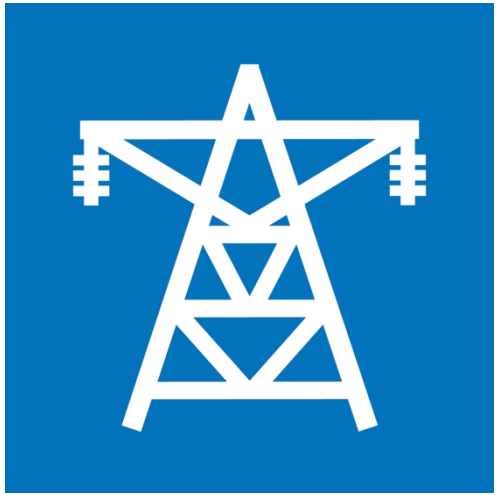


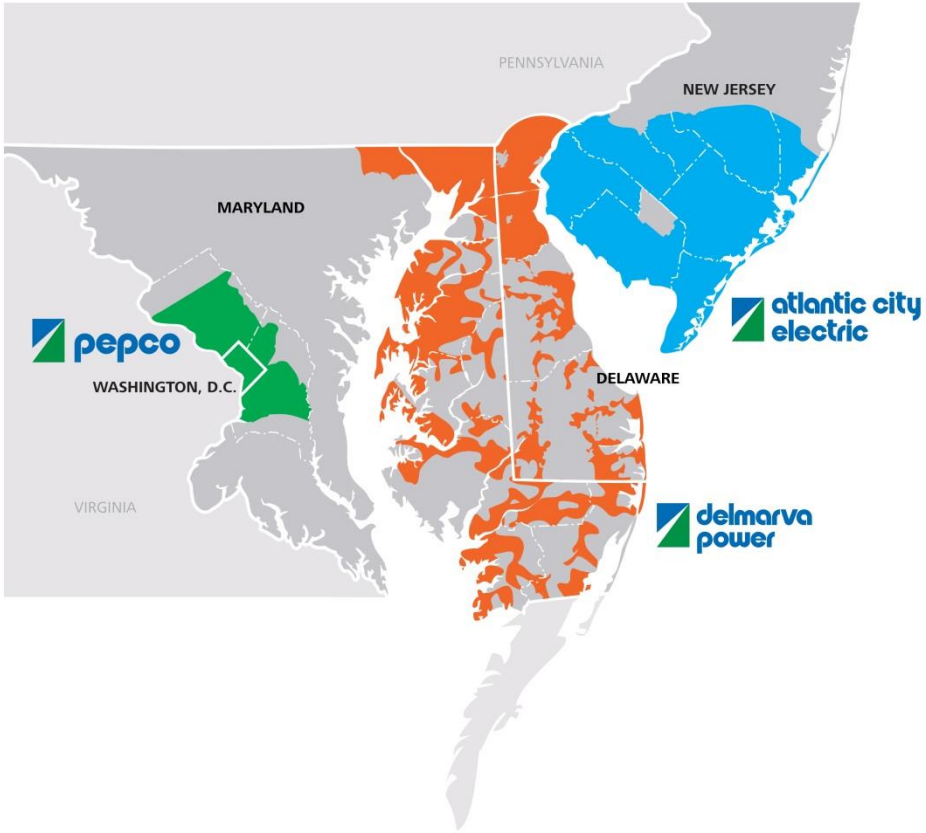
Conservation Voltage Reduction and Smart Meters

Presented by **Timothy Schwarz, PE**

Pepco Holdings, Inc

Pepco Holdings, Inc. Quick Facts

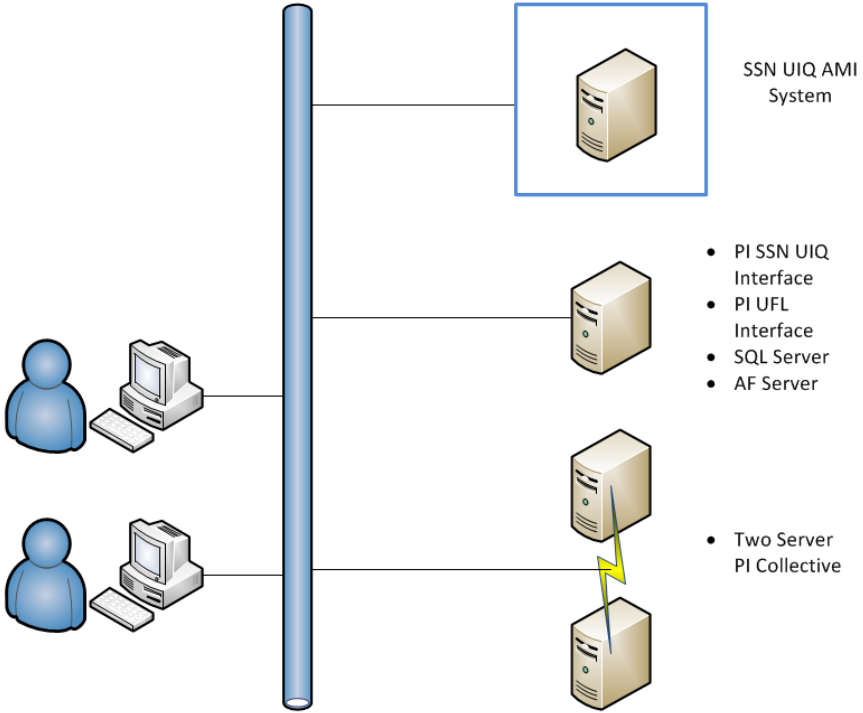
- Incorporated in 2002
- Service territory:
  8,340 square miles
- Customers served
  - Atlantic City Electric:
    - 545,000 – electric
  - Delmarva Power:
    - 503,000 – electric
    - 125,000 – natural gas
  - Pepco:
    - 793,000 – electric
- Total population served:
  5.6 million



