Monitoring Based Commissioning and Data Analytics for Energy Efficiency

HESNI 2016 Annual Conference
May 6, 2016

HESNI Healthcare Engineers Society of Northern Illinois

THE HILL GROUP
ENERGY SOLUTIONS

Presentation Agenda

- Hill Group Overview
- MBCx Definition
- Data Acquisition and Access
- Types of Analytics
- Applications of Analytics
- Examples

Andrew Syrios

- Energy Solutions and Commissioning Manager at The Hill Group
- 12 years in Engineering, Mechanical Service, and Construction Industry
- Registered Professional Engineer
- Certified Energy Manager
- Certified Commissioning Process Management Professional
- LEED AP
- Masters of Business Administration – DePaul University
- Bachelor’s of Science Mechanical Engineering - University of Iowa

Monitoring Based Commissioning

Use of real-time data analytics, algorithms, diagnostics, and fault detection, to ensure the facility is operating properly and to continually improve operation 24x7

MBCx

Monitoring based commissioning (MBCx) combines building energy system monitoring with standard retro-commissioning (RCx) practices. MBCx is a measurement-based paradigm that affords improved risk-management by identifying problems and opportunities that are missed with periodic commissioning or basic functional testing that does not incorporate energy measurement.

ASHRAE Study

Action	Observed Savings
Installation of Meters	0% to 2% The Hawthorne Effect
Bill Allocation Only	2.5% to 5% Improved Occupant Awareness
Building Tune-Up And Load Management	5% to 15% Improved Awareness, Identification of Simple Operations and Maintenance Improvements and Managing Demand Loads Per Electric Rate Schedules
Ongoing Commissioning	15% to 45% Improved Awareness, Ongoing Identification of Simple Operations and Maintenance Improvements and Continuing Management Attention

Table 1: Expected energy savings from utility metering.

ASHRAE Journal - April 2011, p 22

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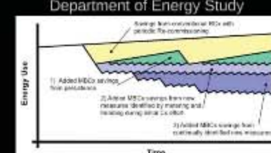

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- Median Simple Payback = 2.5 Years
- Median Source Energy Savings = 11%

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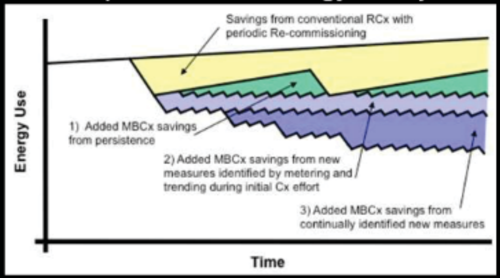

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How do you get the data?

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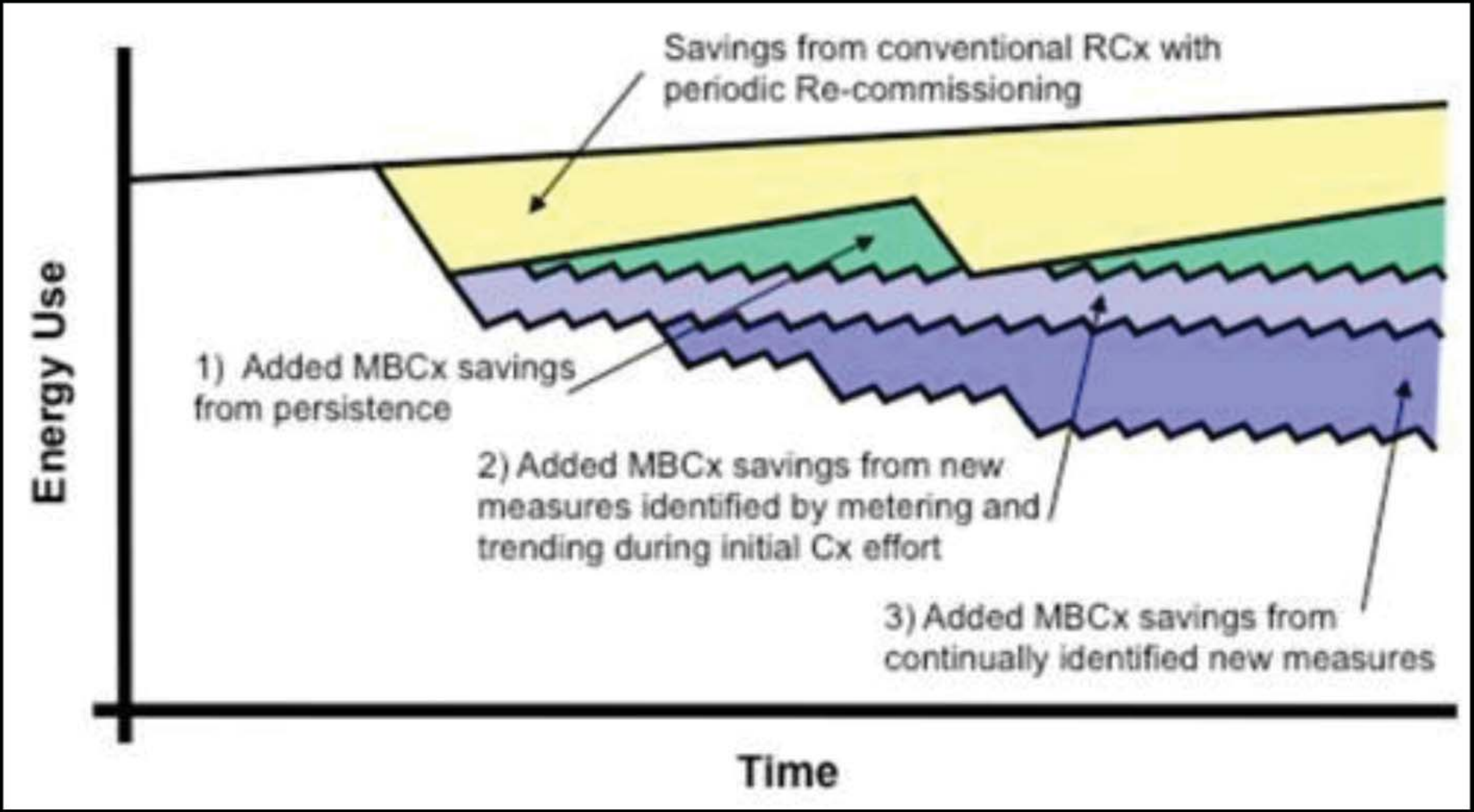

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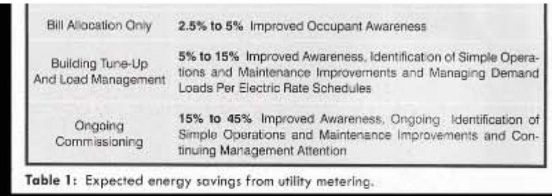

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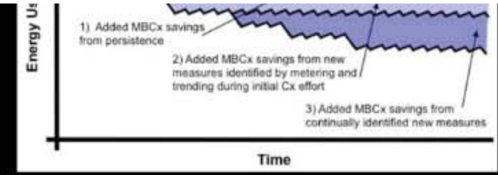

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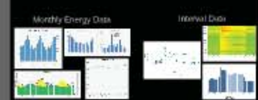
Utility Level



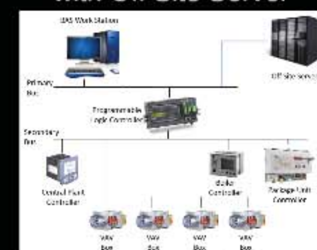
Sub Meters and Data Loggers

IoT Enabled Devices and Equipment

Application Specific

System Level Data Analytics

Direct Backbone Connection with Off Site Server

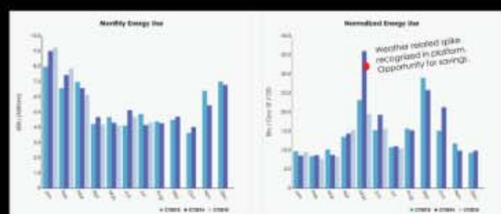


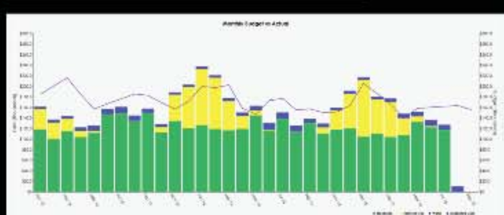
How do you access the data?

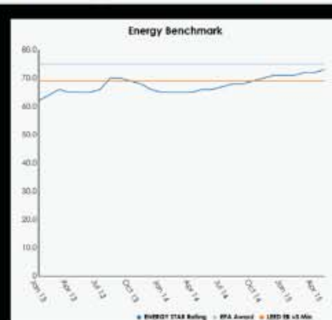
Web Based

Utility Level

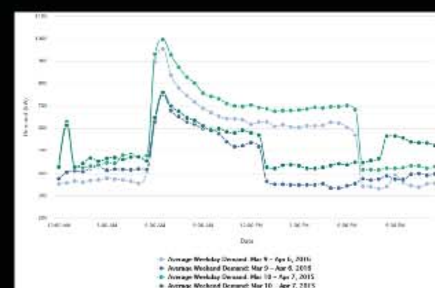
Monthly Energy Data

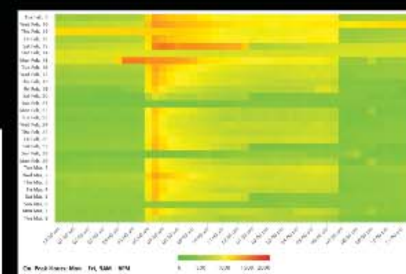


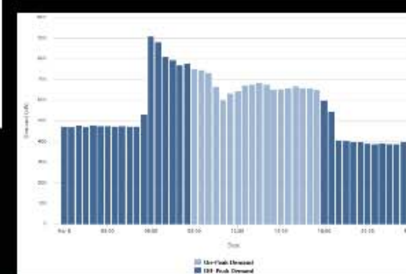




Interval Data







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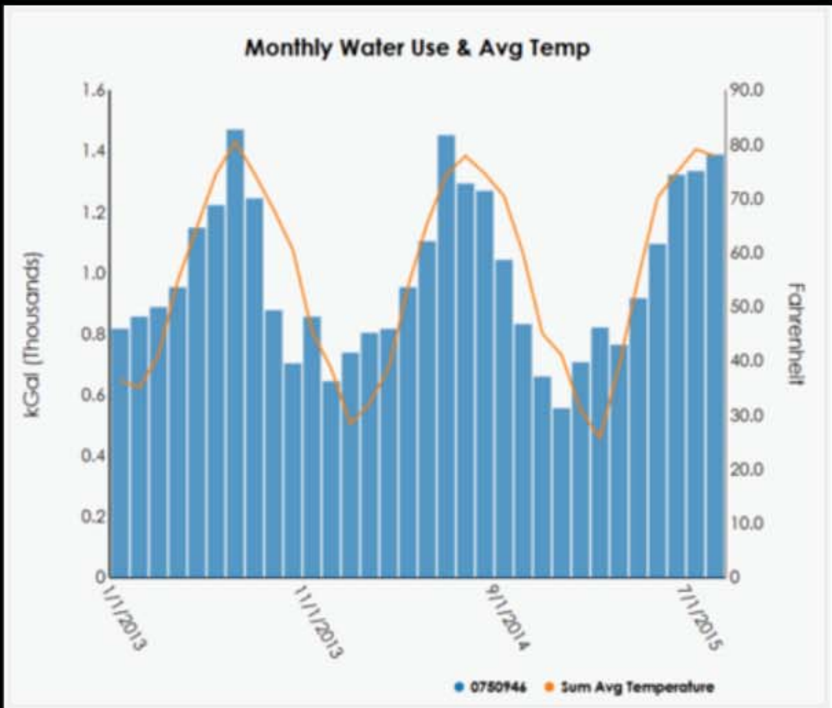

