



Getting DDC Data Into PI

Using it for FDD & EA Modeling



Presenters



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FDD Overview



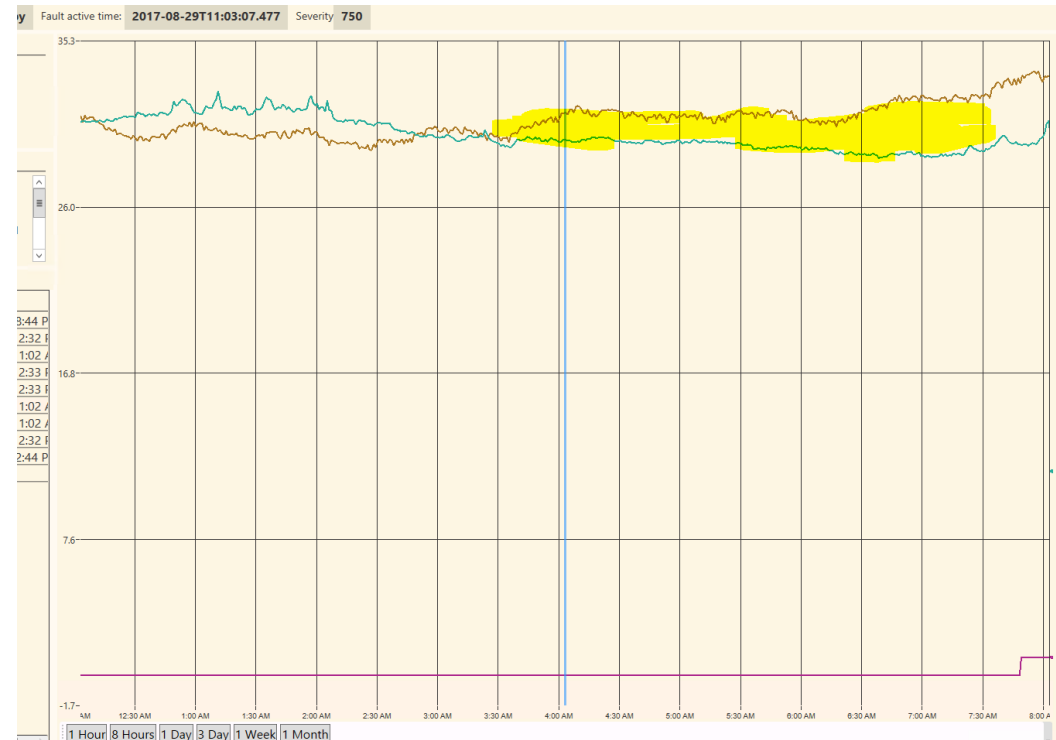
Fault #3 – AS35 Economizer Enthalpy

Observations:

1. Many Faults occur for short times

Analysis:

1. Need Dust Storm Override bit!



Fault Detection & Diagnostics (FDD)

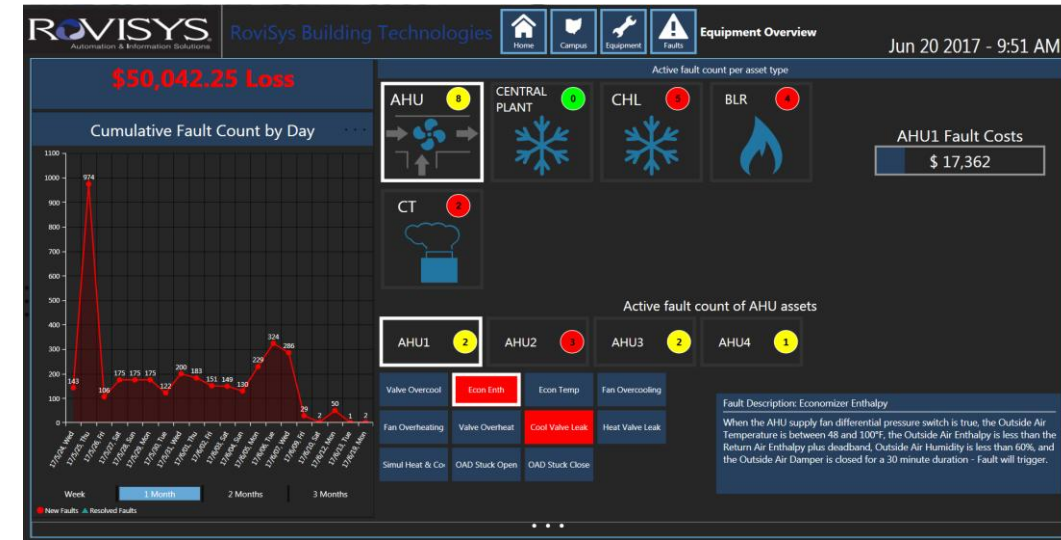
- What is FDD?
- Examples in PI
- How it can benefit you?

