195
		14	1.37	1.24	-0.06	0.816	0.633	51,789	-2.536	-1.965
		15	1.37	1.24	-0.06	0.816	0.694	51,789	-2.536	-2.157
Single Family with Electric Space Heat	7/12/2016	13	0.68	0.63	-0.13	0.776	0.358	994	-0.100	-0.046
		14	0.68	0.63	-0.13	0.776	0.443	994	-0.100	-0.057
		15	0.68	0.63	-0.13	0.776	0.375	994	-0.100	-0.048
		16	0.68	0.63	-0.13	0.776	0.503	994	-0.100	-0.065
	8/4/2016	14	0.68	0.63	-0.13	0.816	0.733	994	-0.105	-0.095
		15	0.68	0.63	-0.13	0.816	0.743	994	-0.105	-0.096
		16	0.68	0.63	-0.13	0.816	0.807	994	-0.105	-0.104
		17	0.68	0.63	-0.13	0.816	0.799	994	-0.105	-0.103

Delivery Service Classes	Date	Hour Ending	Non-Participant Load *(kW)* (a)	Participant Load *(kW)* (b)	Event Impact *(kW)* (c)=(a)-(b)	MER[2] *(MT CO_2/MWh)* (d)	MER[3] *(MT CO_2/MWh)* (e)	# of Participants[4] (f)	Emissions[5] *(MT $CO_2\Delta$)* (g)=(c)*(d)*(f)	Emissions[6] *(MT $CO_2\Delta$)* (h)=(c)*(e)*(f)
Multi Family with Electric Space Heat	8/19/2016	13	0.68	0.63	-0.13	0.816	0.706	994	-0.105	-0.091
		14	0.68	0.63	-0.13	0.816	0.633	994	-0.105	-0.082
		15	0.68	0.63	-0.13	0.816	0.694	994	-0.105	-0.090
	7/12/2016	13	0.77	0.69	-0.08	0.776	0.358	6,475	-0.402	-0.185
		14	0.77	0.69	-0.08	0.776	0.443	6,475	-0.402	-0.230
		15	0.77	0.69	-0.08	0.776	0.375	6,475	-0.402	-0.194
		16	0.77	0.69	-0.08	0.776	0.503	6,475	-0.402	-0.261
	8/4/2016	14	0.77	0.69	-0.08	0.816	0.733	6,475	-0.423	-0.379
		15	0.77	0.69	-0.08	0.816	0.743	6,475	-0.423	-0.385
		16	0.77	0.69	-0.08	0.816	0.807	6,475	-0.423	-0.418
		17	0.77	0.69	-0.08	0.816	0.799	6,475	-0.423	-0.414
	8/19/2016	13	0.77	0.69	-0.08	0.816	0.706	6,475	-0.423	-0.366
		14	0.77	0.69	-0.08	0.816	0.633	6,475	-0.423	-0.328
		15	0.77	0.69	-0.08	0.816	0.694	6,475	-0.423	-0.360
								Total	**-165**	**-127**

The overall results show the load for participants were lower than non-participants during each of the hours of the event days.

Residential Hourly Pricing

Load impacts were estimated by hour using existing load impact models and actual 2016 hourly weather, hourly prices and alert hours.

∑Baseline Load *(kW)* (a)	∑Actual Load *(kW)* (b)	∑Load Δ *(kWh)* (c)=(a)-(b)	2016 Emissions *(MT CO_2)* (d)=(c)*MER[7]	2016 Emissions *(MT CO_2)* (e)=(c)*MER[8]	# of Participants[9] *(f)*	Emissions[10] *(MT $CO_2\Delta$)* (d)*(f)	Emissions[11] *(MT $CO_2\Delta$)* (e)*(f)
12,147	11,320	-827	-0.604	-0.586	7,281	-4,398	-4,267

The overall results show that participants reduced their peak loads for all four seasons.

ComEd will continue to explore and analyze other elements identified as contributors to the GHG emissions for inclusion in future reporting including GHG emissions related to reduction in line losses related to metric 20.