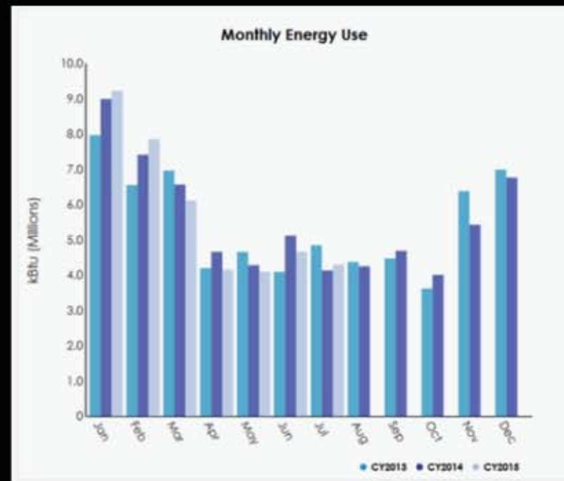

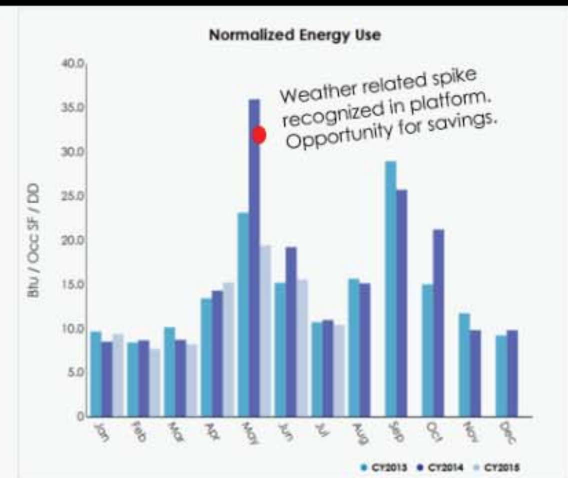

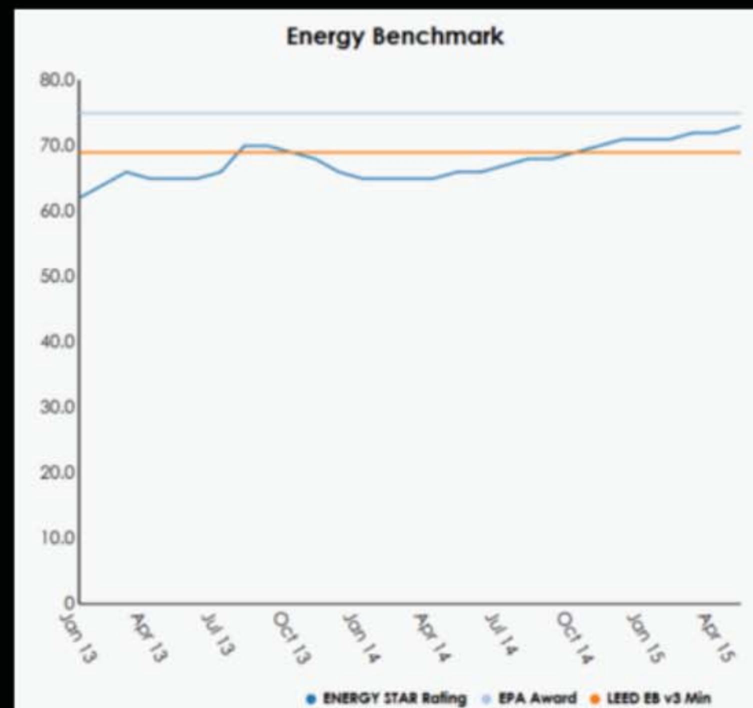

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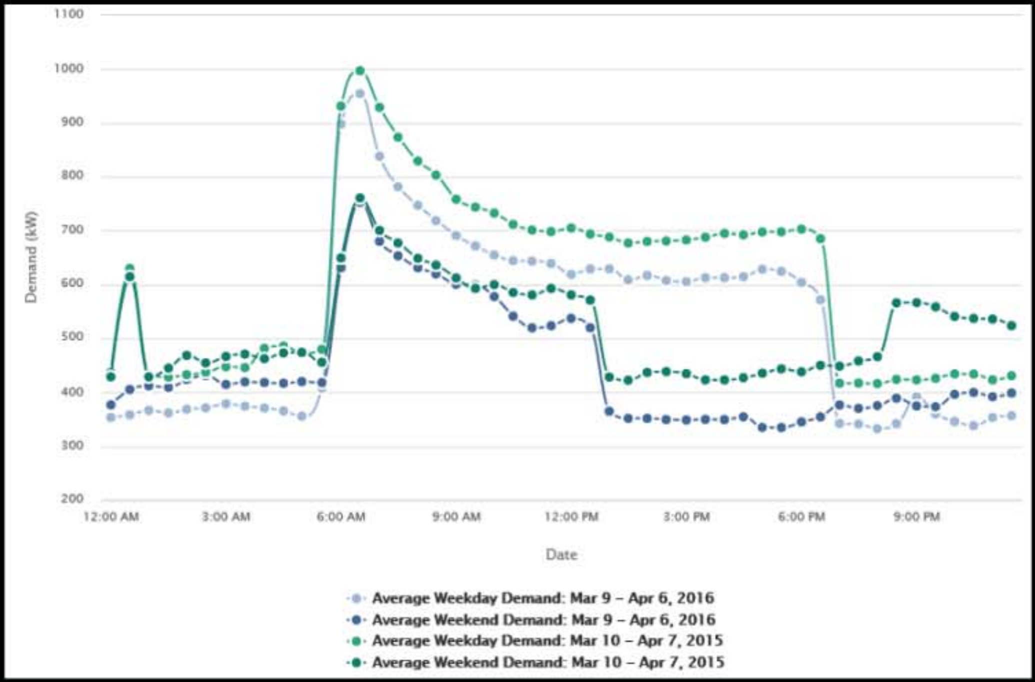
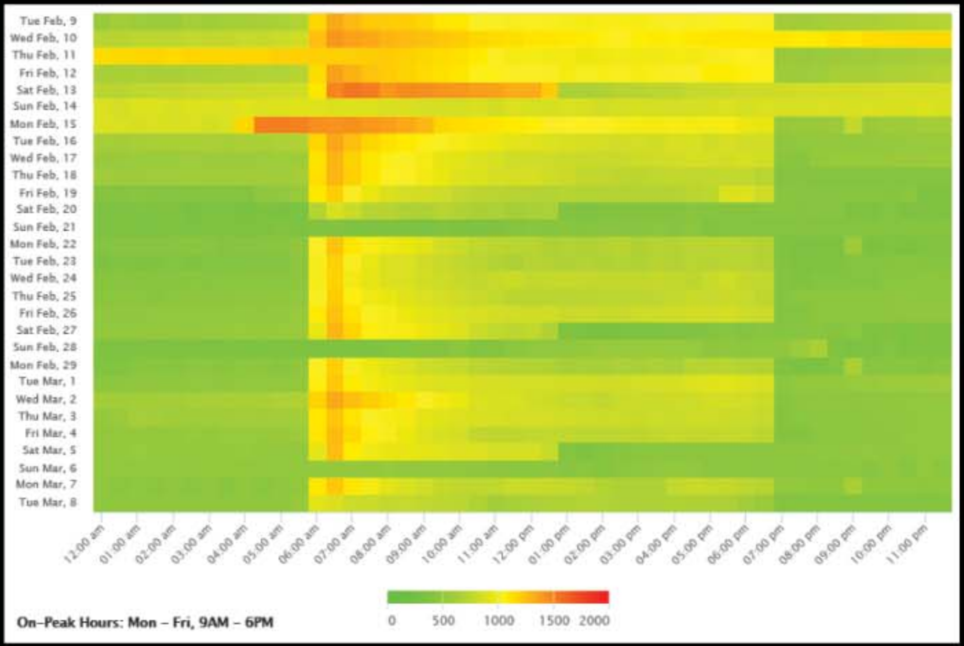
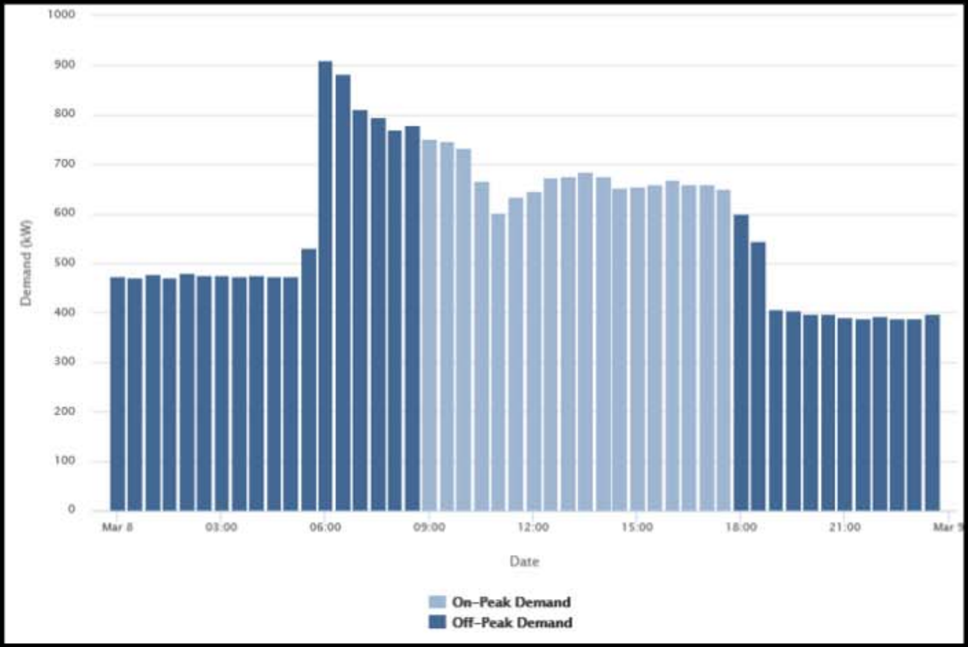






Sub Meters and Data Loggers

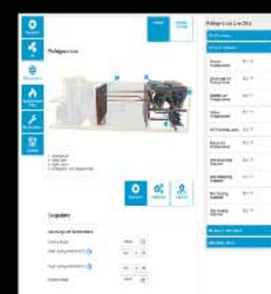
IoT Enabled Devices and Equipment









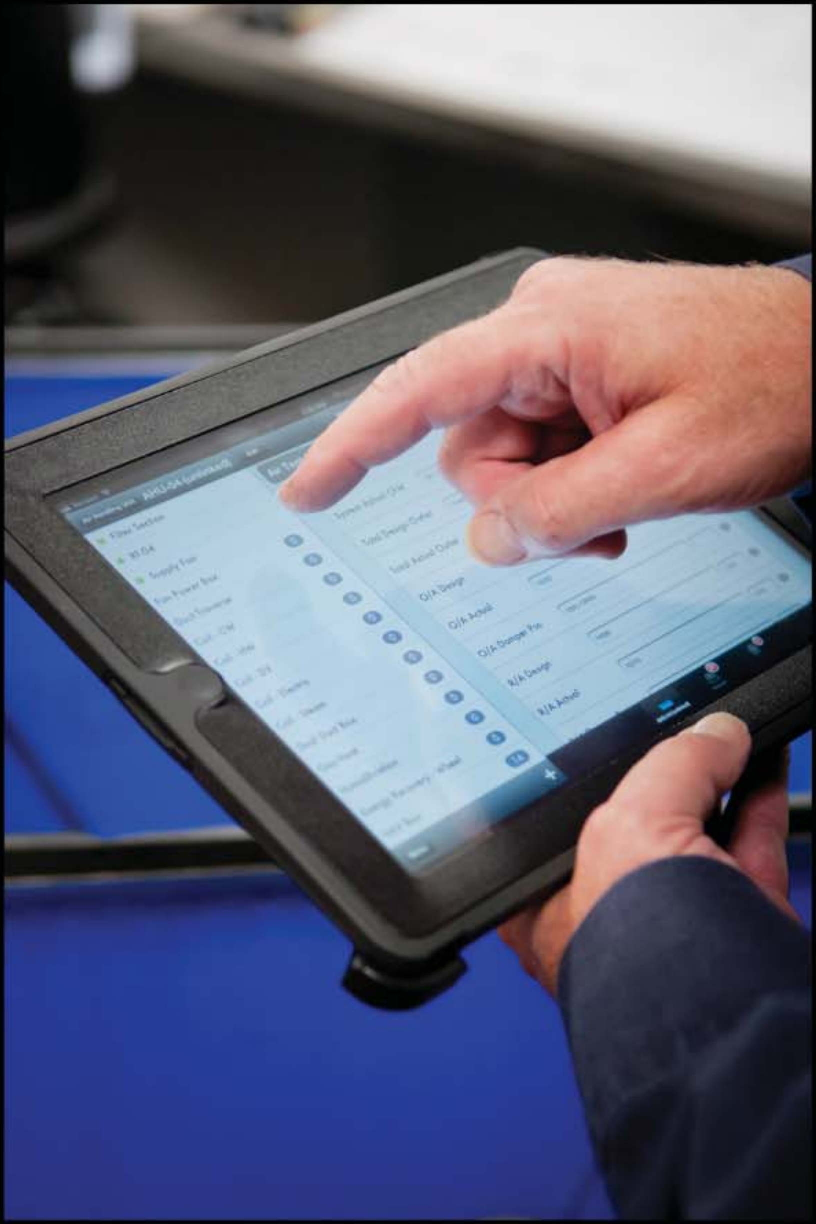


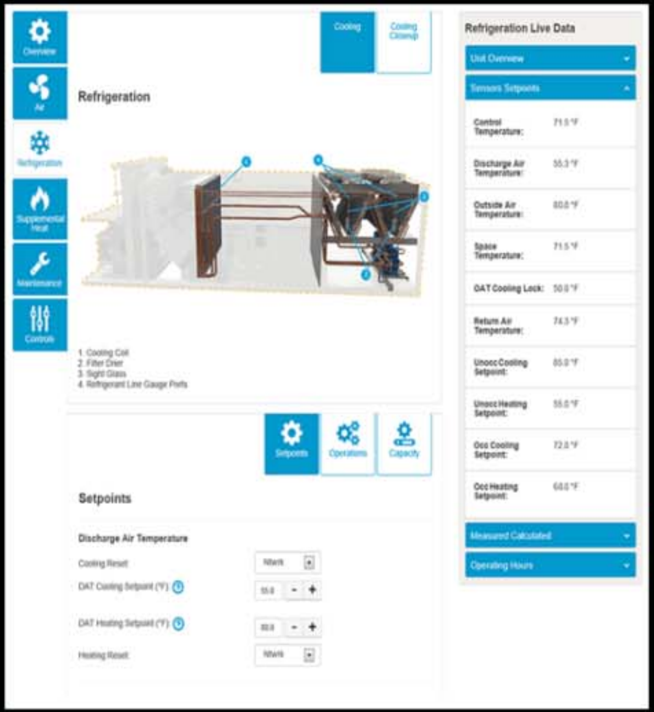

73.5°F


20
20
20
20

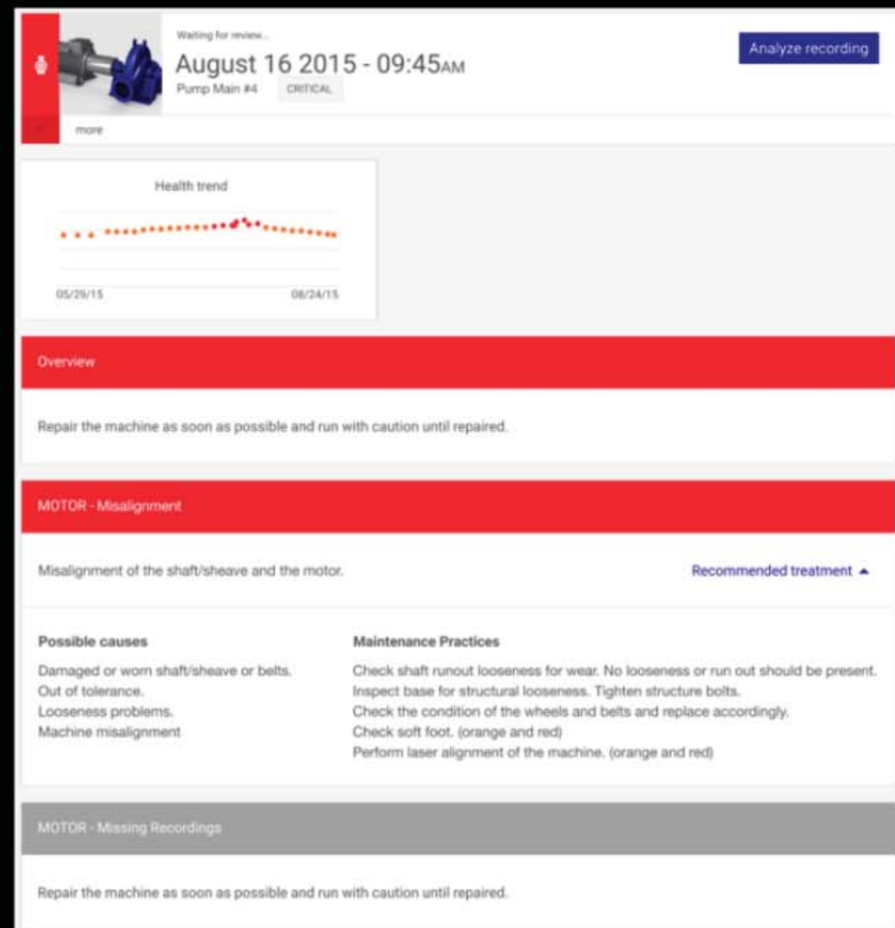

70.5°F


ALWAYS ON
OCCUPANCY SENSITIVE



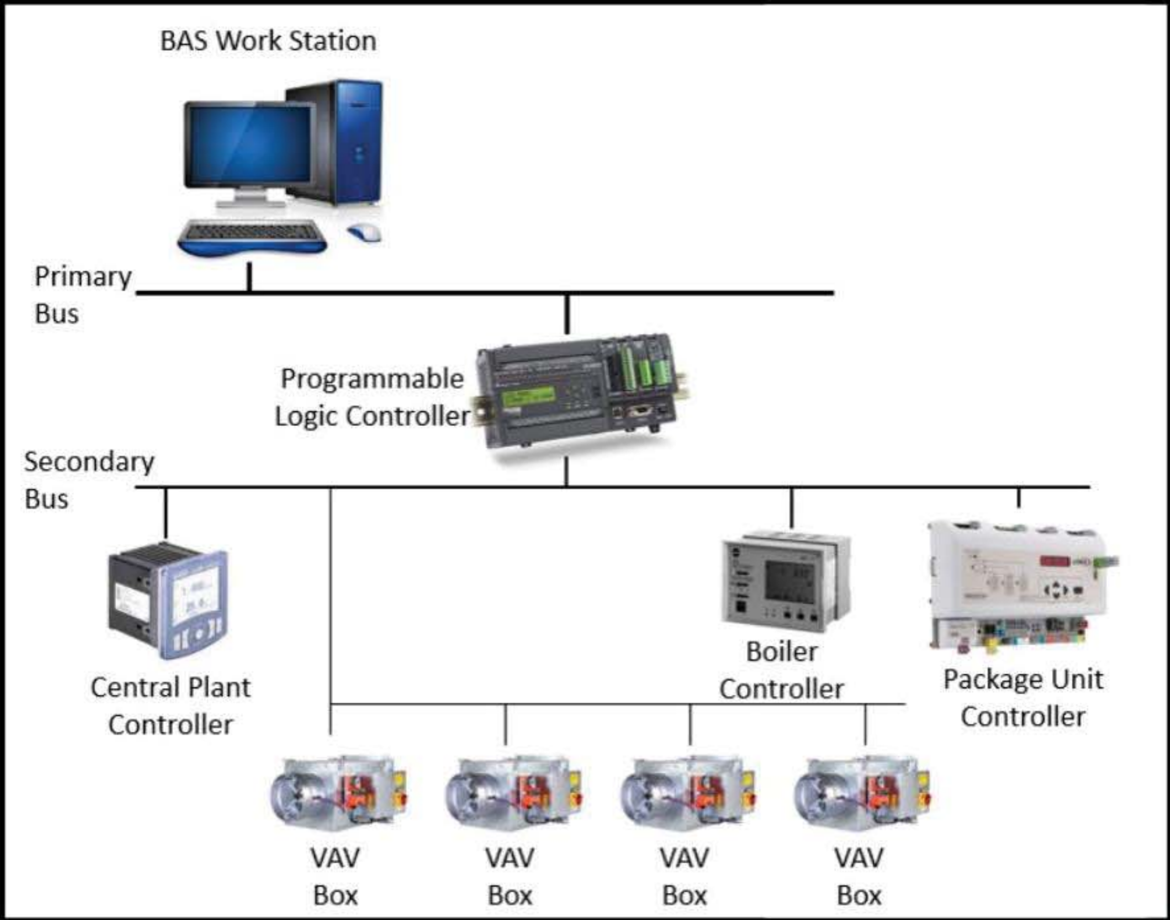

Overview
Air
Refrigeration
Supplemental Heat
Maintenance
Controls
Cooling
Cooling Cleanup
Refrigeration
1. Cooling Coil
2. Filter Drier
3. Sight Glass
4. Refrigerant Line Gauge Ports
Setpoints
Operations
Capacity
Setpoints
Discharge Air Temperature
Cooling Reset
DAT Cooling Setpoint (°F)
DAT Heating Setpoint (°F)
Heating Reset
Refrigeration Live Data
Unit Overview
Sensors Setpoints
Control Temperature:
Discharge Air Temperature:
Outside Air Temperature:
Space Temperature:
OAT Cooling Lock:
Return Air Temperature:
Unocc Cooling Setpoint:
Unocc Heating Setpoint:
Occ Cooling Setpoint:
Occ Heating Setpoint:
Measured Calculated
Operating Hours