FDD Allows Continuous Cx

Analytics software that monitors actual **equipment performance**:

- Uses multivariable historical, realtime and static design data
- Evaluates the data using rules to identify equipment and process faults
- Monetizes the cost of active faults
- Guides the user in diagnosing the root problem

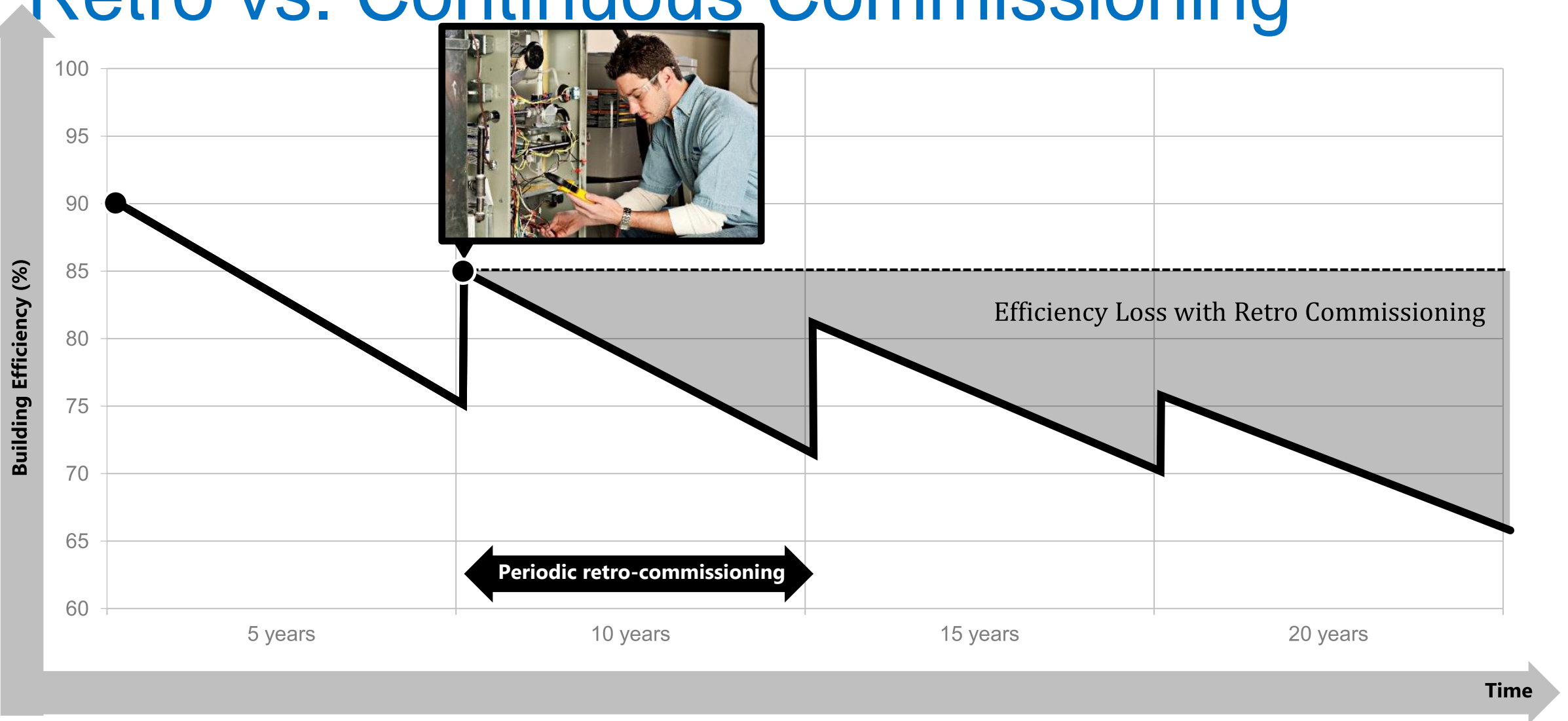
Continuous Commissioning: tuning, adjusting and fixing issues when they start to erode system performance rather than waiting for failure.