Project Driver

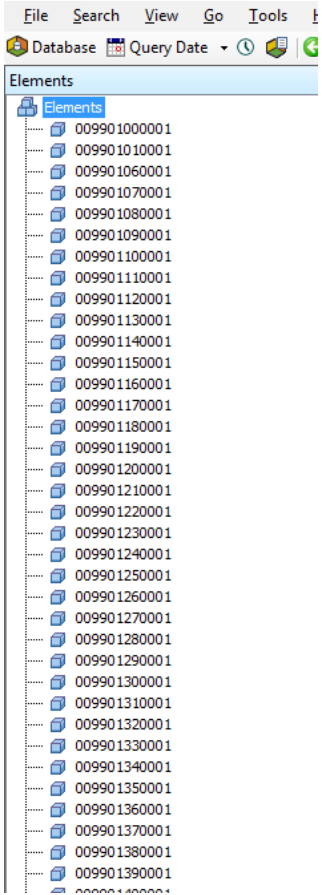
- Conservation Voltage Reduction (CVR) pilot mandated by the Maryland Public Service Commission
  - CVR is a reduction in energy consumption that results from a reduction in source voltage
  - Not all loads benefit from CVR
    - Constant impedance loads result in lower energy consumption with lower voltage (incandescent lights)
    - Constant power loads offer no savings since reduction in voltage will just result in higher currents
      - This could be more problematic than helpful since it could reduce equipment life

PI Architecture



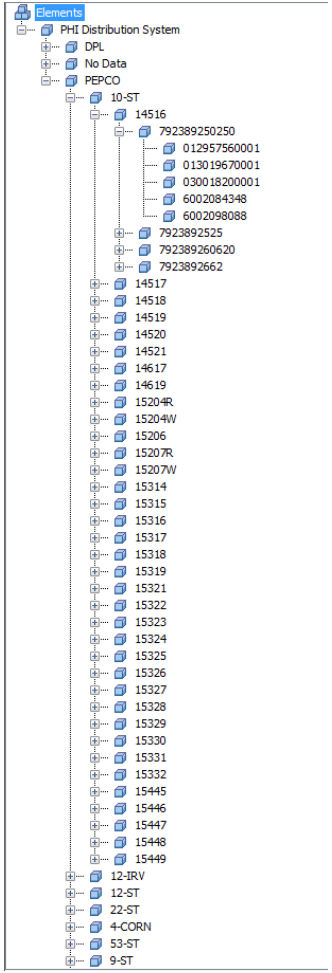
PI Architecture

- PI SSN UIQ Interface processes tab separated files from the AMI system to automatically create the PI tags and the AF elements/attributes
  - AF elements are stored in a flat structured database
- PI UFL Interface processes comma separated files from the AMI system to load the actual value data into the PI tags
- PI Tags and AF Elements are indexed according to the service point ID
  - This allows for constant voltage profiles for customers regardless of meter swaps
- PI was built out for all PHI AMI customers for a total of 1.4M elements (NJ doesn't allow AMI meters)



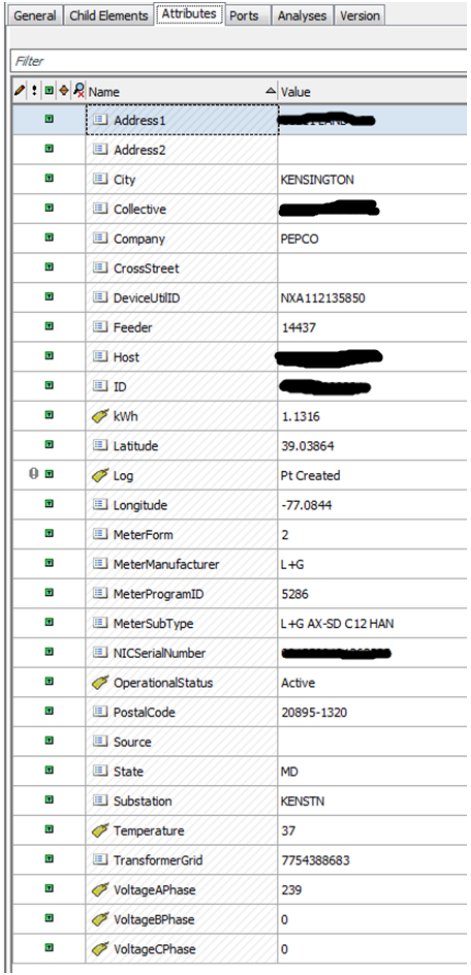
PI Architecture

- Utilize AF-SDK to build a heirarchical AF database
  - Structure format is Company, Substation, Feeder, Transformer, Customer
  - Allows for easing searching/navigating in the core PI client tools
- Program runs weekly and updates the hierarchical database with data in the flat database
- Since the customer information isn't perfect, we utilize a "No Data" hierarchy as a catch-all for customers that cannot be mapped to a particular substation/feeder