Top-Down Approach

For changes in GHG emissions based on aggregate load, ComEd calculates the load differences between those customers with AMI meters and those without AMI meters and any associated impact on GHG emissions. ComEd started reporting the results of this calculation in the 2016 AIPR.

Approach 1

An average load per customer was developed for customers with AMI meters and compared to an average load per customer for IDR *(Interval Demand Recording Meters e.g. non-AMI)* meters during the same calendar year within an operating center and for each delivery service class. These IDR meters were installed more than three years ago to gather interval level data for customer premises that, at one time, participated in the residential hourly pricing program or that are utilized as load research meters. The usage level of these customers tends to be higher than average-sized customers in annual consumption within each operating center. In order to reduce this sample bias, the loads for the customers with IDR meters were adjusted by using the actual energy sales per customer by operating center and delivery service class.

[7] Method 1 Marginal Emission Rates (MER) as described on page 18-19

[8] Method 2 Marginal Emission Rates (MER) as described on pages 19-20

[9] Based on the number of customers who participated in the Residential Hourly Pricing program in 2016

[10] Final results based on Method 1 of Marginal Emission Rates

[11] Final results based on Method 2 of Marginal Emission Rates

As deployment of AMI meters in an operating center increases, the number of customers with IDR meters decreases, which reduces the amount of operating centers that provide meaningful results. This primarily impacts those operating centers that have had AMI meters fully deployed and therefore, have almost no non-AMI IDR meters to compare against. Therefore, operating centers without meaningful results are not included in the tables below.

Operating Center: Libertyville

Delivery Service Class	**∑AMI *(kWh)* (a)**	**Adj ∑Non-AMI *(kWh)* (b)**	**∑Load Δ *(kWh)* (c)=(a)-(b)**	**2016 Emissions *(MT CO_2)* (d)=(c)*MER[12]**	**2016 Emissions *(MT CO_2)* (e)=(c)*MER[13]**	**# of AMI Meters[14] (f)**	**Emissions[15] *(MT $CO_2\Delta$)* (d)*(f)**	**Emissions[16] *(MT $CO_2\Delta$)* (e)*(f)**
Single Family without Electric Space Heat	10,749	10,488	262	0.201	0.191	761	150	150
Multi Family without Electric Space Heat	5,175	4,933	242	0.190	0.183	295	60	50
Single Family with Electric Space Heat	17,548	19,475	-1,927	-1.359	-1.368	8	-10	-10
Multi Family with Electric Space Heat	10,969	9,342	1,626	1.185	1.141	40	50	50
						Total	**250**	**240**

Operating Center: Joliet

[12] Method 1 Marginal Emission Rates (MER) as described on page 18-19

[13] Method 2 Marginal Emission Rates (MER) as described on pages 19-20

[14] Based on meters with load for the entire 2016 calendar year

[15] Final results based on Method 1 of Marginal Emission Rates

[16] Final results based on Method 2 of Marginal Emission Rates

Delivery Service Class	∑AMI *(kWh)* (a)	Adj ∑Non-AMI *(kWh)* (b)	∑Load Δ *(kWh)* (c)=(a)-(b)	2016 Emissions *(MT CO_2)* (d)=(c)*MER[12]	2016 Emissions *(MT CO_2)* (e)=(c)*MER[13]	# of AMI Meters[14] (f)	Emissions[15] *(MT $CO_2\Delta$)* (d)*(f)	Emissions[16] *(MT $CO_2\Delta$)* (e)*(f)
Single Family without Electric Space Heat	9,779	10,825	-1,045	-0.742	-0.724	2,174	-1,610	-1,570
Multi Family without Electric Space Heat	6,753	5,168	1,585	1.162	1.129	249	290	280
Single Family with Electric Space Heat	25,182	21,020	4,162	3.052	2.977	33	100	100
Multi Family with Electric Space Heat	10,832	9,127	1,705	1.240	1.269	231	290	290
						Total	**-930**	**-900**