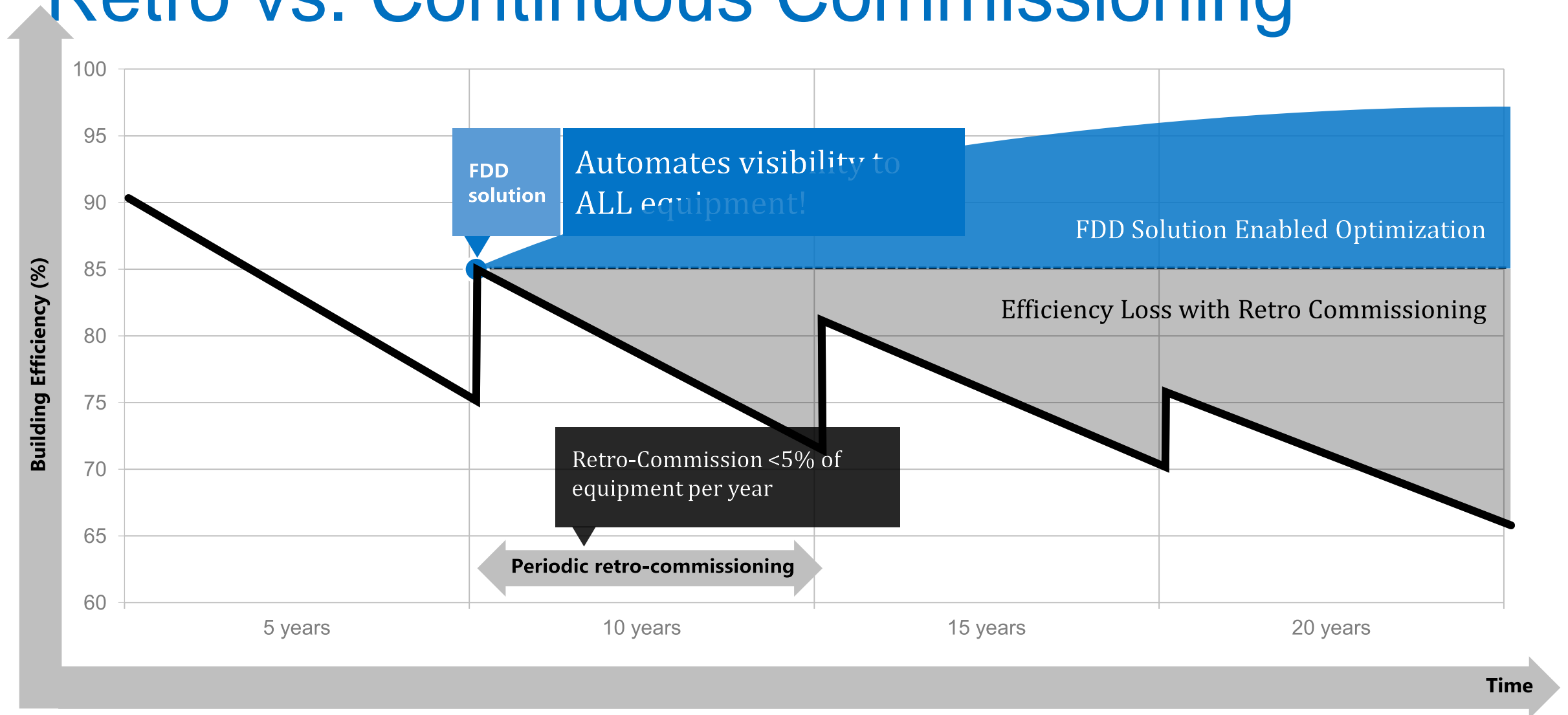
The 'Faults Overview' dashboard provides a detailed table of fault statistics and incidents. The table includes columns for Building, Area, Equipment, Unit, Equipment Type, Fault Name, Severity, Total Fault Count, Total Active Duration (Hours), Total Estimated Cost (\$), and Modification Date. The data is organized by equipment type, with AHU1 having 5 items, AHU2 having 4 items, AHU3 having 6 items, and AHU4 having 4 items. The table lists various faults such as 'Cooling Coil Valve Leaking', 'OA Damper Stuck Closed', 'Fan Overcooling Space', 'Econ Enthalpy', 'Simultaneous Heating and Cooling', 'Valve Overcooling Space', 'Heating Coil Valve Leaking', and 'OA Damper Stuck Open'.