Application Specific



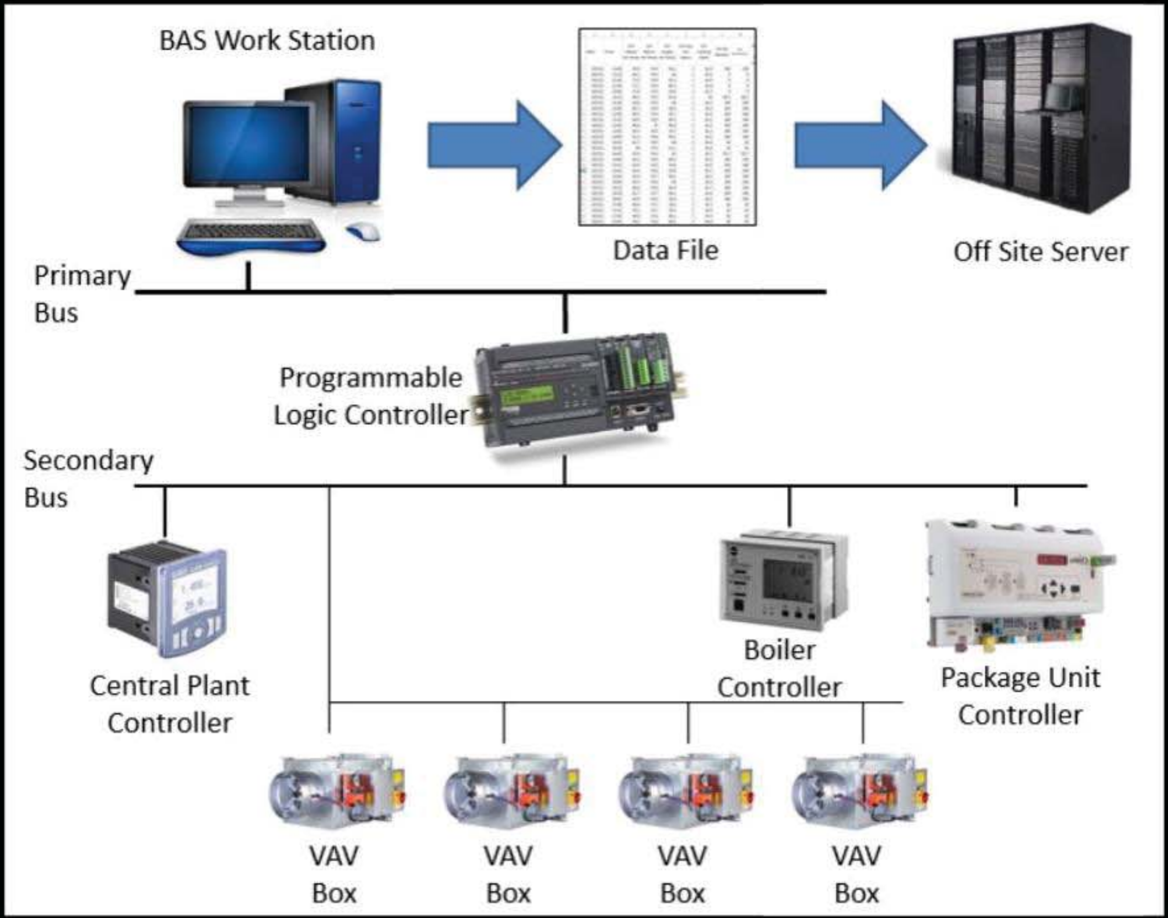
System Level Data Analytics

Typical Architecture



System Level Data Analytics

Front End Data Push



System Level Data Analytics

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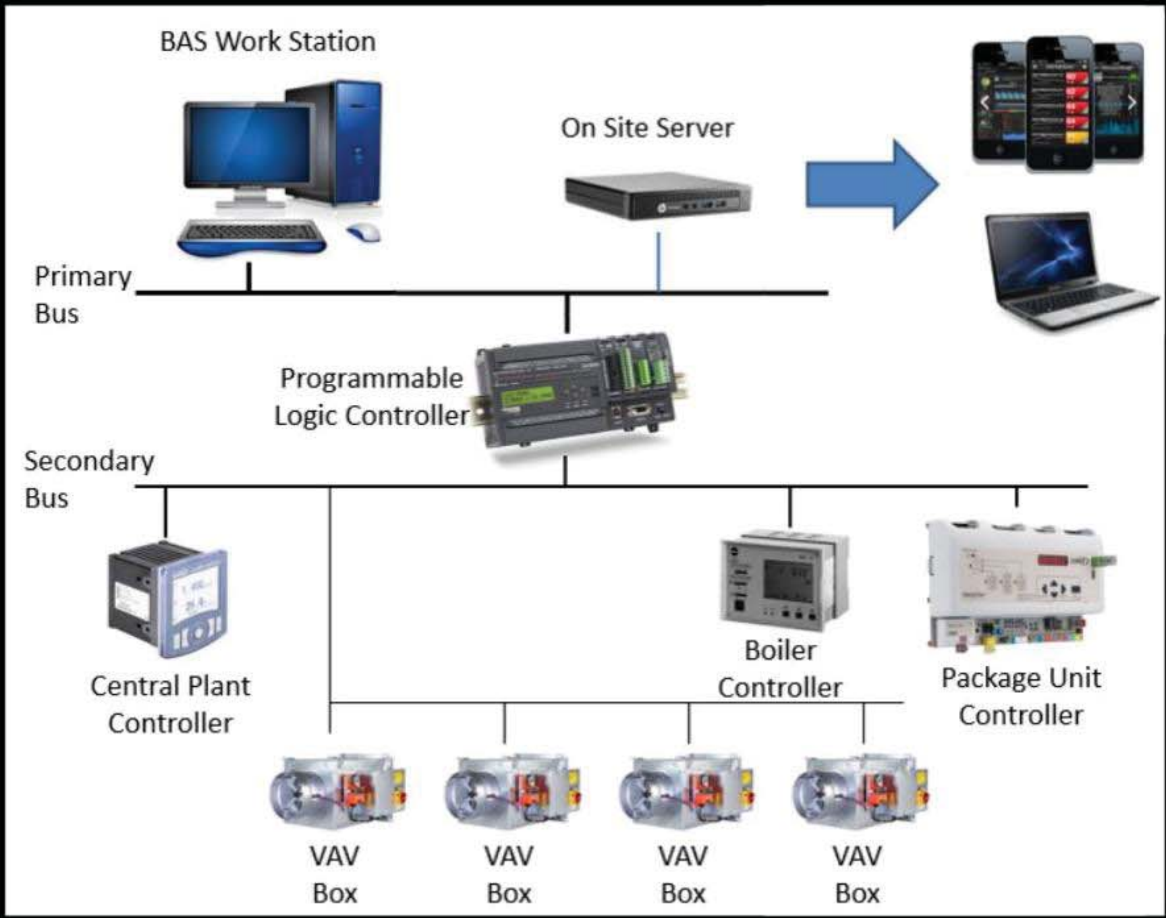

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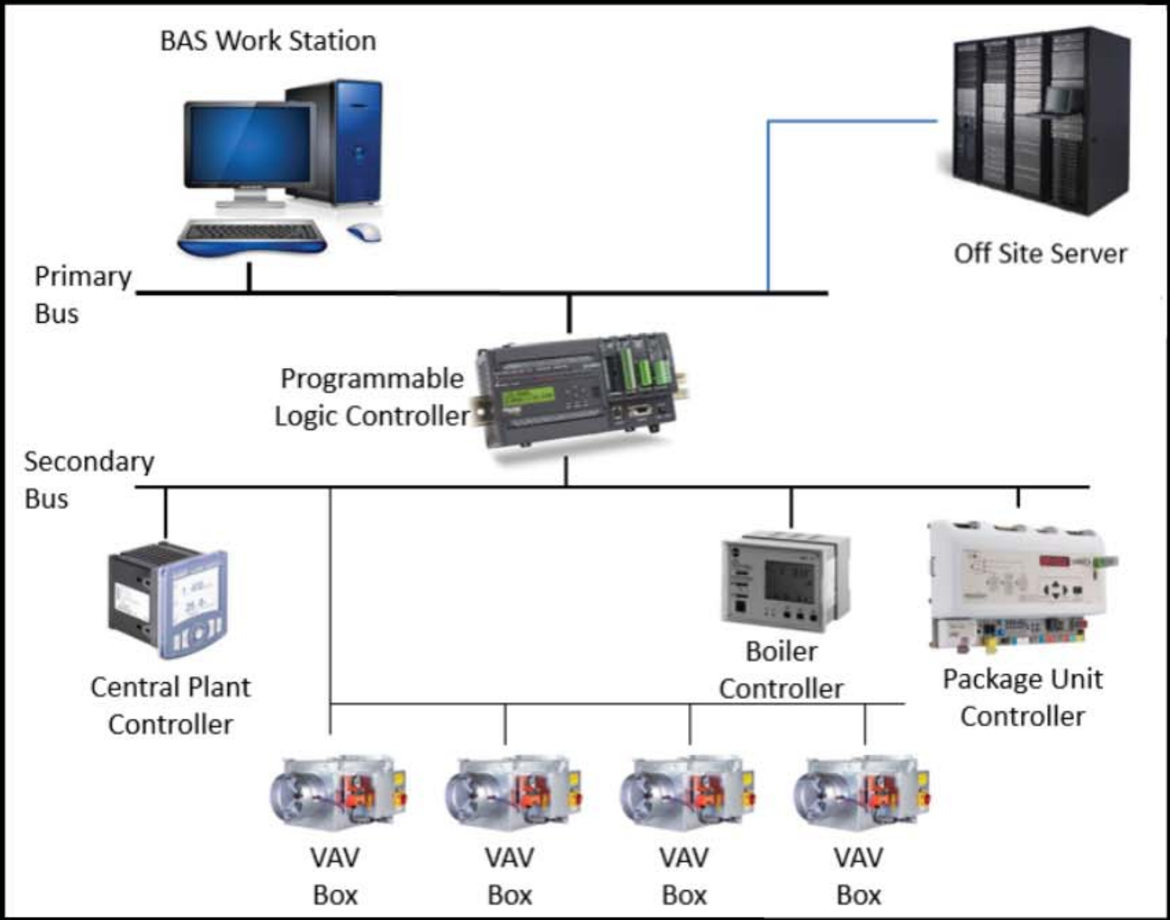


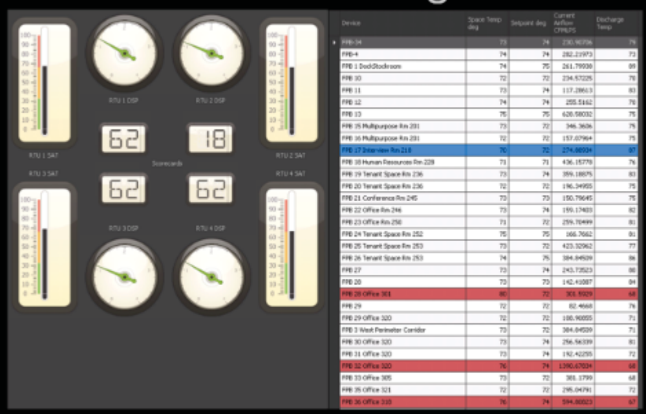
How do you access the data?

- Web-Based
- VPN, Remote Desk-Top Connection, Team Viewer
- Mobile App

Other Considerations

Other Considerations

- Security
- Liability
- Do you want the analytics platform to make changes?
- Dashboards
- Mobile Apps
- FM / CMMS



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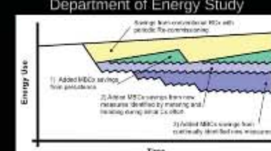

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5 Types of Analytics

- **Fault Detection/Diagnostics** – Is it operating as intended?
- **Performance Analysis and Scoring** – How well is it operating?
- **Operational Tuning** – How can I make it operate better?
- **Predictive Maintenance** – Can we identify any issues early?
- **Failure Forensics** – What happened?

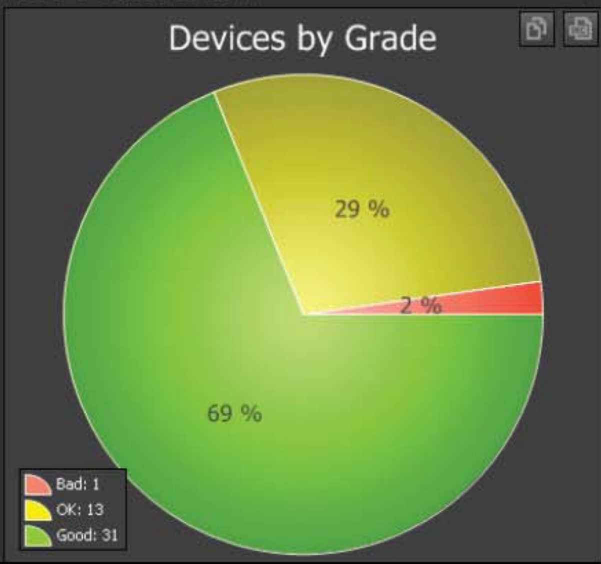
VAV / FPB Scorecard

Scorecard- FPB UC210 Zone Temps- scorecard *

Scorecard

Device	Score	Rank	Grade
FPB-14-11	28	45	Bad
FPB-15-12	44	44	OK
FPB-14-12	56	43	OK
FPB-15-15	64	42	OK
FPB 16-10	65	41	OK
FPB-15-02	66	40	OK
FPB-14-16	67	38	OK
FPB 16-09	67	38	OK
FPB 16-17	68	36	OK
FPB-15-14	68	36	OK
FPB 16-11	69	33	OK
FPB-14-09	69	33	OK
FPB-14-14	69	33	OK
FPB-14-08	70	32	OK
FPB 16-14	72	30	Good
FPB-15-16	72	30	Good
FPB-14-07	74	28	Good