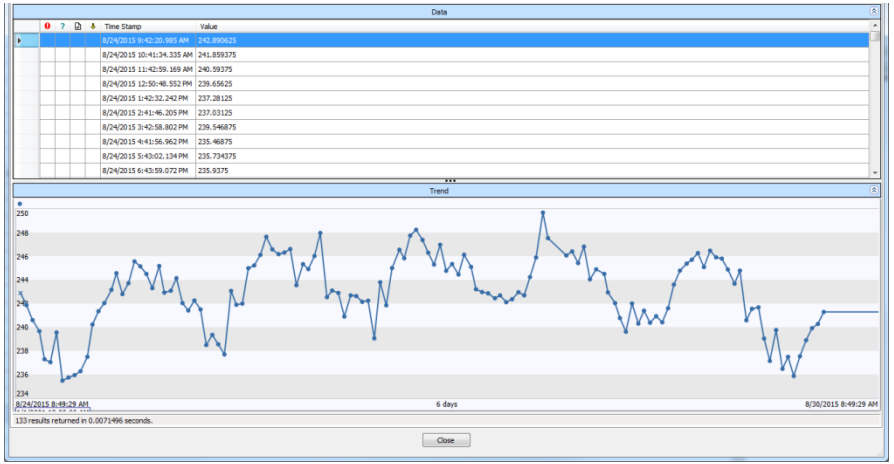
PI Data

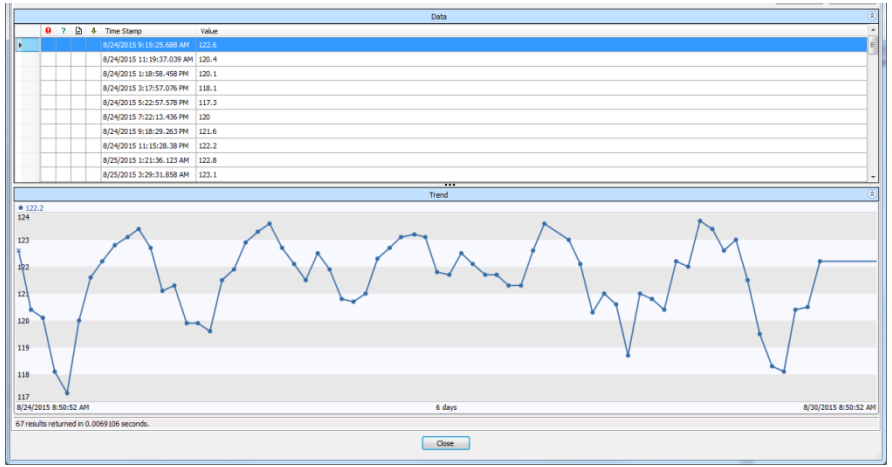
- The data coming from the AMI meters is very different from normal EMS data
- Users in EMS environments typically query data with a specific purpose in mind
  - i.e. look at a trend for an overloaded facility, plot substation voltage, etc.
- The users in the CVR environment want to see customers that have experienced voltage excursions
  - This requires developing custom reports that query the entire PI system and output the results to some usable format



PI Data

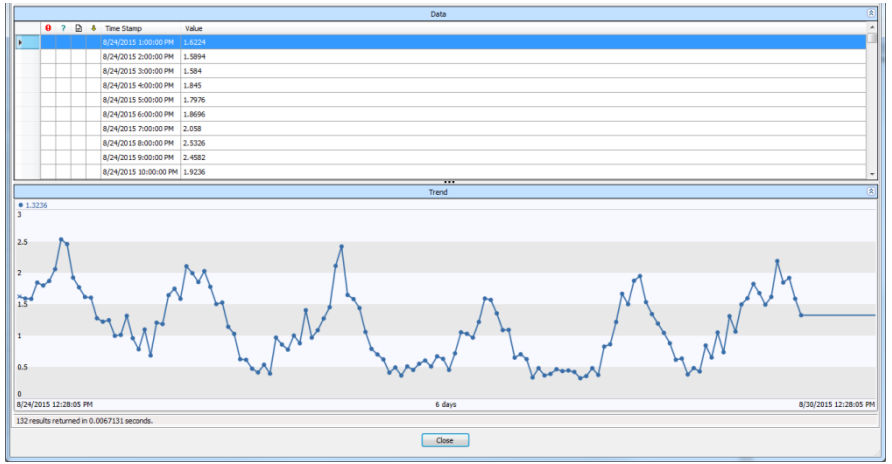
- The voltage data received from the meters is not normalized and represents the actual delivered service voltage
  - This can make the reporting and querying difficult when finding excursions due to many scales
- PHI has custom built voltage exception report logic for each meter manufacturer/type
  - Even voltage values in the same meter type can be different nominal voltage depending on the service voltage