Building	Area	Equipment	Unit	Equipment Type	Fault Name	Severity	Total Fault Count	Total Active Duration (Hours)	Total Estimated Cost (\$)	Modification Date
<None>					A Wild Fault Appeared	500	2	17.76	0.00	6/1/2017
Campus, OH	HVAC	AHU1	AHU1	AHU	Cooling Coil Valve Leaking	500	44	293.66	99.01	6/12/2017
Campus, OH	HVAC	AHU1	AHU1	AHU	OA Damper Stuck Closed	500	121	2.23	0.00	5/25/2017
Campus, OH	HVAC	AHU1	AHU1	AHU	OA Damper Stuck Open	500	32	144.89	1.73	6/9/2017
Campus, OH	HVAC	AHU1	AHU1	AHU	Cooling Coil Valve Leaking	500	1	0.01	0.00	5/31/2017
Campus, OH	HVAC	AHU1	AHU1	AHU	Econ Enthalpy	750	15	757.89	603.25	6/12/2017
Campus, OH	HVAC	AHU2	AHU2	AHU	OA Damper Stuck Closed	500	2226	221.97	2,797.44	6/12/2017
Campus, OH	HVAC	AHU2	AHU2	AHU	Fan Overcooling Space	750	8	188.35	1.50	6/9/2017
Campus, OH	HVAC	AHU2	AHU2	AHU	Simultaneous Heating and Cooling	750	8	219.52	0.00	6/12/2017
Campus, OH	HVAC	AHU2	AHU2	AHU	Valve Overcooling Space	750	11	306.93	154.62	6/12/2017
Campus, OH	HVAC	AHU3	AHU3	AHU	OA Damper Stuck Closed	500	131	2.36	0.00	5/25/2017
Campus, OH	HVAC	AHU3	AHU3	AHU	OA Damper Stuck Open	500	9	209.04	1.24	6/9/2017
Campus, OH	HVAC	AHU3	AHU3	AHU	Econ Enthalpy	750	5	121.50	401.31	6/9/2017
Campus, OH	HVAC	AHU3	AHU3	AHU	Fan Overcooling Space	750	7	98.48	1.13	6/9/2017
Campus, OH	HVAC	AHU3	AHU3	AHU	Simultaneous Heating and Cooling	750	8	192.09	0.00	6/12/2017
Campus, OH	HVAC	AHU3	AHU3	AHU	Valve Overcooling Space	750	12	341.00	241.08	6/12/2017
Campus, OH	HVAC	AHU4	AHU4	AHU	Heating Coil Valve Leaking	500	33	230.64	0.00	6/9/2017
Campus, OH	HVAC	AHU4	AHU4	AHU	OA Damper Stuck Closed	500	130	2.36	0.00	5/25/2017
Campus, OH	HVAC	AHU4	AHU4	AHU	OA Damper Stuck Open	500	30	144.72	0.84	6/7/2017

Retro vs. Continuous Commissioning



Retro vs. Continuous Commissioning



FDD – The Rules

- NISTIR 6964
 - Faults pertaining to AHUs & Terminal Units
- ASHRAE-D-7190
 - Expert Rules Set for Fault Detection in AHUs
- Our/Your own Custom Rules

File View Go Tools Help

Database Query Date Back Check In Refresh New Template Search Element Templates

Library

- Demo Database
 - Templates
 - Element Templates
 - AHU
 - AHU_VAV
 - Boiler
 - Chiller
 - Cooling_Tower
 - CRAH
 - VAV
 - Event Frame Templates
 - Model Templates
 - Transfer Templates
 - Enumeration Sets
 - Reference Types
 - Tables
 - Table Connections
 - Categories
 - Analysis Categories
 - Attribute Categories
 - Element Categories
 - Notification Rule Categories
 - Reference Type Categories
 - Table Categories

Elements

Event Frames

Library

Unit of Measure

Contacts

Management

AHU Modified: 8/8/2018 11:47:29 AM.

AHU

General Attribute Templates Ports Analysis Templates Notification Rule Templates

Name: AHU

Description: Air Handling Unit

Base Template: <None> Type: Element

Categories: Default Attribute: <None>

Naming Pattern:

☒ Allow Extensions [Extended Properties \(1\)](#) [Location](#) [Security](#)

Find: [Derived Templates](#) [Elements](#) [Referenced Parent Templates](#)
[Derived Elements](#) [Referenced Child Templates](#)

Find Derived Elements for 'AHU'

Group by: ☐ Category ☐ Template

Filter

Name	Description	Category	Type	Template
AHU1	Air Handling Unit		None	AHU
AHU-23	Air Handling Unit		None	AHU
AHU-4	Air Handling Unit		None	AHU

Close

\\OSI-SALES\Demo Database - PI System Explorer

File View Go Tools Help

Database Query Date Back Check In Refresh New Template Search Element Templates

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 - Categories
 - Analysis Categories
 - Attribute Categories
 - Element Categories
 - Notification Rule Categories
 - Reference Type Categories
 - Table Categories