Pie Chart - Grade Breakdown



Device Summary

FPB-15-12

44

Rank: 44 of 45

Average Device Score: 75

Zone Temps 44

Next Device

Previous Device

Select Device

Date Time Stamp	Active Cool Setpoint	Active Heat Setpoint	Space Temperature Active	Actual Air Valve Position	Discharge Air Flow	Discharge Air Temperature	Heat Output 1	Heat Output 2	Air Flow Setpoint Active	Zone Temps (Score)	(Ovr Score)
4/28/2016 8:12:00 AM	24.16667	23.05556	22.53	0	0	30.02703	1	0	0	47	47
4/28/2016 8:22:00 AM	24.16667	23.05556	22.64	0	0	30.02703	1	0	0	58	58
4/28/2016 8:32:00 AM	24.16667	23.05556	22.65	0	0	26.25783	0	0	0	59	59
4/28/2016 8:42:00 AM	24.16667	23.05556	22.4	0	0	30.00006	1	0	0	34	34
4/28/2016 8:52:00 AM	24.16667	23.05556	22.73	0	0	30.20023	1	0	0	67	67
4/28/2016 9:02:00 AM	24.16667	23.05556	22.73	0	0	27.36682	0	0	0	67	67
4/28/2016 9:12:00 AM	24.16667	23.05556	22.75	0	0	25.48743	0	0	0	69	69
4/28/2016 9:22:00 AM	24.16667	23.05556	22.49	0	0	30.25426	1	0	0	43	43
4/28/2016 9:32:00 AM	24.16667	23.05556	22.72	0	0	30.25426	1	0	0	66	66
4/28/2016 9:42:00 AM	24.16667	23.05556	22.86	0	0	30.48182	1	0	0	80	80
4/28/2016 9:52:00 AM	24.16667	23.05556	22.6	0	0	25.85148	0	0	0	54	54
4/28/2016 10:02:00 AM	24.16667	23.05556	22.6	0	0	30.27677	1	0	0	54	54
4/28/2016 10:12:00 AM	24.16667	23.05556	22.6	0	0	27.64864	0	0	0	54	54
4/28/2016 10:22:00 AM	24.16667	23.05556	22.82	0	0	25.71245	0	0	0	76	76
4/28/2016 10:32:00 AM	24.16667	23.05556	22.57	0	0	24.93416	0	0	0	51	51
4/28/2016 10:42:00 AM	24.16667	23.05556	22.53	0	0	30.44349	1	0	0	47	47
4/28/2016 10:52:00 AM	24.16667	23.05556	22.78	0	0	26.46781	0	0	0	72	72
4/28/2016 11:02:00 AM	24.16667	23.05556	22.67	0	0	25.17656	0	0	0	61	61
4/28/2016 11:12:00 AM	24.16667	23.05556	22.51	0	0	25.17656	0	0	0	45	45
4/28/2016 11:22:00 AM	24.16667	23.05556	22.62	0	0	30.32632	1	0	0	56	56
4/28/2016 11:32:00 AM	24.16667	23.05556	22.62	0	0	30.53369	1	0	0	56	56
4/28/2016 11:42:00 AM	24.16667	23.05556	22.86	0	0	26.03252	0	0	0	80	80
4/28/2016 11:52:00 AM	24.16667	23.05556	22.75	0	0	24.99365	0	0	0	69	69
4/28/2016 12:02:00 PM	24.16667	23.05556	22.65	0	0	24.62357	0	0	0	59	59
4/28/2016 12:12:00 PM	24.16667	23.05556	22.51	0	0	30.40517	1	0	0	45	45
4/28/2016 12:22:00 PM	24.16667	23.05556	22.62	0	0	30.40517	1	0	0	56	56
4/28/2016 12:32:00 PM	24.16667	23.05556	22.86	0	0	30.63522	1	0	0	80	80

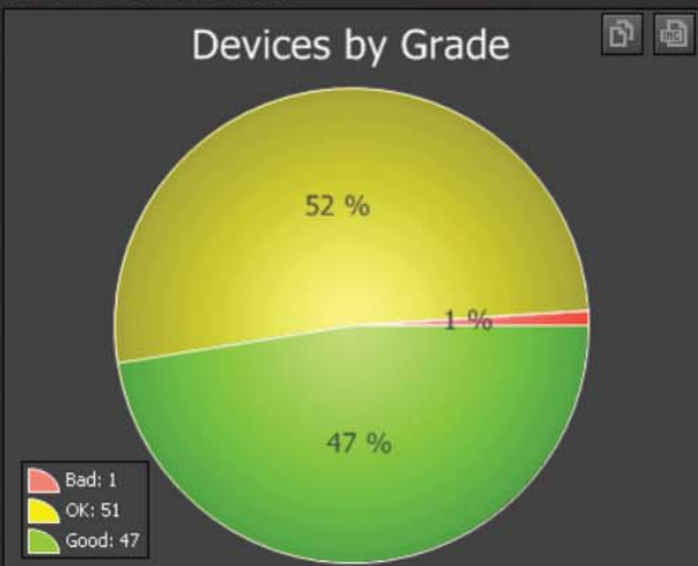
Score Duration | Device Data | Bar Chart - Individual Scores | Bar Chart - Device Averages

Fault Detection / Diagnostics

Scorecard

Device	Score	Rank	Grade
FPB 13	**4**	**99**	**Bad**
FPB 26 Tenant Space Rm 253	64	98	OK
FPB 54 Tenant Space 432	81	97	Good
FPB 42 Office 401	82	96	Good
FPB 52 Tenant Space 432	83	94	Good
FPB 32 Office 320	83	94	Good
FPB 3 West Perimeter Corridor	84	93	Good
FPB 48 Tenant Space 427	85	92	Good
FPB 15 Multipurpose Rm 201	87	91	Good
FPB 31 Office 320	88	90	Good
FPB-34	89	89	Good
FPB 24 Tenant Space Rm 252	90	88	Good
FPB 49 Office 428	91	86	Good
FPB-4	91	86	Good

Pie Chart - Grade Breakdown



Device Summary

FPB 13

4

Rank: 99 of 99

Average Device Score: 91

Current Airflow CFMLPS 4

Next Device

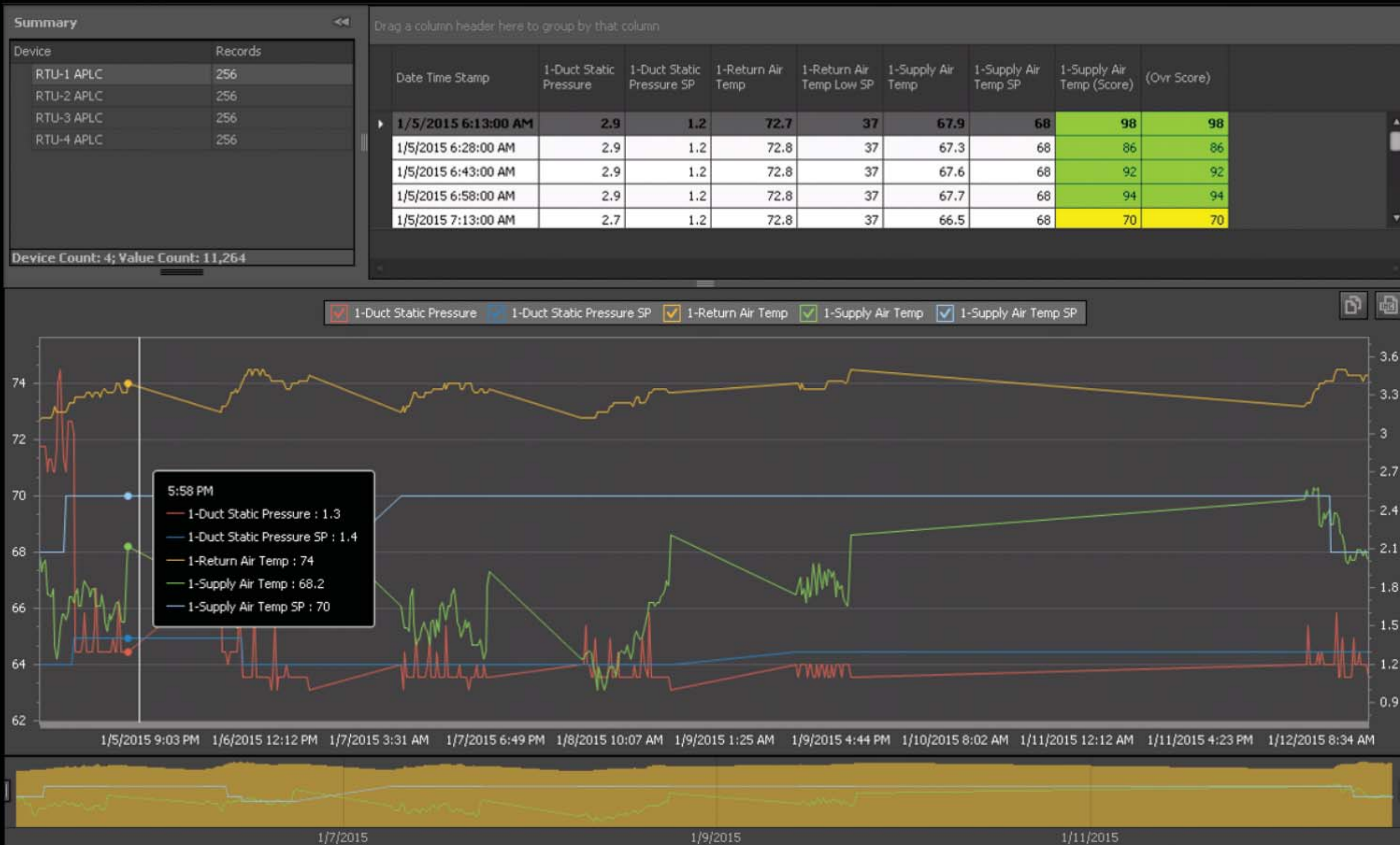
Previous Devi

Select Device

Date Time Stamp	Current Airflow CFMLPS	Rht Airflow SP CFMLPS	Discharge Temp	Current Htg Signal	k W Waste	Heating Status	Heating Step-1 Status	Heating Step-2 Status	Heating Step-3 S
1/5/2015 12:13:00 AM	615.75214	359.18875	91	100	2.1114595...	1	1	0	
1/5/2015 12:28:00 AM	679.89301	359.18875	91	100	2.6393246...	1	1	0	
1/5/2015 12:43:00 AM	615.75214	359.18875	91	100	2.1114595...	1	1	0	
1/5/2015 12:58:00 AM	615.75214	359.18875	91	100	2.1114595...	1	1	0	
1/5/2015 1:13:00 AM	654.23669	359.18875	91	100	2.4281788...	1	1	0	
1/5/2015 1:28:00 AM	628.58032	359.18875	91	100	2.2170326...	1	1	0	
1/5/2015 1:43:00 AM	628.58032	359.18875	91	100	2.2170326...	1	1	0	
1/5/2015 1:58:00 AM	667.06482	359.18875	91	100	2.5337514...	1	1	0	
1/5/2015 2:13:00 AM	628.58032	359.18875	91	100	2.2170326...	1	1	0	
1/5/2015 2:28:00 AM	628.58032	359.18875	91	100	2.2170326...	1	1	0	
1/5/2015 2:43:00 AM	628.58032	359.18875	90	100	2.1317621...	1	1	0	
1/5/2015 2:58:00 AM	654.23669	359.18875	90	100	2.3347873...	1	1	0	
1/5/2015 3:13:00 AM	628.58032	359.18875	91	100	2.2170326...	1	1	0	
1/5/2015 3:28:00 AM	667.06482	359.18875	91	100	2.5337514...	1	1	0	
1/5/2015 3:43:00 AM	667.06482	359.18875	90	100	2.4362994...	1	1	0	
1/5/2015 3:58:00 AM	628.58032	359.18875	90	100	2.1317621...	1	1	0	
1/5/2015 4:13:00 AM	628.58032	359.18875	90	100	2.1317621...	1	1	0	
1/5/2015 4:28:00 AM	654.23669	359.18875	90	100	2.3347873...	1	1	0	
1/5/2015 4:43:00 AM	654.23669	359.18875	90	100	2.3347873...	1	1	0	
1/5/2015 4:58:00 AM	628.58032	359.18875	90	100	2.1317621...	1	1	0	
1/5/2015 5:13:00 AM	628.58032	359.18875	91	100	2.2170326...	1	1	0	
1/5/2015 5:28:00 AM	667.06482	359.18875	91	100	2.5337514...	1	1	0	

Device Data | Bar Chart - Device Averages | Bar Chart - Individual Scores | Score Duration

Data Analysis



Critical Zone Analysis

Critical Zone

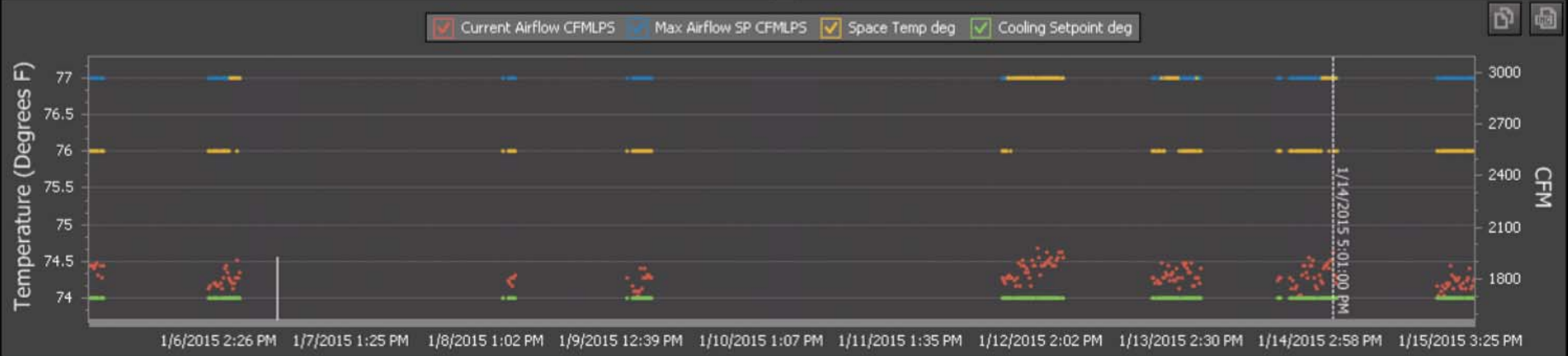
Summary

Device	Records
VAV 39	198
VAV 23	114
VAV 11	13
VAV 3-2 2nd Flr East Wing	4
VAV 28 A	2
FPB 19 Tenant Space Rm 236	1
FPB 32 Office 320	1
VAV 20	1
VAV 3-1 2nd Flr Center and ...	1
VAV 34	1
VAV 41	1

Device Count: 11; Value Count: 23,253

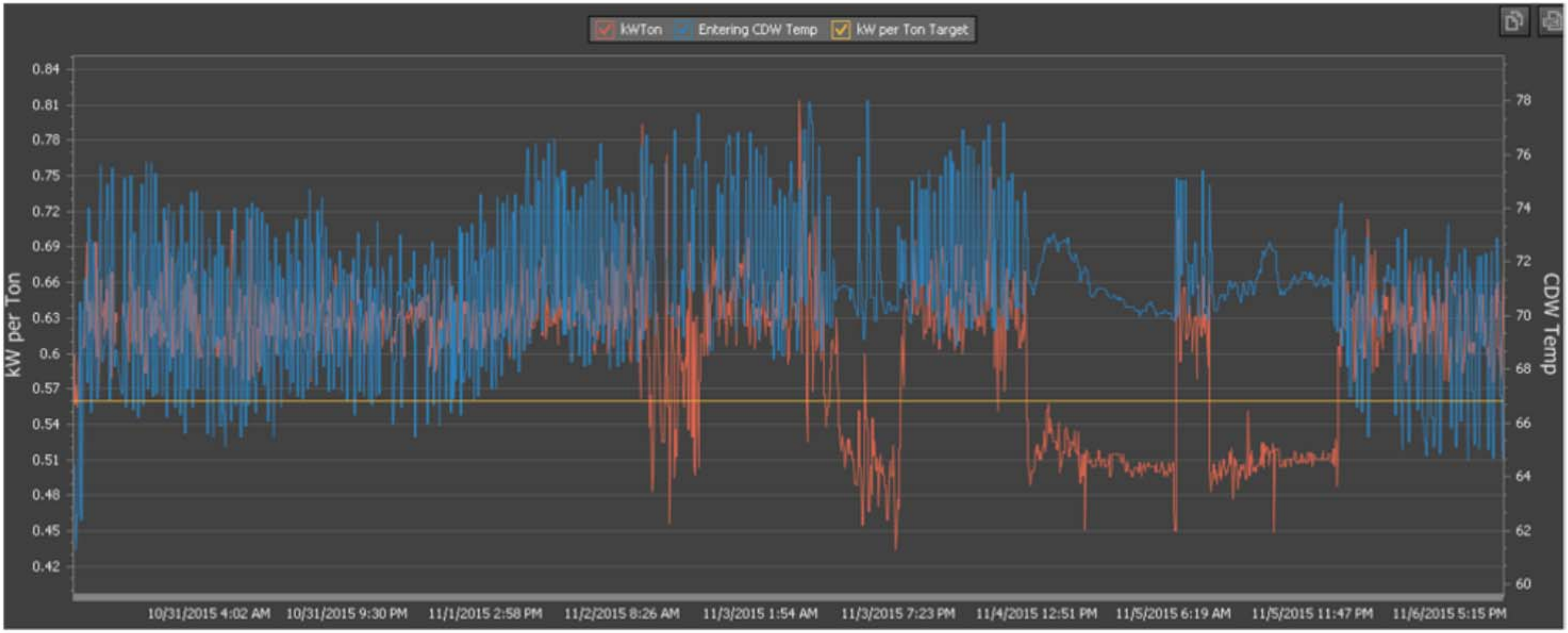
Drag a column header here to group by that column

Date Time Stamp	Current Clg Signal	Current Airflow CFMLPS	Max Airflow SP CFMLPS	Space Temp deg	Cooling Setpoint deg	After-hours Limit hrs	After-hours Timer hrs	After-hours Timer Status	ALM - High Space Temp
1/14/2015 5:01:00 PM	100	1960.35376	2965.66357	77	74	0	0	0	0
1/14/2015 5:16:00 PM	100	1826.3125	2965.66357	76	74	0	0	0	0
1/14/2015 5:31:00 PM	100	1776.047	2965.66357	77	74	0	0	0	0
1/14/2015 5:46:00 PM	100	1809.55737	2965.66357	76	74	0	0	0	0
1/15/2015 11:15:00 AM	98.03922	1759.29187	2965.66357	76	74	0	0	0	0
1/15/2015 11:30:00 AM	100	1709.02637	2965.66357	76	74	0	0	0	0
1/15/2015 11:45:00 AM	100	1725.78162	2965.66357	76	74	0	0	0	0
1/15/2015 12:00:00 PM	100	1759.29187	2965.66357	76	74	0	0	0	0
1/15/2015 12:15:00 PM	100	1709.02637	2965.66357	76	74	0	0	0	0
1/15/2015 12:30:00 PM	100	1742.53674	2965.66357	76	74	0	0	0	0
1/15/2015 12:45:00 PM	100	1776.047	2965.66357	76	74	0	0	0	0



Chiller Performance and Predictive Maintenance

Chiller Trend and Efficiency Analysis



Comments: Higher than target kW/ton due to large fluctuations in entering condenser water temperature.