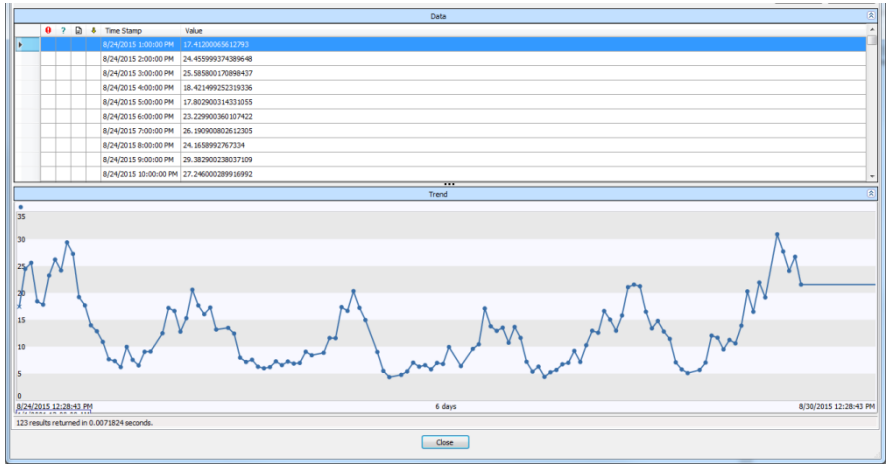




PI Data

- KWH data is received for each meter type
- Utilize custom code to roll up the KWH data for customers to transformer, roll up transformer KWH to feeder
- Collaborative effort with OSISoft to develop rollup code due to the process to input data into the PI System from our meter system
  - The data could come in late for non-communicating meters
  - Our data comes into the PI system in bulk
  - Our code looks back several days to sum up the KWH and store the data into PI



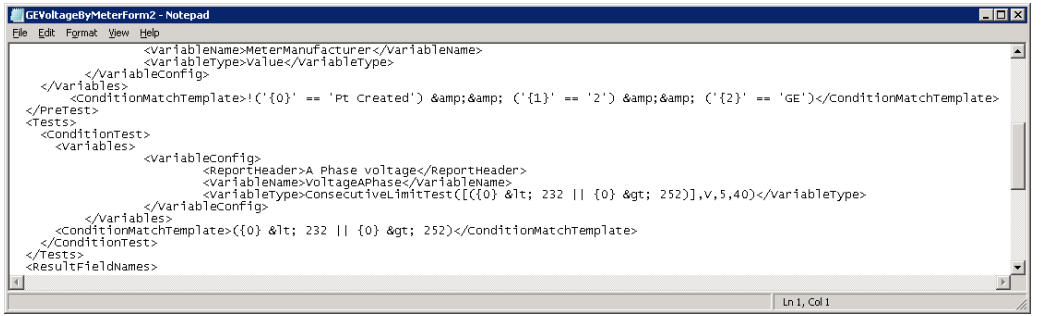


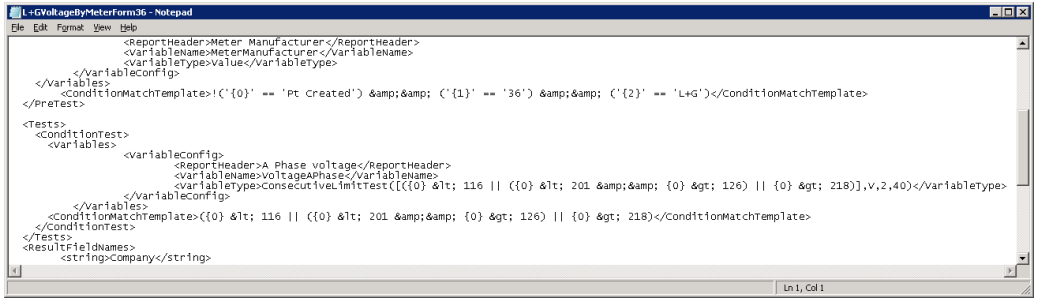
Data Extraction and Reports

- Data is different than normal EMS data
  - Requires the system to tell you to look at something
- Massive amount of data
  - Built the system for 1.4M meters with approx 9M PI tags
  - Collecting data for only a subset of the tags
  - Regular voltage (every hour or every two hours) and kwh (every hour or every 15 minutes) for the CVR impacted customers (approx 200k customers)
  - Periodically do full system scan for a one time instantaneous voltage read during peak conditions
- Custom daily reports
  - Developed voltage exception reports and transformer overload reports
  - Utilizing the AF SDK
  - Reports are uploaded to a Sharepoint server for users to access