Event Frame Templates

Group by: Category

Filter

Name	Description	Category	Severity
AHU Counter	Daily Fault counter		None
AHU FDD Rule 1	Outside Air Damper Stuck Closed		None
AHU FDD Rule 10	Heating Coil Valve Leaking		None
AHU FDD Rule 11	Dirty Filter		None
AHU FDD Rule 12	Minimum Fan Speed		None
AHU FDD Rule 13	Off Hours Operation		None
AHU FDD Rule 14	Simultaneous Heating and Cooling		None
AHU FDD Rule 2	Outside Air Damper Stuck Open		None
AHU FDD Rule 3	Valve Overcooling Space		None
AHU FDD Rule 4	Fan Overcooling Space		None
AHU FDD Rule 5	Cooling Coil Valve Leaking		None
AHU FDD Rule 6	Economizer Optimization (Enthalpy)		None
AHU FDD Rule 7	Economizer Optimization (Temperature)		None
AHU FDD Rule 8	Valve Overheating Space		None
AHU FDD Rule 9	Fan Overheating Space		None
AlarmDevice	Alarm state history at the device level indicating that one or more device attributes is in a state of alarm (e.g. caution, cri...		None
AlarmDeviceAttribute	Alarm state history at the device attribute level for a single alarm.		None
AlarmDeviceCaution	Alarm state history at the device level containing a set of alarms with the same logical caution priority as child events.		None
AlarmDeviceCritical	Alarm state history at the device level containing a set of alarms with the same logical critical priority as child events.		None
AlarmDeviceNoComm	Alarm state history at the device level indicating that one or more device attributes is in a state of No Communication.		None
AlarmLimit	History of changes to limit(s) for a single alarm.	AlarmLimitHistory	None
BLR FDD Rule 1	Boiler Pump Operation		None
BLR FDD Rule 2	Excessive Cycling		None
BLR FDD Rule 3	High Supply Pressure		None
BLR FDD Rule 4	Overheated Supply Water		None
BLR FDD Rule 5	Low Supply Temperature		None
BLR FDD Rule 6	Low Efficiency		None
Chiller FDD Rule 1	Leaking Chiller Isolation Valve		None
Chiller FDD Rule 2	Leaking Condenser Isolation Valve		None
Chiller FDD Rule 3	Overcooling		None
Chiller FDD Rule 4	Low Efficiency		None
Chiller FDD Rule 5	Excessive Exercise		None
Chiller FDD Rule 6	Low Delta T		None
Chiller FDD Rule 7	High Approach Temperature		None
Cooling Tower FDD R...	Fan Operation		None
Cooling Tower FDD R...	Minimum Fan Speed		None
Cooling Tower FDD R...	Fan On in Hand		None

Elements

- Event Frames
- Library**
- Unit of Measure
- Contacts
- Management

40 Event Frame Templates

Why This Matters

Acknowledged Faults							
Equipment	Fault	Most Recent Ack Time	ACK Fault Count	ACK Total Duration (hr)	ACK Fault Cost	ACK Fault Cost per hr	Most Recent Comment
CHL4	Chiller Overcooling	10/25/2017 12:35	99	16.85	\$59.60	\$5.48	N/A
CHL4	Low Efficiency	10/25/2017 12:34	2	0.25	\$0.11	\$0.85	N/A
AS19	Cooling Coil Valve Leaking	10/18/2017 19:57	7512	1411.33	\$13,302.32	\$26.70	N/A
AS19	Economizer Enthalpy	10/18/2017 19:57	6540	6812.2	\$35,032.71	\$13.07	N/A
AS19	OA Damper Stuck Open	10/18/2017 19:56	2590	2797.78	\$734.97	\$3.56	N/A
AS16	Cooling Coil Valve Leaking	10/18/2017 18:08	65492	36795.09	\$521,443.64	\$52.85	N/A
AS46	OA Damper Stuck Open	10/12/2017 18:02	78	41.01	\$3.60	\$1.24	N/A
AS46	Economizer Enthalpy	10/12/2017 18:02	1515	7114.53	\$160,339.28	\$79.54	valve commanded close by hmi button
AS46	OA Damper Stuck Closed	10/12/2017 18:02	1968	6005.47	\$0.00	\$0.00	N/A
AS43	Cooling Coil Valve Leaking	10/12/2017 18:01	30	0.09	\$0.41	\$7.28	N/A
AS43	Economizer Enthalpy	10/12/2017 18:01	2853	10059.81	\$64,374.89	\$46.94	N/A
AS43	OA Damper Stuck Closed	10/12/2017 18:01	230	74.07	\$0.00	\$0.00	N/A
AS41	OA Damper Stuck Open	10/12/2017 18:00	888	2095.77	\$1,076.61	\$2.73	N/A
AS41	Economizer Enthalpy	10/12/2017 18:00	210	330.13	\$840.92	\$11.15	N/A
AS41	OA Damper Stuck Closed	10/12/2017 18:00	16	1.73	\$0.00	\$0.00	N/A
AS40	Economizer Enthalpy	10/12/2017 18:00	22	31.31	\$274.04	\$19.53	N/A
AS39	OA Damper Stuck Closed	10/12/2017 17:59	108	97.73	\$0.00	\$0.00	N/A
AS39	Economizer Enthalpy	10/12/2017 17:59	1746	1693.47	\$1,860.39	\$3.77	N/A
AS39	OA Damper Stuck Open	10/12/2017 17:59	1111	1208.31	\$193.78	\$1.20	N/A
AS38	Economizer Enthalpy	10/12/2017 17:59	120	216.97	\$191.16	\$2.98	N/A
AS36	Economizer Enthalpy	10/12/2017 17:58	256	452.8	\$3,583.59	\$25.83	N/A
AS36	OA Damper Stuck Closed	10/12/2017 17:58	234	57.84	\$0.00	\$0.00	N/A
AS35	Economizer Enthalpy	10/12/2017 17:58	1316	6429.14	\$124,078.14	\$67.78	N/A
AS35	OA Damper Stuck Closed	10/12/2017 17:58	310	53.71	\$0.00	\$0.00	N/A