Operating Center: Streator								
Delivery Service Class	**∑AMI *(kWh)* (a)**	**Adj ∑Non-AMI *(kWh)* (b)**	**∑Load Δ *(kWh)* (c)=(a)-(b)**	**2016 Emissions *(MT CO_2)* (d)=(c)*MER[12]**	**2016 Emissions *(MT CO_2)* (e)=(c)*MER[13]**	**# of AMI Meters[14] (f)**	**Emissions[15] *(MT $CO_2\Delta$)* (d)*(f)**	**Emissions[16] *(MT $CO_2\Delta$)* (e)*(f)**
Single Family without Electric Space Heat	12,550	10,884	1,666	1.275	1.275	96	120	120
Multi Family without Electric Space Heat	3,094	5,049	-1,955	-1.422	-1.386	15	-20	-20
Single Family with Electric Space Heat	41,143	22,227	18,916	13.553	13.221	9	120	120
Multi Family with Electric Space Heat	4,232	8,748	-4,517	-3.264	-3.217	6	-20	-20
						Total	**200**	**200**

Operating Center: University Park								
Delivery Service Class	**∑AMI *(kWh)* (a)**	**Adj ∑Non-AMI *(kWh)* (b)**	**∑Load Δ *(kWh)* (c)=(a)-(b)**	**2016 Emissions *(MT CO_2)* (d)=(c)*MER[12]**	**2016 Emissions *(MT CO_2)* (e)=(c)*MER[13]**	**# of AMI Meters[14] (f)**	**Emissions[15] *(MT $CO_2\Delta$)* (d)*(f)**	**Emissions[16] *(MT $CO_2\Delta$)* (e)*(f)**
Single Family without Electric Space Heat	9,545	9,740	-196	-0.087	-0.065	504	-40	-30
Multi Family without Electric Space Heat	4,768	4,874	-106	-0.078	-0.086	118	-10	-10
Single Family with Electric Space Heat	23,866	21,480	2,386	1.800	1.802	21	40	40
Multi Family with Electric Space Heat	9,783	10,051	-269	-0.199	-0.192	36	-10	-10
						Total	**-20**	**-10**

Operating Center: Bolingbrook								
Delivery Service Class	**∑AMI *(kWh)* (a)**	**Adj ∑Non-AMI *(kWh)* (b)**	**∑Load Δ *(kWh)* (c)=(a)-(b)**	**2016 Emissions *(MT CO_2)* (d)=(c)*MER[12]**	**2016 Emissions *(MT CO_2)* (e)=(c)*MER[13]**	**# of AMI Meters[14] (f)**	**Emissions[15] *(MT $CO_2\Delta$)* (d)*(f)**	**Emissions[16] *(MT $CO_2\Delta$)* (e)*(f)**
Single Family without Electric Space Heat	10,885	10,871	14	0.014	0.014	1,175	20	20
Multi Family without Electric Space Heat	4,670	4,599	71	0.054	0.047	477	30	20
Single Family with Electric Space Heat	19,977	18,354	1,623	1.099	1.096	14	20	20
Multi Family with Electric Space Heat	12,479	10,330	2,149	1.542	1.530	41	60	60
						Total	**130**	**120**

Operating Center: Dekalb								
Delivery Service Class	**∑AMI *(kWh)* (a)**	**Adj ∑Non-AMI *(kWh)* (b)**	**∑Load Δ *(kWh)* (c)=(a)-(b)**	**2016 Emissions *(MT CO_2)* (d)=(c)*MER[12]**	**2016 Emissions *(MT CO_2)* (e)=(c)*MER[13]**	**# of AMI Meters[14] (f)**	**Emissions[15] *(MT $CO_2\Delta$)* (d)*(f)**	**Emissions[16] *(MT $CO_2\Delta$)* (e)*(f)**
Single Family without Electric Space Heat	12,292	10,951	1,341	0.969	0.947	257	250	240
Multi Family without Electric Space Heat	4,328	5,068	-740	-0.549	-0.553	9	-10	-10
Single Family with Electric Space Heat	35,977	23,412	12,565	9.144	8.988	18	160	160
Multi Family with Electric Space Heat	7,831	8,617	-787	-0.563	-0.587	1	0	0
						Total	**400**	**390**