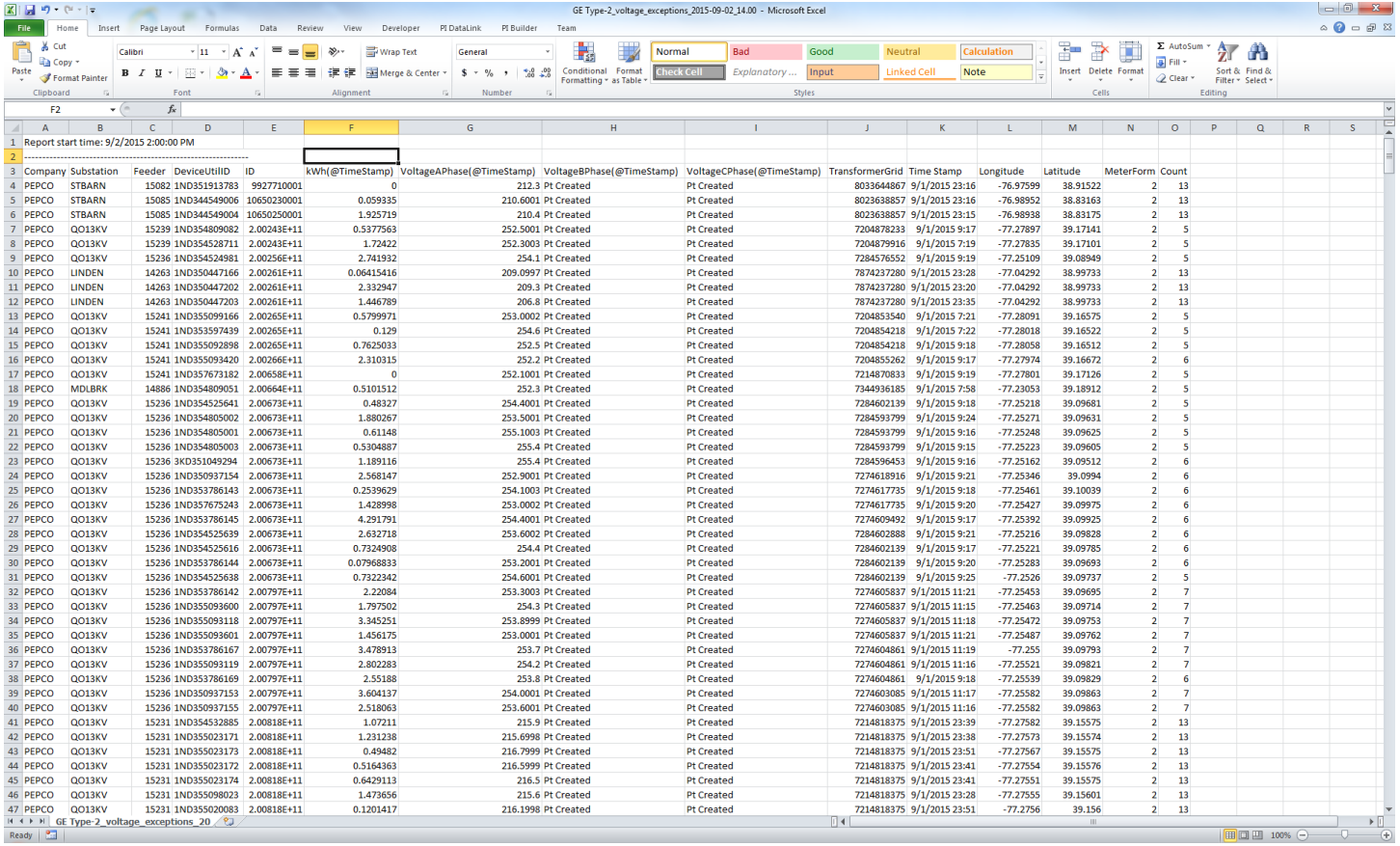
Data Extraction and Reports

- Voltage exception report will list the customers who have had voltage deviations outside a defined range
- Different meter types can have many different acceptable ranges due to the service voltage difference
- Look for several consecutive excursions to trigger inclusion to the report
  - Based on frequency of the meter voltage read