\\OSI-SALES\\Demo Database - PI System Explorer

File Search View Go Tools Help

Database Query Date Back Check In Refresh New Element Search Elements

Elements

- Argonne
 - Building 241
 - AHU_VAV1
 - VAV1
 - VAV2
 - VAV3
 - Building200
 - AHU_VAV1
 - AHU-23
 - AHU-4
 - CH-1
 - CT-1
 - Building214

Element Searches

CH-1

General Child Elements Attributes Ports Analyses Notification Rules Version

Name: Rule 1 - Fault

Description: Rule 1 Fault

Categories:

Analysis Type: ☒ Expression ☐ Rollup ☐ Event Frame Generation ☐ SQC

Backfilling

Name	Expression	Value at Evaluation	Value at Last Trigg	Output Attribute
Fault	if 'STS'="On" and 'CHW_ISO_VLV_CMD'="Closed" and 'CHW_FLOW'>10 then 1 else 0			Rule 1 Fault

if 'STS'="On" and 'CHW_ISO_VLV_CMD'="Closed" and 'CHW_FLOW'>10 then 1 else 0

Functions

Insert functions into the expression

All

- Abs
- Acos
- And
- Ascii
- Asin
- Atn
- Atn2
- Avg
- BadVal
- Bod
- Bom
- Bonm
- Ceiling
- Char
- Compare
- Concat
- Contains
- Convert
- Cos
- Cosh
- Cot

Abs(number x)
Return the absolute value of an integer or real number.
Example: Abs(1)

Attributes

Add a new variable

Scheduling: ☒ Event-Triggered ☐ Periodic

Trigger on: Any Input

Advanced...

Connected to the PI Analysis Service.

CH-1 Modified:8/8/2018 8:44:55 AM. Version: 1/1/1970 12:00:00 AM, Revision 1

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File Search View Go Tools Help

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 - AHU-4
 - CH-1
 - CT-1
 - Building214

Element Searches

CH-1

General Child Elements Attributes Ports Analyses Notification Rules Version

Name: Rule 1 - Cost

Description: Fault Rule 1 Cost Calculations

Categories:

Analysis Type: ☒ Expression ☐ Rollup ☐ Event Frame Generation ☐ SQC

Name	Expression	Value at Evaluation	Value at Last Trigg	Output Attribute
Cost	Max('CHWP_SPD'*'CHWP_HP'*0.716*'RATE'*8760,0)			Map
EventFrameActive	IF (TagVal('Rule_1_Fault','*-30s') <> 0 and SecSinceCh...			Map
CostRateYearly	If EventFrameActive=1 then cost else 0			Rule 1 Cost

Add a new variable

Scheduling: ☒ Event-Triggered ☐ Periodic

Trigger on: Any Input

Advanced...

Connected to the PI Analysis Service.