Logs and Scheduled Auto Reports to Engineers

	A	G	H	I	J	K	L	M	N	O	P	Q	R
1	DateTimeStamp	kWTon	Entering CDW Temp	Leaving CDW Temp	Condenser Pressure	Condenser Sat Temp	Evaporator Pressure	Evaporator Sat Temp	Discharge Temp	Oil Pressure	Oil Temp	Motor Current	Phase A Motor C
143	10/27/15 12:27 PM	0.65	76.5	74.0	15.5	82.7	7.4	41.7	116.6	32.5	136.4	49.0	
144	10/27/15 12:32 PM	0.65	66.2	74.0	14.2	74.9	7.4	41.7	116.6	31.3	136.4	49.0	
145	10/27/15 12:37 PM	0.63	66.2	74.0	14.2	74.9	7.4	41.7	116.6	31.3	136.4	49.0	
146	10/27/15 12:42 PM	0.62	70.6	80.7	16.4	74.9	7.4	42.9	120.1	31.3	136.1	51.0	
147	10/27/15 12:47 PM	0.62	70.6	80.7	16.4	72.4	7.3	42.9	120.1	30.5	136.1	51.0	
148	10/27/15 12:52 PM	0.61	70.6	76.7	14.7	72.4	7.3	41.7	116.9	30.5	136.1	49.0	
149	10/27/15 12:57 PM	0.61	73.8	76.7	14.7	72.4	7.3	41.7	116.9	30.5	136.0	49.0	
150	10/27/15 01:02 PM	0.61	73.8	76.7	14.7	76.6	7.4	41.7	116.9	32.1	136.0	49.0	
151	10/27/15 01:07 PM	0.60	73.8	72.4	14.1	76.6	7.4	41.7	116.9	32.1	135.7	49.0	
152	10/27/15 01:12 PM	0.60	67.9	72.4	14.1	76.6	7.4	41.7	115.5	32.1	135.7	49.0	
153	10/27/15 01:17 PM	0.62	67.9	72.4	15.7	76.6	7.4	41.7	115.5	31.5	135.7	49.0	
154	10/27/15 01:22 PM	0.65	68.0	72.0	15.7	77.3	7.4	42.3	117.8	31.5	135.9	50.0	
155	10/27/15 01:27 PM	0.65	68.0	72.0	15.7	77.3	7.3	42.3	117.8	31.5	135.9	50.0	
156	10/27/15 01:32 PM	0.65	68.0	72.0	16.1	77.3	7.3	42.3	117.8	32.1	135.9	50.0	
157	10/27/15 01:37 PM	0.62	70.1	72.0	16.1	77.3	7.3	41.7	118.6	32.1	136.0	50.0	
158	10/27/15 01:42 PM	0.64	70.1	74.5	16.1	77.3	7.3	41.7	118.6	32.1	136.0	50.0	
159	10/27/15 01:47 PM	0.63	70.1	74.5	16.1	77.3	7.3	41.7	118.6	32.1	136.0	50.0	
160	10/27/15 01:52 PM	0.64	72.6	78.8	16.0	79.3	7.3	41.7	117.8	32.1	136.0	50.0	
161	10/27/15 01:57 PM	0.64	72.6	78.8	16.0	79.3	7.3	41.7	117.8	31.2	136.0	50.0	
162	10/27/15 02:02 PM	0.62	72.6	78.8	16.0	79.3	7.3	41.7	115.7	31.2	136.0	49.0	
163	10/27/15 02:07 PM	0.62	72.0	74.7	15.1	77.9	7.3	42.3	115.7	31.2	135.6	49.0	
164	10/27/15 02:12 PM	0.62	72.0	74.7	15.1	77.9	7.3	42.3	115.7	32.3	135.6	49.0	
165	10/27/15 02:17 PM	0.64	72.0	74.7	14.1	77.9	7.2	42.3	117.0	32.3	135.6	49.0	
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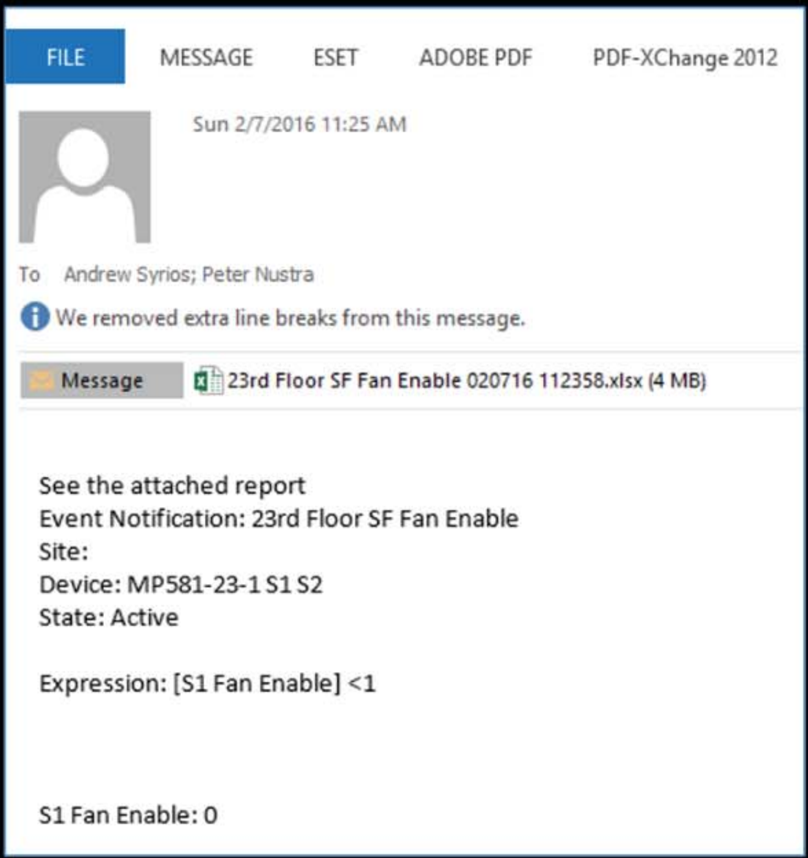
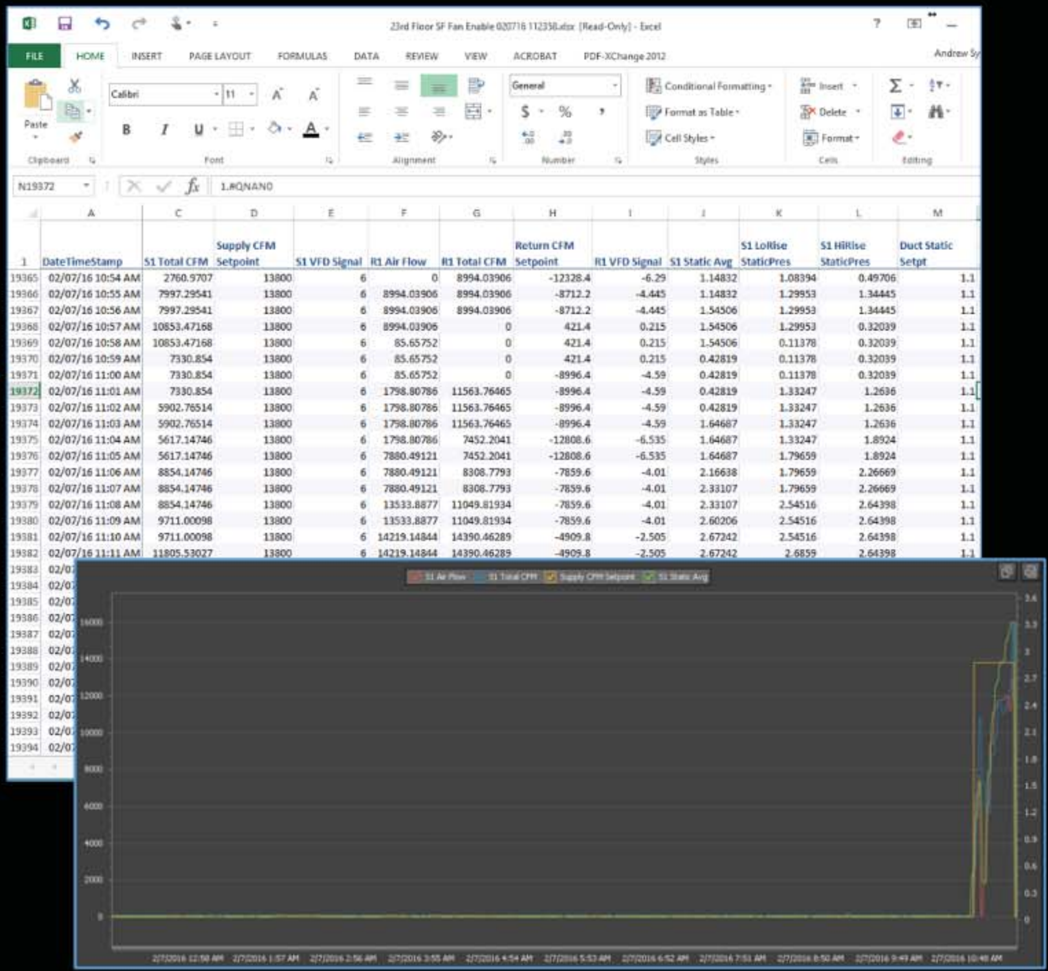
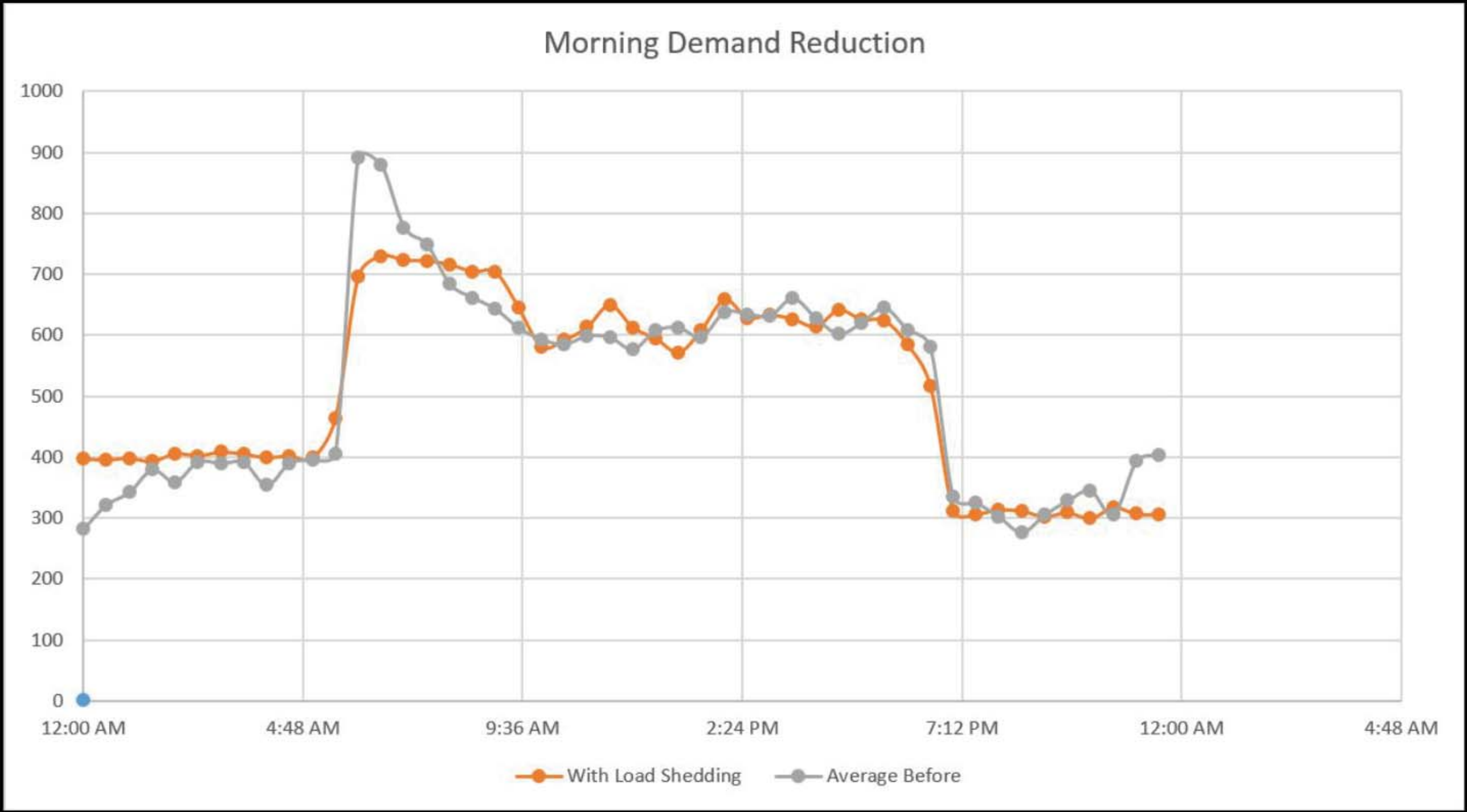
167	10/27/15 02:27 PM	0.60	69.4	72.0	14.1	72.8	7.2	41.1	117.0	31.3	135.6	50.0	
168	10/27/15 02:32 PM	0.59	69.4	72.0	14.1	72.8	7.2	41.1	118.6	32.1	135.6	50.0	
169	10/27/15 02:37 PM	0.61	65.3	74.8	14.2	72.8	7.3	41.7	118.6	32.1	135.6	50.0	
170	10/27/15 02:42 PM	0.60	65.3	74.8	14.2	72.8	7.3	41.7	118.6	32.1	135.7	49.0	
332	MIN=	0.58	65.3	72.0	14.1	72.4	7.2	41.1	115.5	30.5	135.3	48.0	
333	MAX=	0.73	78.2	83.7	17.5	84.3	7.6	43.5	121.1	33.2	136.9	51.0	
334	AVG=	0.64	71.1	77.4	15.7	78.2	7.4	42.2	118.4	31.9	136.1	49.5	