Operating Center: Rockford								
Delivery Service Class	**∑AMI *(kWh)* (a)**	**Adj ∑Non-AMI *(kWh)* (b)**	**∑Load Δ *(kWh)* (c)=(a)-(b)**	**2016 Emissions *(MT CO_2)* (d)=(c)*MER[12]**	**2016 Emissions *(MT CO_2)* (e)=(c)*MER[13]**	**# of AMI Meters[14] (f)**	**Emissions[15] *(MT $CO_2\Delta$)* (d)*(f)**	**Emissions[16] *(MT $CO_2\Delta$)* (e)*(f)**
Single Family without Electric Space Heat	8,611	9,403	-792	-0.535	-0.533	11,796	-6,310	-6,280
Multi Family without Electric Space Heat	4,389	4,859	-470	-0.348	-0.342	1,570	-550	-540
Single Family with Electric Space Heat	17,472	20,015	-2,544	-1.841	-1.834	63	-120	-120
Multi Family with Electric Space Heat	8,476	8,689	-213	-0.161	-0.159	207	-30	-30
						Total	**-7,010**	**-6,970**

Operating Center: Aurora								
Delivery Service Class	**∑AMI *(kWh)* (a)**	**Adj ∑Non-AMI *(kWh)* (b)**	**∑Load Δ *(kWh)* (c)=(a)-(b)**	**2016 Emissions *(MT CO_2)* (d)=(c)*MER[12]**	**2016 Emissions *(MT CO_2)* (e)=(c)*MER[13]**	**# of AMI Meters[14] (f)**	**Emissions[15] *(MT $CO_2\Delta$)* (d)*(f)**	**Emissions[16] *(MT $CO_2\Delta$)* (e)*(f)**
Single Family without Electric Space Heat	8,889	10,205	-1,316	-0.952	-0.934	589	-560	-550
Multi Family without Electric Space Heat	4,167	5,304	-1,137	-0.819	-0.813	144	-120	-120
Single Family with Electric Space Heat	19,040	18,433	606	0.424	0.428	10	0	0
Multi Family with Electric Space Heat	11,265	10,242	1,023	0.731	0.746	16	10	10
						Total	**-670**	**-660**

Operating Center: Elgin								
Delivery Service Class	**∑AMI *(kWh)* (a)**	**Adj ∑Non-AMI *(kWh)* (b)**	**∑Load Δ *(kWh)* (c)=(a)-(b)**	**2016 Emissions *(MT CO_2)* (d)=(c)*MER[12]**	**2016 Emissions *(MT CO_2)* (e)=(c)*MER[13]**	**# of AMI Meters[14] (f)**	**Emissions[15] *(MT $CO_2\Delta$)* (d)*(f)**	**Emissions[16] *(MT $CO_2\Delta$)* (e)*(f)**
Single Family without Electric Space Heat	8,995	9,839	-844	-0.614	-0.599	678	-420	-400
Multi Family without Electric Space Heat	3,762	4,969	-1,207	-0.875	-0.861	86	-80	-70
Single Family with Electric Space Heat	37,336	19,745	17,591	12.515	12.482	1	10	10
Multi Family with Electric Space Heat	10,686	10,053	632	0.492	0.473	2	0	0
						Total	**-490**	**-460**

After making the adjustment to reduce sample bias and excluding the operating centers that did not provide meaningful results, as discussed above, the overall results continue to show a reduction in GHG emissions for customers with AMI meters. However, individual delivery service classes for certain operating centers may show either reductions or increases in the emissions.

Approach 2

An average load per customer was developed for customers with AMI meters for the most recent year and compared to the same customers who had IDR meters two years prior. Due to the number of meters that were exchanged from IDR to AMI prior to 2015, there was insufficient data to complete this calculation for the 2016 calendar year.