CH-1 Modified:8/8/2018 8:44:55 AM. Version: 1/1/1970 12:00:00 AM, Revision 1

Functions

Insert functions into the expression

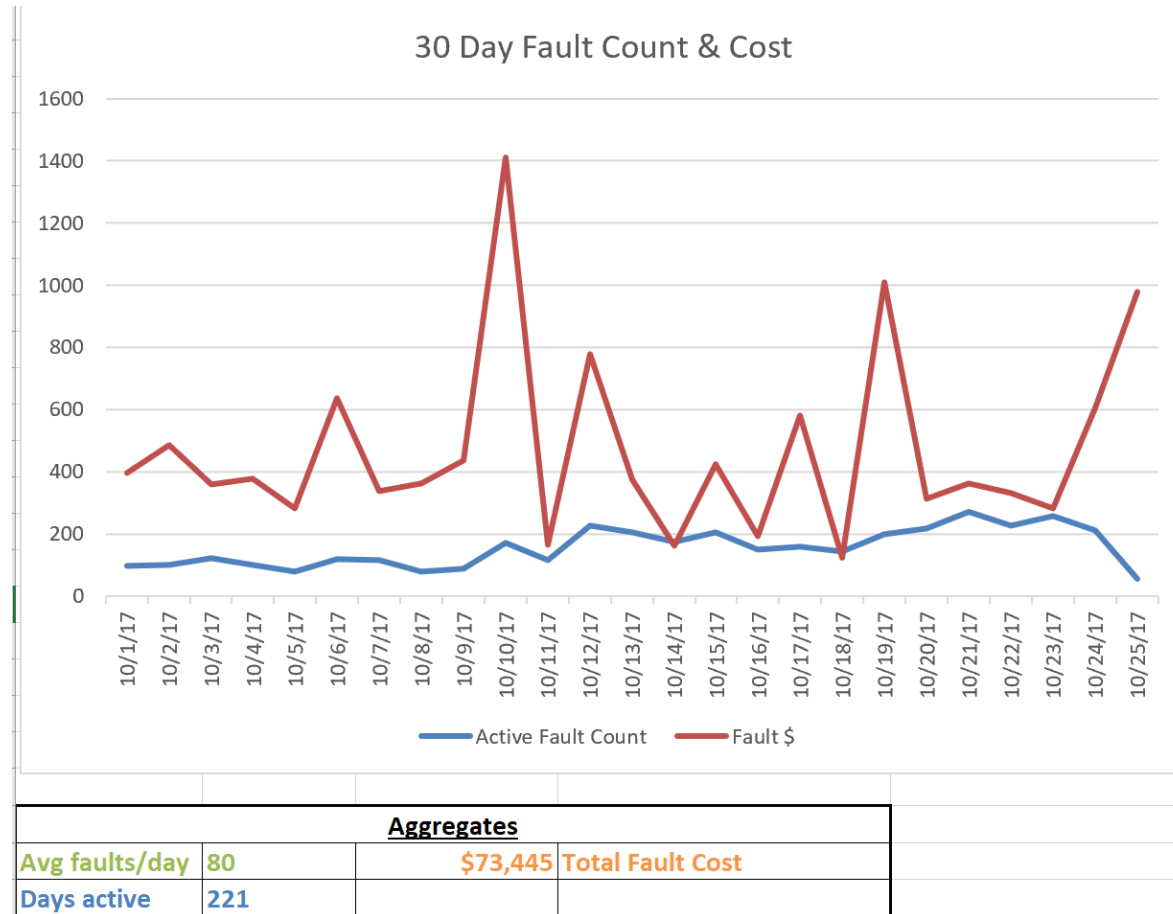
All

- Abs
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- And
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Example: Abs(1)