Event Notifications - AHU Enabled when scheduled off



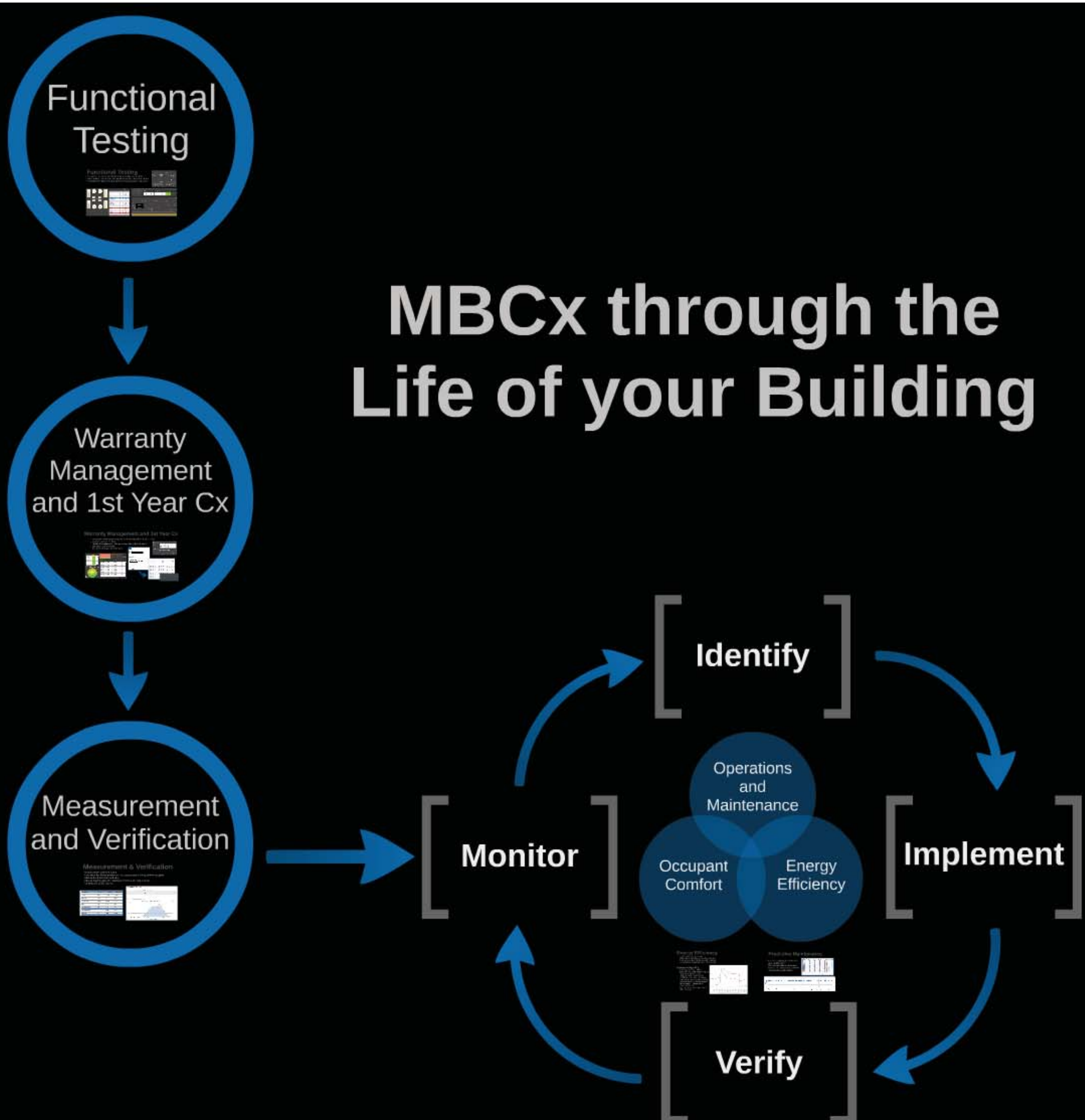


Demand Reduction and Load Shedding



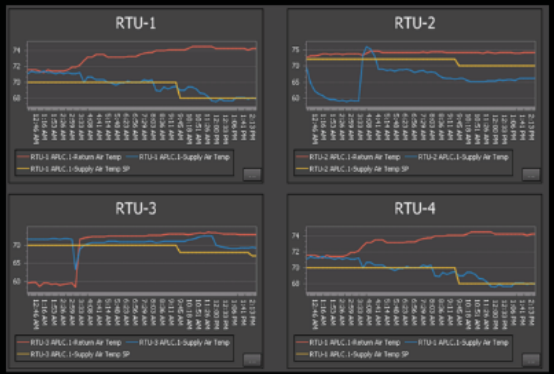
Morning peak demand reduction from 892 kW to 730kW.
Resulting savings of $907 for 1 month ($10,886 annual potential)

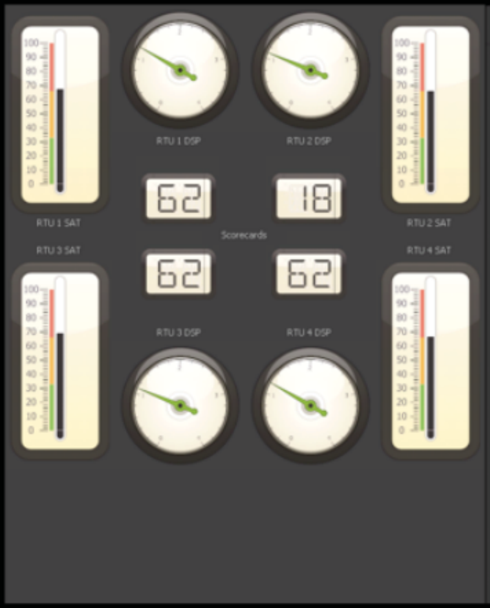
MBCx through the Life of your Building

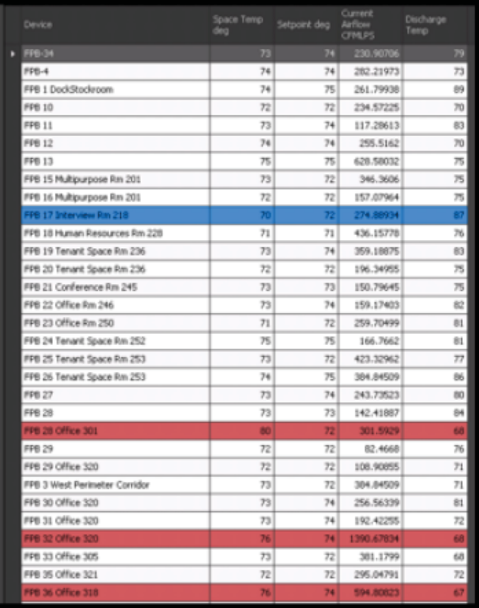


Functional Testing

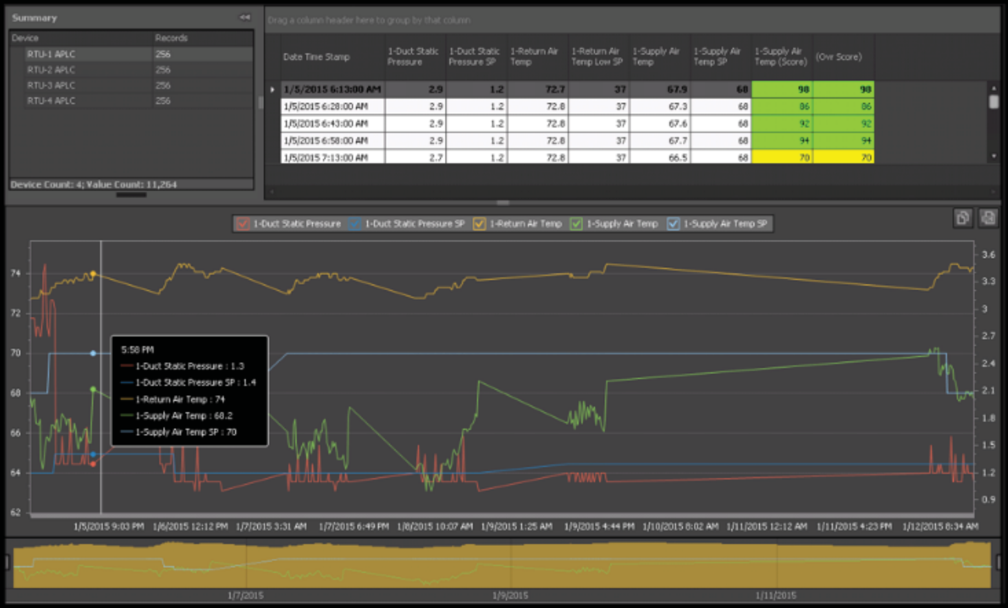
- Document and record functional testing with data and analytics.
- Utilize software as a tool to address issues quickly and ensure quality.
- Cost effectively test 100% of all devices without sampling restrictions







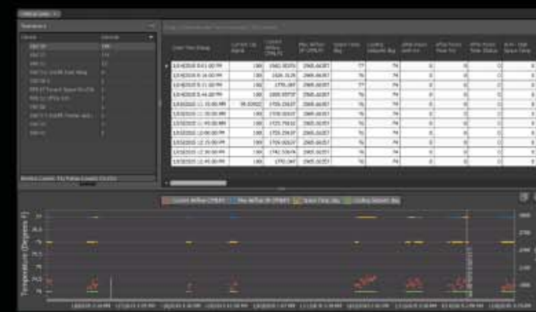
Device	Space Temp deg	Setpoint deg	Current Airflow CFMLPS	Discharge Temp
FPB-34	73	74	230.90706	79
FPB-4	74	74	282.21973	73
FPB 1 DockStockroom	74	75	261.79938	89
FPB 10	72	72	234.57225	70
FPB 11	73	74	117.28613	83
FPB 12	74	74	255.5162	70
FPB 13	75	75	628.58032	75
FPB 15 Multipurpose Rm 201	73	72	346.3606	75
FPB 16 Multipurpose Rm 201	72	72	157.07964	75
FPB 17 Interview Rm 218	70	72	274.88934	87
FPB 18 Human Resources Rm 228	71	71	436.15778	76
FPB 19 Tenant Space Rm 236	73	74	359.18875	83
FPB 20 Tenant Space Rm 236	72	72	196.34955	75
FPB 21 Conference Rm 245	73	73	150.79645	75
FPB 22 Office Rm 246	73	74	159.17403	82
FPB 23 Office Rm 250	71	72	259.70499	81
FPB 24 Tenant Space Rm 252	75	75	166.7662	81
FPB 25 Tenant Space Rm 253	73	72	423.32962	77
FPB 26 Tenant Space Rm 253	74	75	384.84509	86
FPB 27	73	74	243.73523	80
FPB 28	73	73	142.41887	84
FPB 28 Office 301	80	72	301.5929	68
FPB 29	72	72	82.4668	76
FPB 29 Office 320	72	72	108.90855	71
FPB 3 West Perimeter Corridor	73	72	384.84509	71
FPB 30 Office 320	73	74	256.56339	81
FPB 31 Office 320	73	74	192.42255	72
FPB 32 Office 320	76	74	1390.67834	68
FPB 33 Office 305	73	72	381.1799	68
FPB 35 Office 321	72	72	295.04791	72
FPB 36 Office 318	76	74	594.80823	67

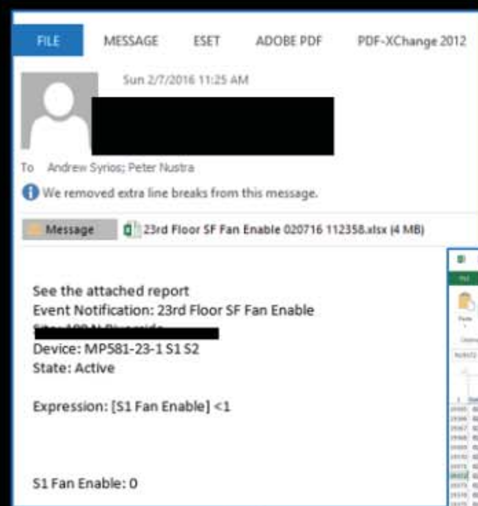


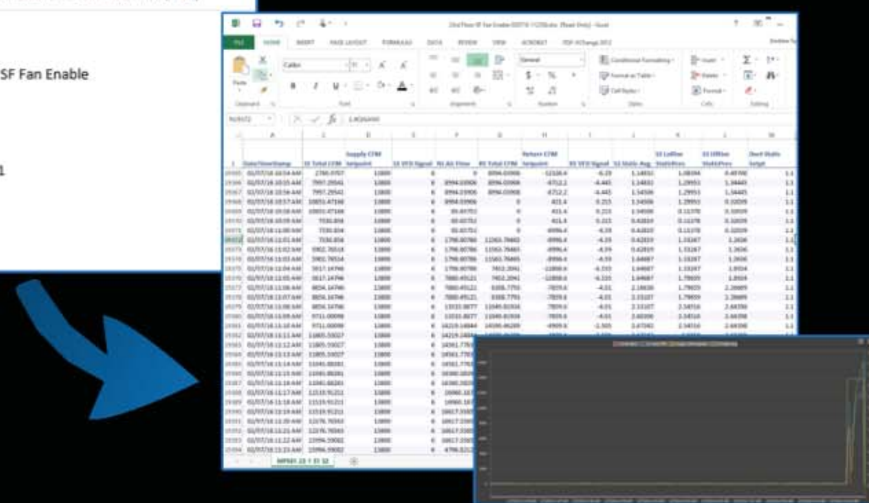
Date Time Stamp	1-Duct Static Pressure	1-Duct Static Pressure SP	1-Return Air Temp	1-Return Air Temp Low SP	1-Supply Air Temp	1-Supply Air Temp SP	1-Supply Air Temp (Score)	(Ovr Score)
1/5/2015 6:13:00 AM	2.9	1.2	72.7	37	67.9	68	98	98
1/5/2015 6:28:00 AM	2.9	1.2	72.8	37	67.3	68	86	86
1/5/2015 6:43:00 AM	2.9	1.2	72.8	37	67.6	68	92	92
1/5/2015 6:58:00 AM	2.9	1.2	72.8	37	67.7	68	94	94
1/5/2015 7:13:00 AM	2.7	1.2	72.8	37	66.5	68	70	70

Warranty Management and 1st Year Cx

- Ensure the facility operates per the OPR and specifications at all times.
- Assist in operator training.
- Identify, Investigate and, Address issues during the 1st year of operation under warranty.
- Document changes and overrides.