Marginal Emission Rates

The Marginal Emission Rates are based on publicly available data. Two methods for determining marginal emissions rates and applying them to the bottom up and top down approaches have been identified. Recognizing the limitations of each method, the parties agree that ComEd will apply both, though neither CUB and EDF nor ComEd support both methods. These will continue to be developed amongst the parties in good faith, working together to improve or replace them as better methods and additional public information become available. For any AIPR reporting GHG Metrics that reflect these alternate marginal emission derivation methods, ComEd will also include a detailed explanation of the limitations of each approach.

Method 1: Available Emissions Data Method

Locational Marginal Pricing *("LMP")* is a calculation of the price of electricity based on the marginal energy generating unit *("EGU")* in a particular five-minute interval. While the LMP data are publicly available, the information about the specific EGU is not released by PJM Interconnection, L.L.C. *("PJM")* given the sensitivity and confidentiality of the information.

However, PJM calculates weighted average marginal emissions rates for peak and off-peak hours in each month using five-minute interval data. The most recent report describing these methods and data for 2012-2016 was released on March 17, 2017[17], and PJM has committed to release updated reports on an annual basis. Under this method, ComEd will determine the marginal emissions rates based on these data unless and until more granular marginal emissions rates data from PJM becomes publicly available.

Limitations:
Method 1 uses EGU data to calculate weighted average marginal emission rates for peak and off-peak periods in each month. Therefore, the marginal emission rates are not available for each hour in a calendar year. Also, the marginal emission rates are calculated for the entire PJM footprint, not just ComEd's service territory.

Method 2: Estimated Generation Data Method

While the specific data about EGUs determining LMP for a given interval is not available to the public, they are available to Monitoring Analytics *(MA)*, "the Independent Market Monitor for PJM under a long-term contract."[18] MA has developed a monthly

[17]PJM, 2012-2016 CO2, SO2 and NOX Emission Rates (March 17, 2017) available at http://www.pjm.com/~/media/library/reports-notices/special-reports/20170317-2016-emissions-report.ashx
[18]Monitoring Analytics, http://www.monitoringanalytics.com/home/index.shtml

report that summarizes the fuel type of marginal or jointly marginal units in the PJM Real-Time Energy Market for each hour. MA calculates the share of each fuel in each hour based on the number of five minute intervals that a unit burning each fuel type is marginal or jointly marginal.[19] CUB and EDF propose that ComEd use these shares to derive the generation by fuel type per hour in the program year.

This generation by fuel type is multiplied by the Average Heat Rate by Energy Source data published by the U.S. Energy Information Administration *("EIA")*[20], and the Carbon Dioxide Uncontrolled Emissions Factor data *(lbs CO2/million BTU)* published by EIA[21] to derive a weighted average hourly emissions rate for the marginal and jointly marginal units.

Limitations:
Method 2 does not use actual EGU data because this information is not available to the public. Instead, this method uses generation shares for marginal and jointly marginal units and system averages for unit efficiency and carbon emission rates to derive the marginal emission rates by hour. Also, the marginal emission rates are calculated for the entire PJM footprint, not just ComEd's service territory.

[19]Monitoring Analytics – Marginal Fuel Posting,http://www.monitoringanalytics.com/data/marginal_fuel.shtml
[20]http://www.eia.gov/electricity/annual/html/epa_08_02.html
[21]https://www.eia.gov/electricity/annual/html/epa_a_03.html, which compiles data from two sources: 1. Energy Information Administration, Office of Integrated Analysis and Forecasting, Voluntary Reporting of Greenhouse Gases Program, Table of Fuel and Energy Source: Codes and Emission Coefficients; available at: http://www.eia.doe.gov/oiaf/1605/coefficients.html; and 2. U.S. Environmental Protection Agency, AP 42, Fifth Edition (Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources); available at: http://www.epa.gov/ttn/chief/ap42/