Data Extraction and Reports



GE Type-2_voltage_exceptions_2015-09-02_14.00 - Microsoft Excel

Report start time: 9/2/2015 2:00:00 PM

Company	Substation	Feeder	DeviceUtilID	ID	kWh(@TimeStamp)	VoltageAPhase(@TimeStamp)	VoltageBPhase(@TimeStamp)	VoltageCPhase(@TimeStamp)	TransformerGrid	Time Stamp	Longitude	Latitude	MeterForm	Count
PEPCO	STBARN	15082	1ND351913783	9927710001	0	212.3	Pt Created	Pt Created	8033644867	9/1/2015 23:16	-76.97599	38.91522	2	13
PEPCO	STBARN	15085	1ND344549006	10650230001	0.059335	210.6001	Pt Created	Pt Created	8023638857	9/1/2015 23:16	-76.98952	38.83163	2	13
PEPCO	STBARN	15085	1ND344549004	10650250001	1.925719	210.4	Pt Created	Pt Created	8023638857	9/1/2015 23:15	-76.98938	38.83175	2	13
PEPCO	QO13KV	15239	1ND354809082	2.00243E+11	0.5377563	252.5001	Pt Created	Pt Created	7204878233	9/1/2015 9:17	-77.27897	39.17141	2	5
PEPCO	QO13KV	15239	1ND354528711	2.00243E+11	1.72422	252.3003	Pt Created	Pt Created	7204879916	9/1/2015 7:19	-77.27835	39.17101	2	5
PEPCO	QO13KV	15236	1ND354524981	2.00256E+11	2.741932	254.1	Pt Created	Pt Created	7284576552	9/1/2015 9:19	-77.25109	39.08949	2	5
PEPCO	LINDEN	14263	1ND350447166	2.00261E+11	0.06415416	209.0997	Pt Created	Pt Created	7874237280	9/1/2015 23:28	-77.04292	38.99733	2	13
PEPCO	LINDEN	14263	1ND350447202	2.00261E+11	2.332947	209.3	Pt Created	Pt Created	7874237280	9/1/2015 23:20	-77.04292	38.99733	2	13
PEPCO	LINDEN	14263	1ND350447203	2.00261E+11	1.446789	206.8	Pt Created	Pt Created	7874237280	9/1/2015 23:35	-77.04292	38.99733	2	13
PEPCO	QO13KV	15241	1ND355099166	2.00265E+11	0.5799971	253.0002	Pt Created	Pt Created	7204853540	9/1/2015 7:21	-77.28091	39.16575	2	5
PEPCO	QO13KV	15241	1ND353597439	2.00265E+11	0.129	254.6	Pt Created	Pt Created	7204854218	9/1/2015 7:22	-77.28018	39.16522	2	5
PEPCO	QO13KV	15241	1ND355092898	2.00265E+11	0.7625033	252.5	Pt Created	Pt Created	7204854218	9/1/2015 9:18	-77.28058	39.16512	2	5
PEPCO	QO13KV	15241	1ND355093420	2.00266E+11	2.310315	252.2	Pt Created	Pt Created	7204855262	9/1/2015 9:17	-77.27974	39.16672	2	6
PEPCO	QO13KV	15241	1ND357673182	2.00658E+11	0	252.1001	Pt Created	Pt Created	7214870833	9/1/2015 9:19	-77.27801	39.17126	2	5
PEPCO	MDLBRK	14886	1ND354809051	2.00664E+11	0.5101512	252.3	Pt Created	Pt Created	7344936185	9/1/2015 7:58	-77.23053	39.18912	2	5
PEPCO	QO13KV	15236	1ND354525641	2.00673E+11	0.48327	254.4001	Pt Created	Pt Created	7284602139	9/1/2015 9:18	-77.25218	39.09681	2	5
PEPCO	QO13KV	15236	1ND354805002	2.00673E+11	1.880267	253.5001	Pt Created	Pt Created	7284593799	9/1/2015 9:24	-77.25271	39.09631	2	5
PEPCO	QO13KV	15236	1ND354805001	2.00673E+11	0.61148	255.1003	Pt Created	Pt Created	7284593799	9/1/2015 9:16	-77.25248	39.09625	2	5
PEPCO	QO13KV	15236	1ND354805003	2.00673E+11	0.5304887	255.4	Pt Created	Pt Created	7284593799	9/1/2015 9:15	-77.25223	39.09605	2	5
PEPCO	QO13KV	15236	3KD351049294	2.00673E+11	1.189116	255.4	Pt Created	Pt Created	7284596453	9/1/2015 9:16	-77.25162	39.09512	2	6