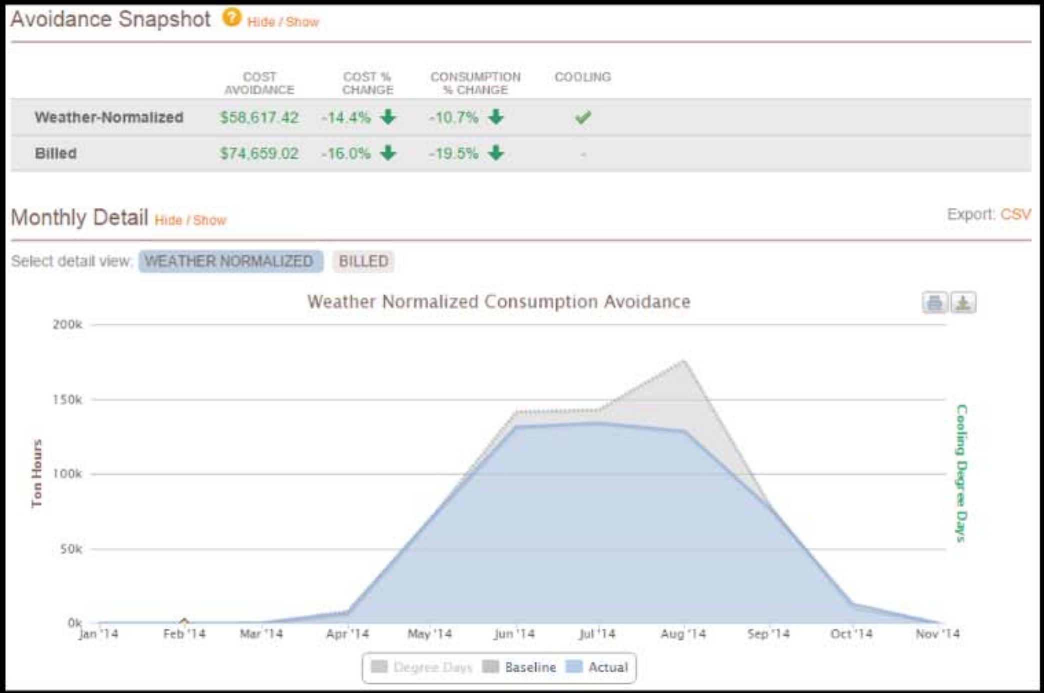


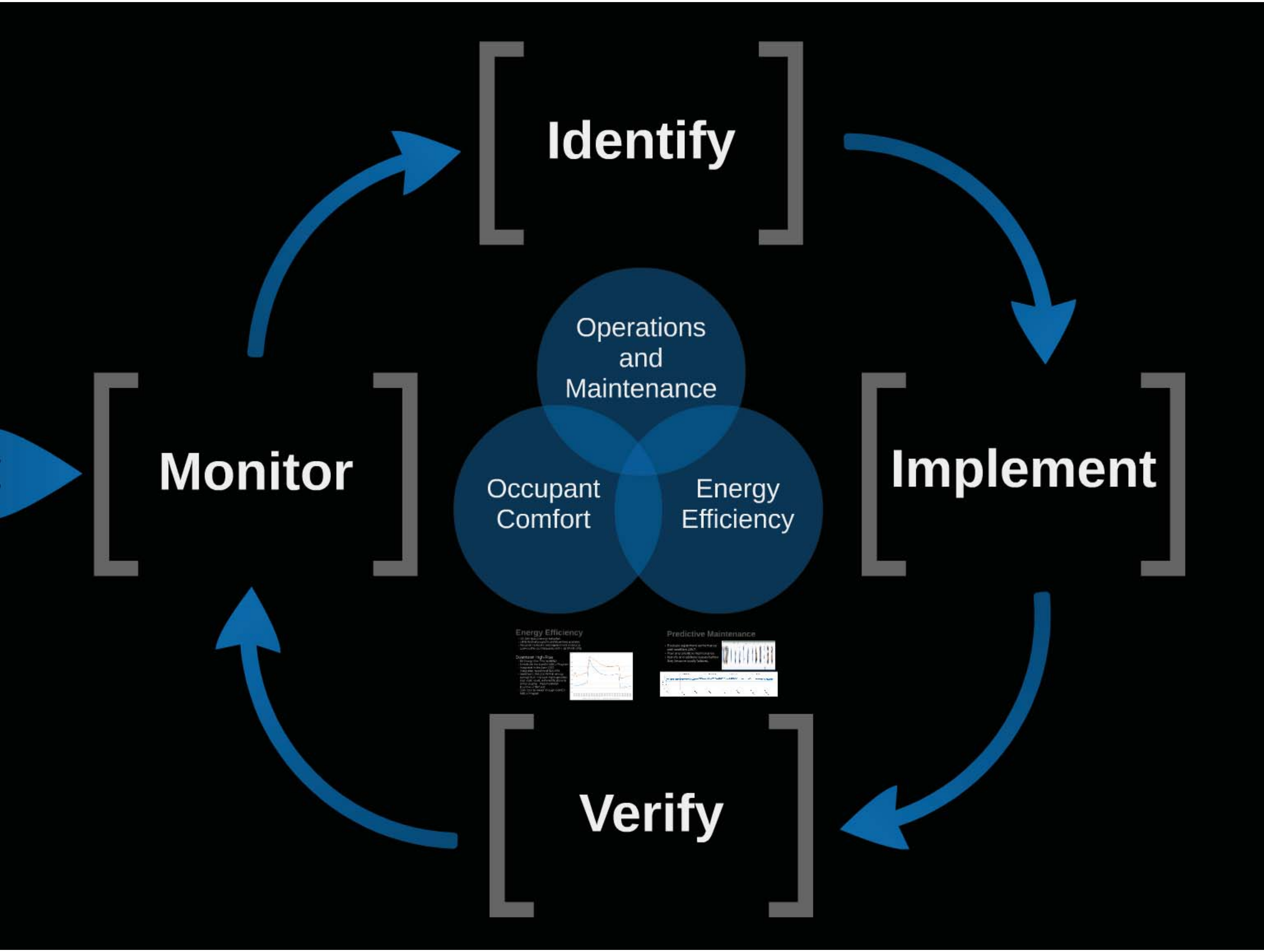


Measurement & Verification

- Measurement and Verification
- How does the facility perform vs. the energy model and performance goals.
- Identify the differences and why.
- Identify opportunities for improvement and make adjustments.
- Qualifies for LEED credits.

TYPE OF SOURCE	TOTALS (ACTUAL)	TOTALS (BASELINE)	TOTALS (PROPOSED)
SPARE	233,801	0	0
COOLING	3,516,735	2,229,436	1,602,073
FANS	2,320,235	1,559,521	2,437,293
HEATING(ELEC)	422,267	0	344,672
INDOOR LIGHTING	1,611,290	989,263	703,225
OUTDOOR LIGHTING	333,640	1,070,680	604,523
PROCESS	5,378,713	3,888,813	3,888,813
PUMPS	11,742	34,249	19,144
RECEPTACLE	212,735	508,166	508,166
DOMESTIC HOT WATER	13,011	51,578	50,910
Total Annual Electric Usage (kWh)	14,054,171	10,331,706	10,158,819
DOMESTIC HOT WATER		51578	50910
KITCHEN EQUIPMENT (GAS)	156000		0
HEATING(GAS)	104831	306648	114518
Total Annual Gas Usage (Therms)	260831	358226	165428



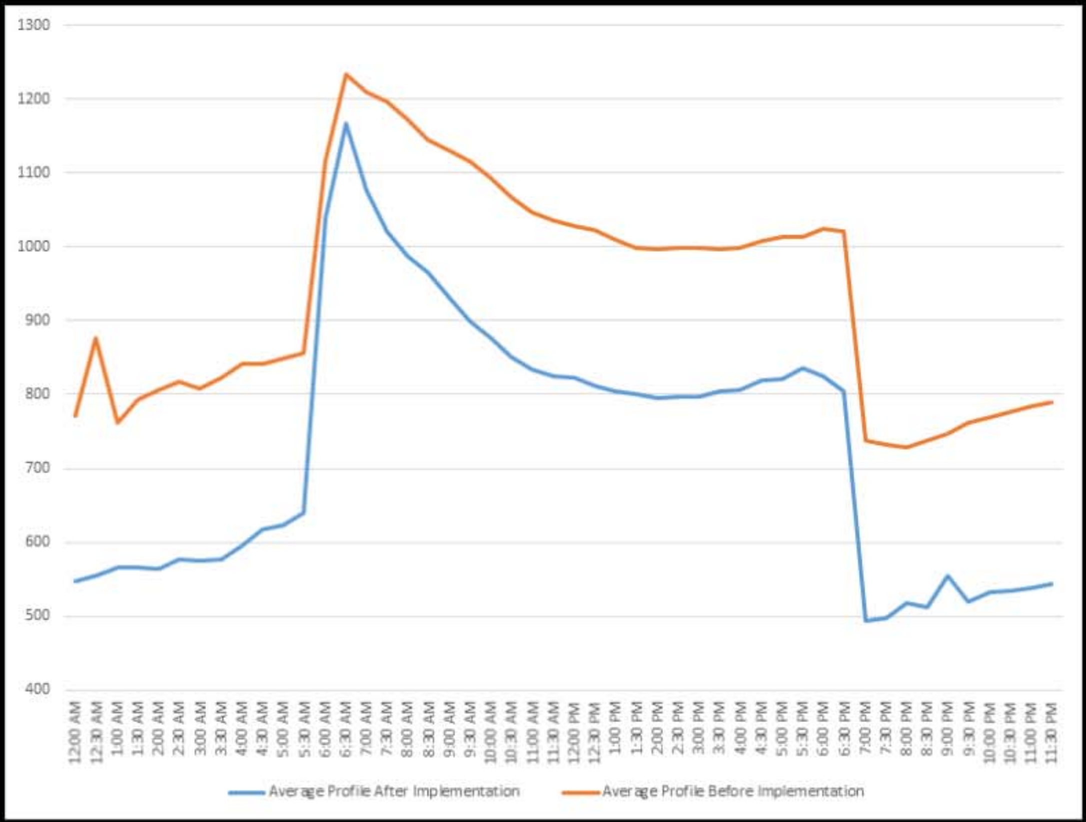

Identify
Implement
Verify
Monitor
Operations and Maintenance
Occupant Comfort
Energy Efficiency
Energy Efficiency
Predictive Maintenance

Energy Efficiency

- 10-15% typical energy reduction.
- Utility funded programs and incentives available.
- Focus on corrective and improvement measures.
- Low cost/no cost measures with < 18 Month SPB.

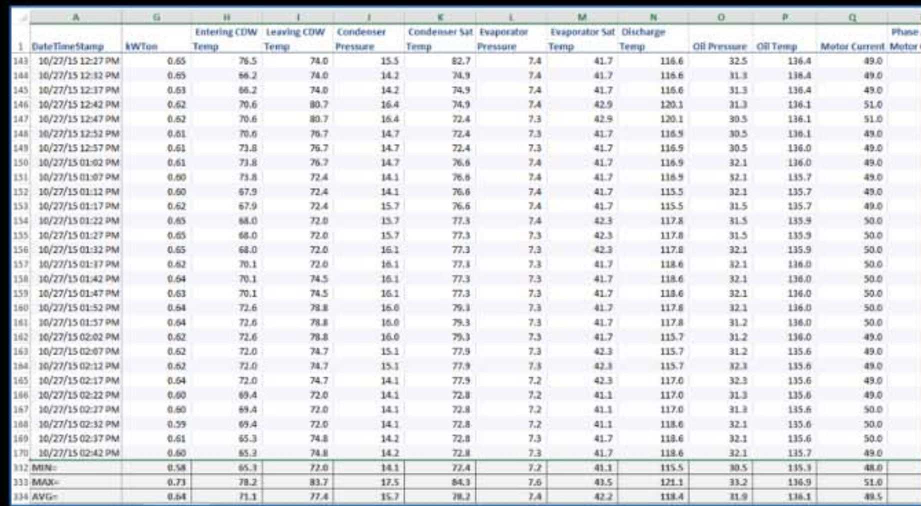
Downtown High-Rise

- 80 Energy Star Prior to MBCx
- Enrolled in the ComEd MBCx Program
- Integrated in the June 2015. Integration incentive of $25,000.
- Identified 1,394,316 kWh in energy savings from improper night operation, duct static reset, and modifications to chiller staging. Implementation incentive of $97,602.
- Zero Cost to Owner through ComEd MBCx Program



Predictive Maintenance

- Evaluate equipment performance and condition 24x7.
- Plan and prioritize maintenance.
- Identify and address issues before they become costly failures.