PEPCO	QO13KV	15236	1ND350937154	2.00673E+11	2.568147	252.9001	Pt Created	Pt Created	7274618916	9/1/2015 9:21	-77.25346	39.0994	2	6
PEPCO	QO13KV	15236	1ND353786143	2.00673E+11	0.2539629	254.1003	Pt Created	Pt Created	7274617735	9/1/2015 9:18	-77.25461	39.10039	2	6
PEPCO	QO13KV	15236	1ND357675243	2.00673E+11	1.428998	253.0002	Pt Created	Pt Created	7274617735	9/1/2015 9:20	-77.25427	39.09975	2	6
PEPCO	QO13KV	15236	1ND353786145	2.00673E+11	4.291791	254.4001	Pt Created	Pt Created	7274609492	9/1/2015 9:17	-77.25392	39.09925	2	6
PEPCO	QO13KV	15236	1ND354525639	2.00673E+11	2.632718	253.6002	Pt Created	Pt Created	7284602888	9/1/2015 9:21	-77.25216	39.09828	2	6
PEPCO	QO13KV	15236	1ND354525616	2.00673E+11	0.7324908	254.4	Pt Created	Pt Created	7284602139	9/1/2015 9:17	-77.25221	39.09785	2	6
PEPCO	QO13KV	15236	1ND353786144	2.00673E+11	0.07968833	253.2001	Pt Created	Pt Created	7284602139	9/1/2015 9:20	-77.25283	39.09693	2	6
PEPCO	QO13KV	15236	1ND354525638	2.00673E+11	0.7322342	254.6001	Pt Created	Pt Created	7284602139	9/1/2015 9:25	-77.2526	39.09737	2	5
PEPCO	QO13KV	15236	1ND353786142	2.00797E+11	2.22084	253.3003	Pt Created	Pt Created	7274605837	9/1/2015 11:21	-77.25453	39.09695	2	7
PEPCO	QO13KV	15236	1ND355093600	2.00797E+11	1.797502	254.3	Pt Created	Pt Created	7274605837	9/1/2015 11:15	-77.25463	39.09714	2	7
PEPCO	QO13KV	15236	1ND355093118	2.00797E+11	3.345251	253.8999	Pt Created	Pt Created	7274605837	9/1/2015 11:18	-77.25472	39.09753	2	7
PEPCO	QO13KV	15236	1ND355093601	2.00797E+11	1.456175	253.0001	Pt Created	Pt Created	7274605837	9/1/2015 11:21	-77.25487	39.09762	2	7
PEPCO	QO13KV	15236	1ND353786167	2.00797E+11	3.478913	253.7	Pt Created	Pt Created	7274604861	9/1/2015 11:19	-77.255	39.09793	2	7
PEPCO	QO13KV	15236	1ND355093119	2.00797E+11	2.802283	254.2	Pt Created	Pt Created	7274604861	9/1/2015 11:16	-77.25521	39.09821	2	7
PEPCO	QO13KV	15236	1ND353786169	2.00797E+11	2.55188	253.8	Pt Created	Pt Created	7274604861	9/1/2015 9:18	-77.25539	39.09829	2	6
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PEPCO	QO13KV	15231	1ND354532885	2.00818E+11	1.07211	215.9	Pt Created	Pt Created	7214818375	9/1/2015 23:39	-77.27582	39.15575	2	13
PEPCO	QO13KV	15231	1ND355023171	2.00818E+11	1.231238	215.6998	Pt Created	Pt Created	7214818375	9/1/2015 23:38	-77.27573	39.15574	2	13
PEPCO	QO13KV	15231	1ND355023173	2.00818E+11	0.49482	216.7999	Pt Created	Pt Created	7214818375	9/1/2015 23:51	-77.27567	39.15575	2	13
PEPCO	QO13KV	15231	1ND355023172	2.00818E+11	0.5164363	216.5999	Pt Created	Pt Created	7214818375	9/1/2015 23:41	-77.27554	39.15576	2	13
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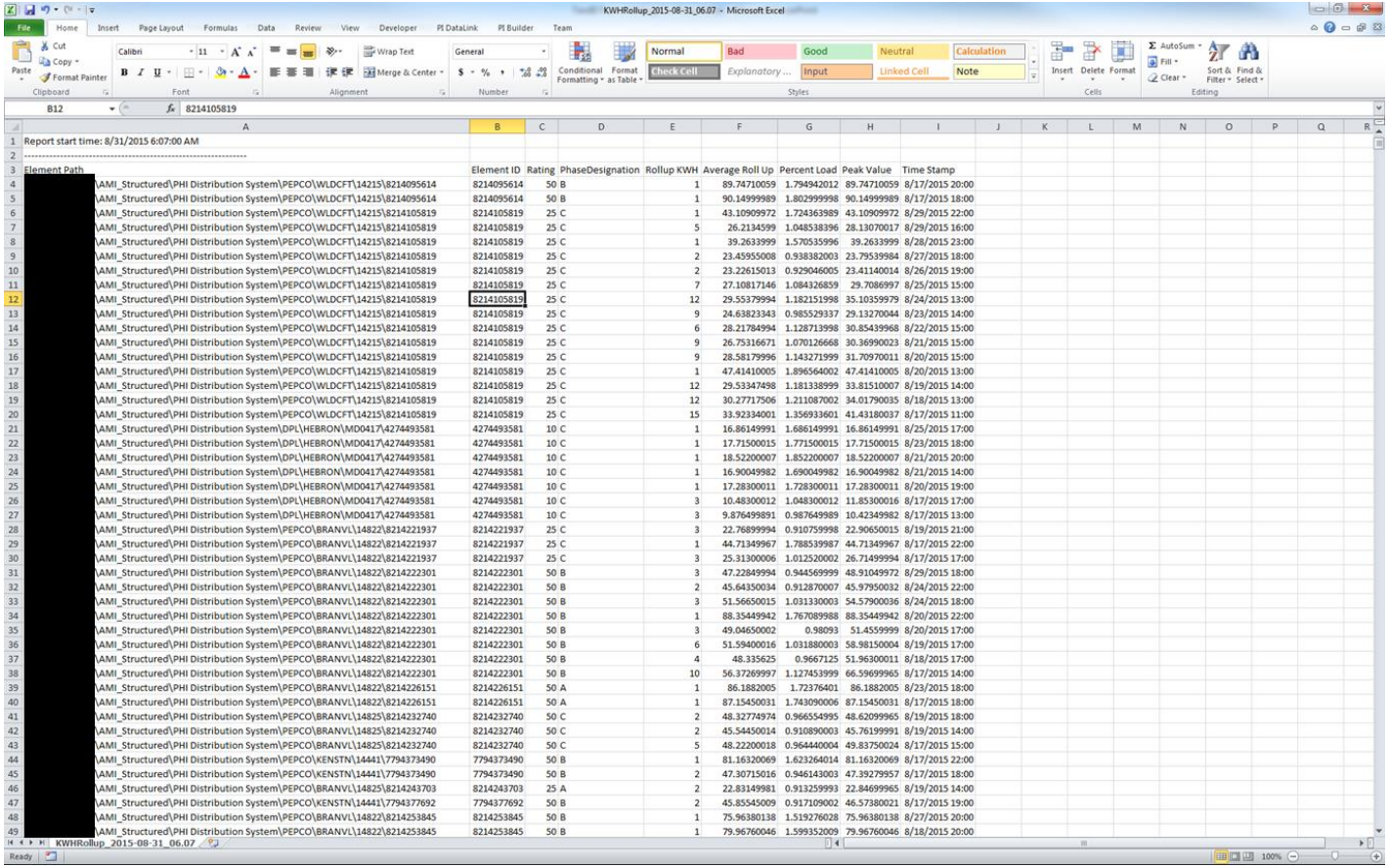
PEPCO	QO13KV	15231	1ND355098023	2.00818E+11	1.473656	215.6	Pt Created	Pt Created	7214818375	9/1/2015 23:28	-77.27555	39.15601	2	13
PEPCO	QO13KV	15231	1ND355020083	2.00818E+11	0.1201417	216.1998	Pt Created	Pt Created	7214818375	9/1/2015 23:51	-77.2756	39.156	2	13

Data Extraction and Reports



KWHRollup_2015-08-31_06.07 - Microsoft Excel

B12: 8214105819

	A	B	C	D	E	F	G	H	I
1	Report start time: 8/31/2015 6:07:00 AM								
2	----------								
3	Element Path	Element ID	Rating	PhaseDesignation	Rollup KWH	Average Roll Up	Percent Load	Peak Value	Time Stamp
4	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214095614	8214095614	50	B	1	89.74710059	1.794942012	89.74710059	8/17/2015 20:00
5	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214095614	8214095614	50	B	1	90.14999989	1.802999998	90.14999989	8/17/2015 18:00
6	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	1	43.10909972	1.724363989	43.10909972	8/29/2015 22:00
7	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	5	26.2134599	1.048538396	28.13070017	8/29/2015 16:00
8	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	1	39.2633999	1.570535996	39.2633999	8/28/2015 23:00
9	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	2	23.45955008	0.938382003	23.79539984	8/27/2015 18:00
10	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	2	23.22615013	0.929046005	23.41140014	8/26/2015 19:00
11	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	7	27.10817146	1.084326859	29.7086997	8/25/2015 15:00
12	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	12	29.55379994	1.182151998	35.10359979	8/24/2015 13:00
13	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	9	24.63823343	0.985529337	29.13270044	8/23/2015 14:00
14	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	6	28.21784994	1.128713998	30.85439968	8/22/2015 15:00
15	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	9	26.75316671	1.070126668	30.36990023	8/21/2015 15:00
16	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	9	28.58179996	1.143271999	31.70970011	8/20/2015 15:00
17	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	1	47.41410005	1.896564002	47.41410005	8/20/2015 13:00
18	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	12	29.53347498	1.181338999	33.81510007	8/19/2015 14:00
19	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	12	30.27717506	1.211087002	34.01790035	8/18/2015 13:00
20	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\WLDCFT\14215\8214105819	8214105819	25	C	15	33.92334001	1.356933601	41.43180037	8/17/2015 11:00
21	[redacted]\AMI_Structured\PHI Distribution System\DPL\HEBRON\MD0417\4274493581	4274493581	10	C	1	16.86149991	1.686149991	16.86149991	8/25/2015 17:00
22	[redacted]\AMI_Structured\PHI Distribution System\DPL\HEBRON\MD0417\4274493581	4274493581	10	C	1	17.71500015	1.771500015	17.71500015	8/23/2015 18:00
23	[redacted]\AMI_Structured\PHI Distribution System\DPL\HEBRON\MD0417\4274493581	4274493581	10	C	1	18.52200007	1.852200007	18.52200007	8/21/2015 20:00
24	[redacted]\AMI_Structured\PHI Distribution System\DPL\HEBRON\MD0417\4274493581	4274493581	10	C	1	16.90049982	1.690049982	16.90049982	8/21/2015 14:00
25	[redacted]\AMI_Structured\PHI Distribution System\DPL\HEBRON\MD0417\4274493581	4274493581	10	C	1	17.28300011	1.728300011	17.28300011	8/20/2015 19:00
26	[redacted]\AMI_Structured\PHI Distribution System\DPL\HEBRON\MD0417\4274493581	4274493581	10	C	3	10.48300012	1.048300012	11.85300016	8/17/2015 17:00
27	[redacted]\AMI_Structured\PHI Distribution System\DPL\HEBRON\MD0417\4274493581	4274493581	10	C	3	9.876499891	0.987649989	10.42349982	8/17/2015 13:00
28	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214221937	8214221937	25	C	3	22.76899994	0.910759998	22.90650015	8/19/2015 21:00
29	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214221937	8214221937	25	C	1	44.71349967	1.788539987	44.71349967	8/17/2015 22:00
30	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214221937	8214221937	25	C	3	25.31300006	1.012520002	26.71499994	8/17/2015 17:00
31	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214222301	8214222301	50	B	3	47.22849994	0.944569999	48.91049972	8/29/2015 18:00
32	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214222301	8214222301	50	B	2	45.64350034	0.912870007	45.97950032	8/24/2015 22:00
33	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214222301	8214222301	50	B	3	51.56650015	1.031330003	54.57900036	8/24/2015 18:00
34	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214222301	8214222301	50	B	1	88.35449942	1.767089988	88.35449942	8/20/2015 22:00
35	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214222301	8214222301	50	B	3	49.04650002	0.98093	51.4559999	8/20/2015 17:00
36	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214222301	8214222301	50	B	6	51.59400016	1.031880003	58.98150004	8/19/2015 17:00
37	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214222301	8214222301	50	B	4	48.335625	0.9667125	51.96300011	8/18/2015 17:00
38	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214222301	8214222301	50	B	10	56.37269997	1.127453999	66.59699965	8/17/2015 14:00
39	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214226151	8214226151	50	A	1	86.1882005	1.72376401	86.1882005	8/23/2015 18:00
40	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214226151	8214226151	50	A	1	87.15450031	1.743090006	87.15450031	8/17/2015 18:00
41	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14825\8214232740	8214232740	50	C	2	48.32774974	0.966554995	48.62099965	8/19/2015 18:00
42	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14825\8214232740	8214232740	50	C	2	45.54450014	0.910890003	45.76199991	8/19/2015 14:00
43	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14825\8214232740	8214232740	50	C	5	48.22200018	0.964440004	49.83750024	8/17/2015 15:00
44	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\KENSTN\14441\7794373490	7794373490	50	B	1	81.16320069	1.623264014	81.16320069	8/17/2015 22:00
45	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\KENSTN\14441\7794373490	7794373490	50	B	2	47.30715016	0.946143003	47.39279957	8/17/2015 18:00
46	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14825\8214243703	8214243703	25	A	2	22.83149981	0.913259993	22.84699965	8/19/2015 14:00
47	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\KENSTN\14441\7794377692	7794377692	50	B	2	45.85545009	0.917109002	46.57380021	8/17/2015 19:00
48	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214253845	8214253845	50	B	1	75.96380138	1.519276028	75.96380138	8/27/2015 20:00
49	[redacted]\AMI_Structured\PHI Distribution System\PEPCO\BRANVL\14822\8214253845	8214253845	50	B	1	79.96760046	1.599352009	79.96760046	8/18/2015 20:00

Summary and Takeaways

- Very cumbersome in general when handling such large amounts of data
- Reporting out of the PI system requires utilization of the AF-SDK
- PI does a good job at storing the massive amount of data
- PI behaves very well with vertical scale as opposed to horizontal scale
- AMI data is very different from the EMS data
- Have found multiple distribution system problems that required immediate attention
- Overall, the system has proved useful and has allowed us to build our CVR program and ensure customer voltages are within tolerance

Questions?

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