	A	G	H	I	J	K	L	M	N	O	P	Q	
1	DateTimeStamp	kWTon	Entering CDW Temp	Leaving CDW Temp	Condenser Pressure	Condenser Sat Temp	Evaporator Pressure	Evaporator Sat Temp	Discharge Temp	Oil Pressure	Oil Temp	Motor Current	Phase A Motor C
143	10/27/15 12:27 PM	0.65	76.5	74.0	15.5	82.7	7.4	41.7	116.6	32.5	136.4	49.0	
144	10/27/15 12:32 PM	0.65	66.2	74.0	14.2	74.9	7.4	41.7	116.6	31.3	136.4	49.0	
145	10/27/15 12:37 PM	0.63	66.2	74.0	14.2	74.9	7.4	41.7	116.6	31.3	136.4	49.0	
146	10/27/15 12:42 PM	0.62	70.6	80.7	16.4	74.9	7.4	42.9	120.1	31.3	136.1	51.0	
147	10/27/15 12:47 PM	0.62	70.6	80.7	16.4	72.4	7.3	42.9	120.1	30.5	136.1	51.0	
148	10/27/15 12:52 PM	0.61	70.6	76.7	14.7	72.4	7.3	41.7	116.9	30.5	136.1	49.0	
149	10/27/15 12:57 PM	0.61	73.8	76.7	14.7	72.4	7.3	41.7	116.9	30.5	136.0	49.0	
150	10/27/15 01:02 PM	0.61	73.8	76.7	14.7	76.6	7.4	41.7	116.9	32.1	136.0	49.0	
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152	10/27/15 01:12 PM	0.60	67.9	72.4	14.1	76.6	7.4	41.7	115.5	32.1	135.7	49.0	
153	10/27/15 01:17 PM	0.62	67.9	72.4	15.7	76.6	7.4	41.7	115.5	31.5	135.7	49.0	
154	10/27/15 01:22 PM	0.65	68.0	72.0	15.7	77.3	7.4	42.3	117.8	31.5	135.9	50.0	
155	10/27/15 01:27 PM	0.65	68.0	72.0	15.7	77.3	7.3	42.3	117.8	31.5	135.9	50.0	
156	10/27/15 01:32 PM	0.65	68.0	72.0	16.1	77.3	7.3	42.3	117.8	32.1	135.9	50.0	
157	10/27/15 01:37 PM	0.62	70.1	72.0	16.1	77.3	7.3	41.7	118.6	32.1	136.0	50.0	
158	10/27/15 01:42 PM	0.64	70.1	74.5	16.1	77.3	7.3	41.7	118.6	32.1	136.0	50.0	
159	10/27/15 01:47 PM	0.63	70.1	74.5	16.1	77.3	7.3	41.7	118.6	32.1	136.0	50.0	
160	10/27/15 01:52 PM	0.64	72.6	78.8	16.0	79.3	7.3	41.7	117.8	32.1	136.0	50.0	
161	10/27/15 01:57 PM	0.64	72.6	78.8	16.0	79.3	7.3	41.7	117.8	31.2	136.0	50.0	
162	10/27/15 02:02 PM	0.62	72.6	78.8	16.0	79.3	7.3	41.7	115.7	31.2	136.0	49.0	
163	10/27/15 02:07 PM	0.62	72.0	74.7	15.1	77.9	7.3	42.3	115.7	31.2	135.6	49.0	
164	10/27/15 02:12 PM	0.62	72.0	74.7	15.1	77.9	7.3	42.3	115.7	32.3	135.6	49.0	
165	10/27/15 02:17 PM	0.64	72.0	74.7	14.1	77.9	7.2	42.3	117.0	32.3	135.6	49.0	
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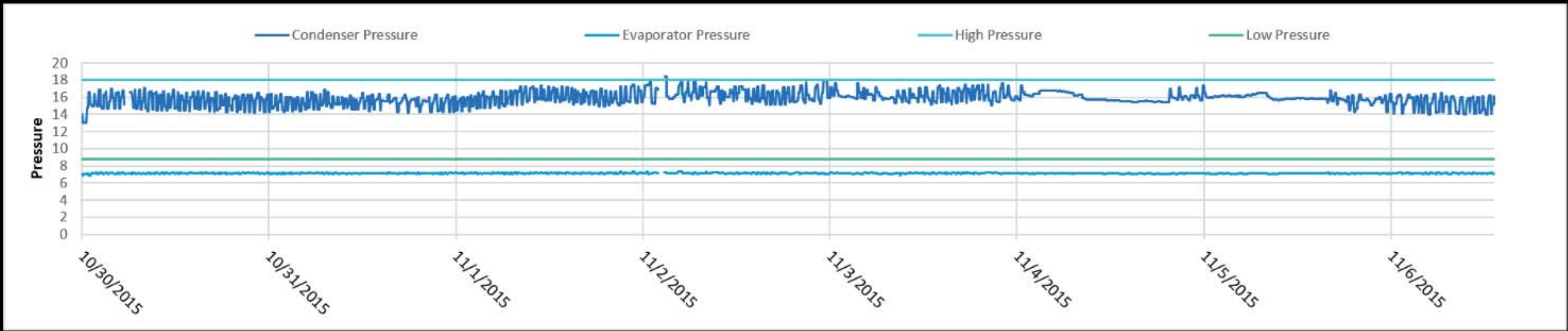
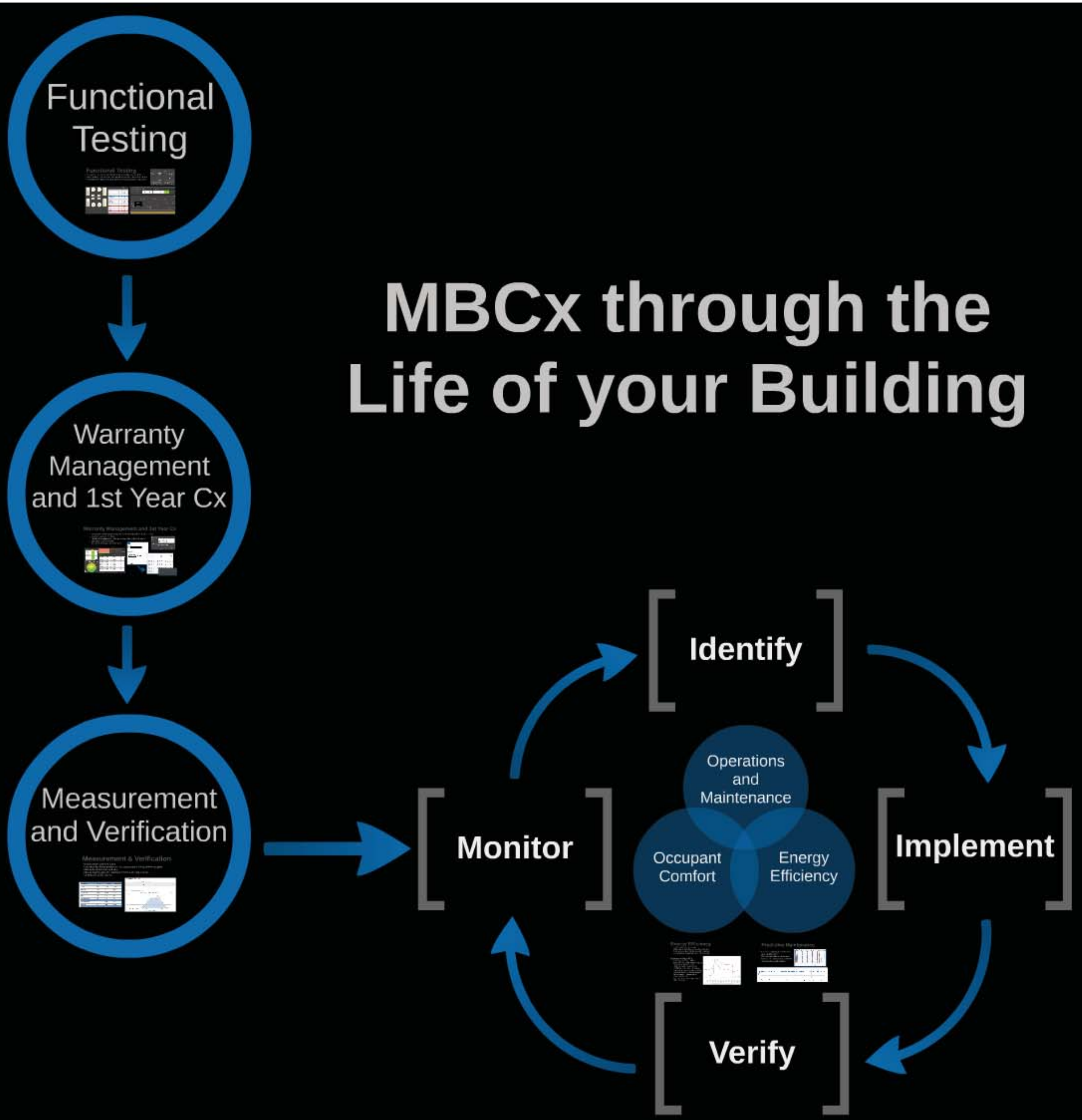
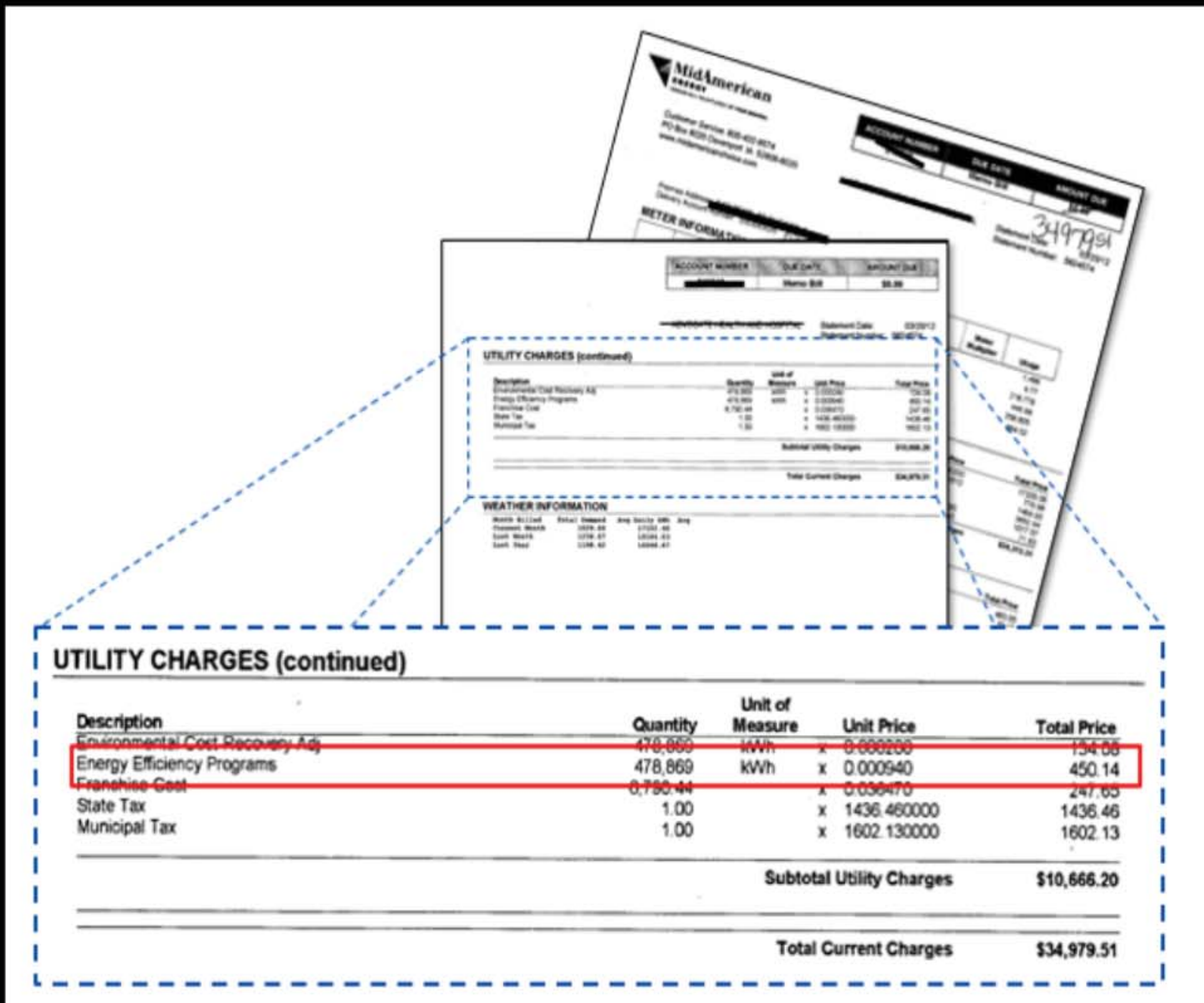
167	10/27/15 02:27 PM	0.60	69.4	72.0	14.1	72.8	7.2	41.1	117.0	31.3	135.6	50.0	
168	10/27/15 02:32 PM	0.59	69.4	72.0	14.1	72.8	7.2	41.1	118.6	32.1	135.6	50.0	
169	10/27/15 02:37 PM	0.61	65.3	74.8	14.2	72.8	7.3	41.7	118.6	32.1	135.6	50.0	
170	10/27/15 02:42 PM	0.60	65.3	74.8	14.2	72.8	7.3	41.7	118.6	32.1	135.7	49.0	
332	MIN=	0.58	65.3	72.0	14.1	72.4	7.2	41.1	115.5	30.5	135.3	48.0	
333	MAX=	0.73	78.2	83.7	17.5	84.3	7.6	43.5	121.1	33.2	136.9	51.0	
334	AVG=	0.64	71.1	77.4	15.7	78.2	7.4	42.2	118.4	31.9	136.1	49.5	



MBCx through the Life of your Building



Utility Funded Programs in Illinois



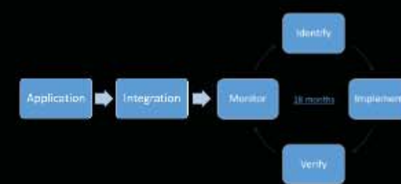
UTILITY CHARGES (continued)

Description	Quantity	Unit of Measure		Unit Price	Total Price
Environmental Cost Recovery Adj	478,869	kWh	x	0.000280	134.08
Energy Efficiency Programs	478,869	kWh	x	0.000940	450.14
Franchise Cost	6,790.44		x	0.036470	247.65
State Tax	1.00		x	1436.460000	1436.46
Municipal Tax	1.00		x	1602.130000	1602.13
				Subtotal Utility Charges	$10,666.20
				Total Current Charges	$34,979.51

ComEd MBCx Overview for Existing Buildings

- Eligible buildings > 400,000 SF
- Annual Usage > 8,000,000 kWh; Peak demand > 500 kW
- 18 month "monitoring" period (Contract)
- Low-cost/no-cost energy-savings corrective and improvement measures are identified and fine-tuned
- $25,000 incentive for software integration and set-up
- $0.07 per kWh incentive for verified energy savings resulting from the "monitoring" period

ComEd MBCx Process



Ameren- Metering and Monitoring Program

- Base incentive of up to $10,000 once the new monitoring equipment or software is installed.
  - Capped at 50% of cost
- Performance incentive of up to $10,000 paid based on annual energy savings from implemented projects.
  - Incentive paid at $0.01 per kWh and $0.20 per therm
- 12 Month monitoring period

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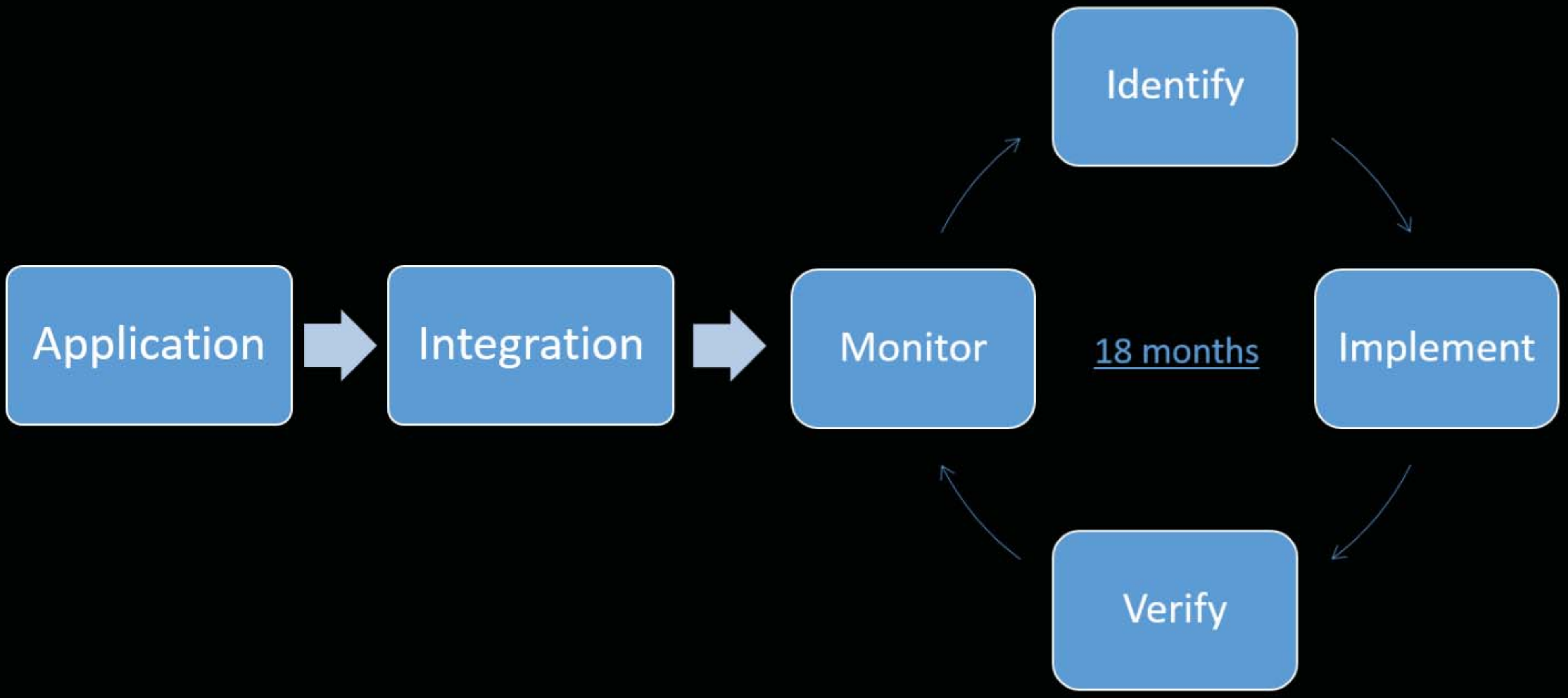

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Example Projects

Corrective Measures

Correct Scheduling of Kitchen Make-up Air and Exhaust System

Example:

- Kitchen make-up air unit and exhaust fans were running 24x7.
- Equipment was scheduled from the front end
- Annual kWh Savings: 296,067 kWh
- Annual Therm Savings: 16,321 Therms
- Annual Cost Savings: $31,998
- Measure Cost: $0
- Simple Payback: Instant

Improper VAV Box Airflow

Example:

- Approx. 1,000,000 SF Facility
- Analytics showed that:
- Some boxes had improperly set airflow minimums (too high)
- Some boxes provided too much airflow at maximum
- Some boxes did not show a change of airflow regardless of damper position (command)
- Annual kWh Savings: 96,425 kWh
- Annual Cost Savings: $7,714
- Measure Cost: In House Corrections

Night Set-Back On VAV and FPBs Not Active

Example:

- Approx. 1,000,000 SF Facility
- All zones had night setbacks programmed at the front end, however none of the zones were actively controlling to night setbacks.
- Annual kWh Savings: 708,985 kWh
- Annual Cost Savings: $46,084
- Measure Cost: $5,563
- Simple Payback: 0.12 Years

Enthalpy Sensor Calibration and Rebalancing of OA Dampers

Example:

- Approx. 500,000 SF Facility
- Existing enthalpy sensors were out of calibration
- OA damper minimum position was bringing in more OA than required
- Enthalpy sensors were replaced and OA damper minimum position was rebalanced.
- Annual kWh Savings: 166,866 kWh
- Annual Cost Savings: $12,132
- Measure Cost: $11,950
- Simple Payback: 0.98 Years

Optimization Measures

Duct Static Reset

Does the system really require a duct static set point of 1.5" or can it be reset to 0.8"?

Example:

- 700,000 SF Facility.
- Duct static set point reset from 1.5" to 1.0" based on ongoing critical zone analysis
- Annual kWh Savings: 153,102 kWh
- Annual Cost Savings: $11,611
- Measure Cost: $3,085
- Simple Payback: 0.27 Years

Condenser Water Reset

Most chillers can function with 25 degrees of lift

- Example: 42 degree CHWS temp = 67 degree CWS temp
- Are chillers set to operate at 80 degree CWS Temp?
- Why not reset to 78 or 75 when the OA WB allows?
- Typically 2% efficiency increase for every one degree decrease in CWS temp

- Chiller Plant with Two (2) 500 Ton Chillers
- Reset CWS from 75F to 65F
- Annual kWh Savings: 160,439 kWh
- Annual Cost Savings: $10,429
- Measure Cost: $1,300
- Simple Payback: 0.12 Years

Chiller Plant Staging Optimization

Example:

- Chiller Plant with Four (4) 600 Ton Chillers
- Optimized the stage-up and stage down set-points to of chillers, pumps, and cooling towers.
- Tuned the PID loop on the condenser water bypass valve to provide more stable operation and optimize chiller efficiency.
- Annual KWh Savings: 475,528 KWh
- Annual Cost Savings: $30,909
- Measure Cost: $2,000
- Simple Payback: 0.06 Years

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Monitoring Based Commissioning

Use of real-time data analytics, algorithms, diagnostics, and fault detection, to ensure the facility is operating properly and to continually improve operation 24x7

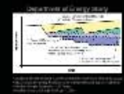
MBCx

Monitoring based commissioning (MBCx) combines building energy system monitoring with standard retro-commissioning (RCx) practices. MBCx is a measurement-based paradigm that affords improved risk-management by identifying problems and opportunities that are missed with periodic commissioning or basic functional testing that does not incorporate energy measurement.

ASHRAE Study

ASHRAE Journal - April 2011, p 22

Department of Energy study



How do you get the data?

How do you access the data?

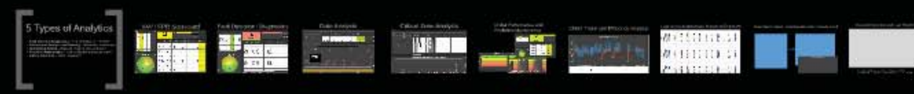
- Web-Based
- VPN, Remote Desk-Top Connection, Team Viewer
- Mobile App

Other Considerations

- Security
- Liability
- Do you want the analytics platform to make changes?
- Dashboards
- Mobile Apps
- FM / CMMS

Monitoring Based Commissioning and Data Analytics for Energy Efficiency

HESNI 2016 Annual Conference
May 6, 2016



MBCx through the Life of your Building