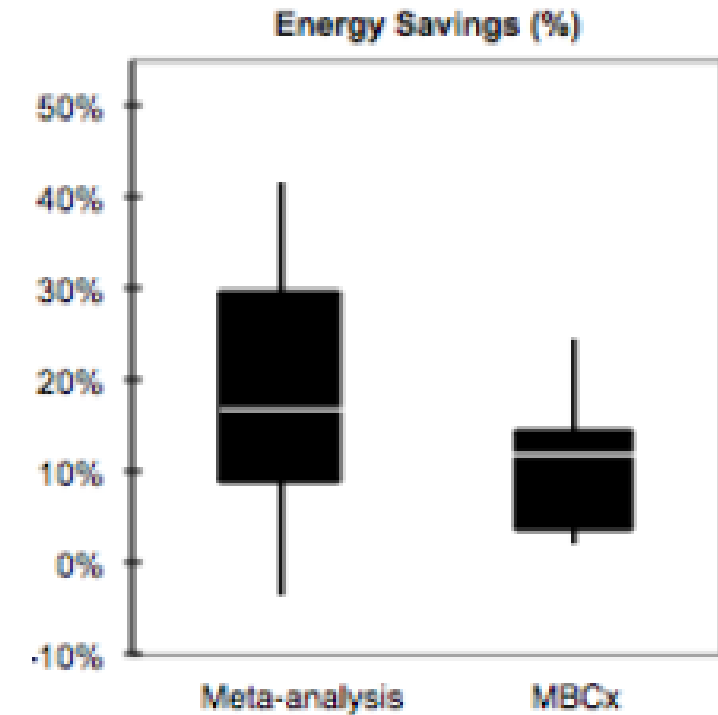
Attributes

Prioritize What You Pay Attention To



Berkeley Lab Study of 154 Buildings

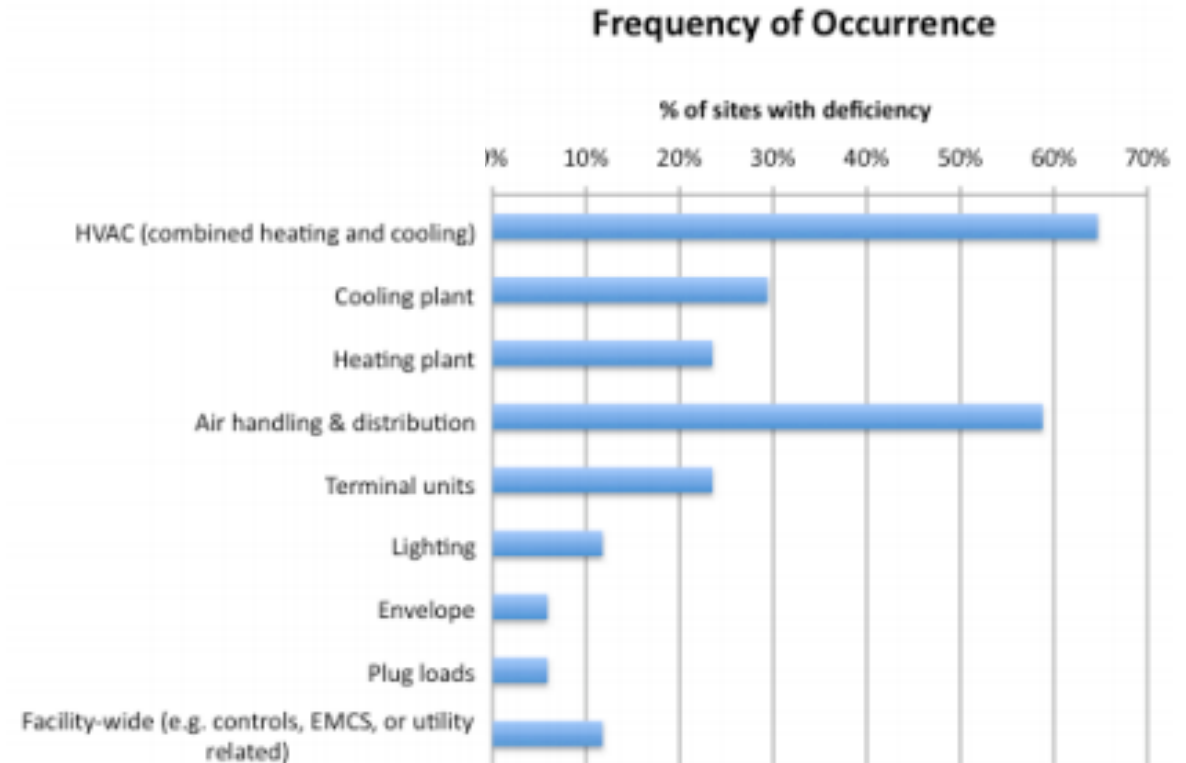
- Half of commercial lab buildings waste 16% - 30% of total energy consumed
- Waste increases with the size and complexity of the facility
- Median cost \$.46/sqft per year = \$46,000/yr wasted for a 100,000 sqft facility



Evan Mills, Paul A Mathew (2012) *Monitoring-based Commissioning: Benchmarking Analysis of 24 University Buildings in California*

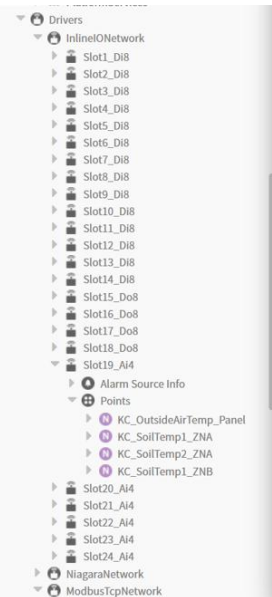
Berkeley Lab Study of 154 Buildings

- 98% of issues are easy fixes:
 - 2% Design or Installation Deficiencies
 - 56% Controls & Operations Errors
 - 42% Overlooked Maintenance
- 1.9 yr simple payback to correct issues with monitoring based continuous commissioning

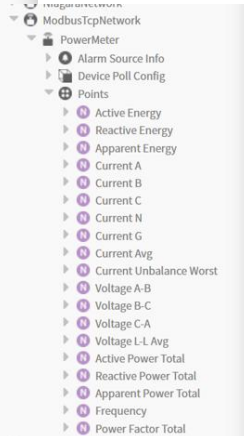


Evan Mills, Paul A Mathew (2012) *Monitoring-based Commissioning: Benchmarking Analysis of 24 University Buildings in California*

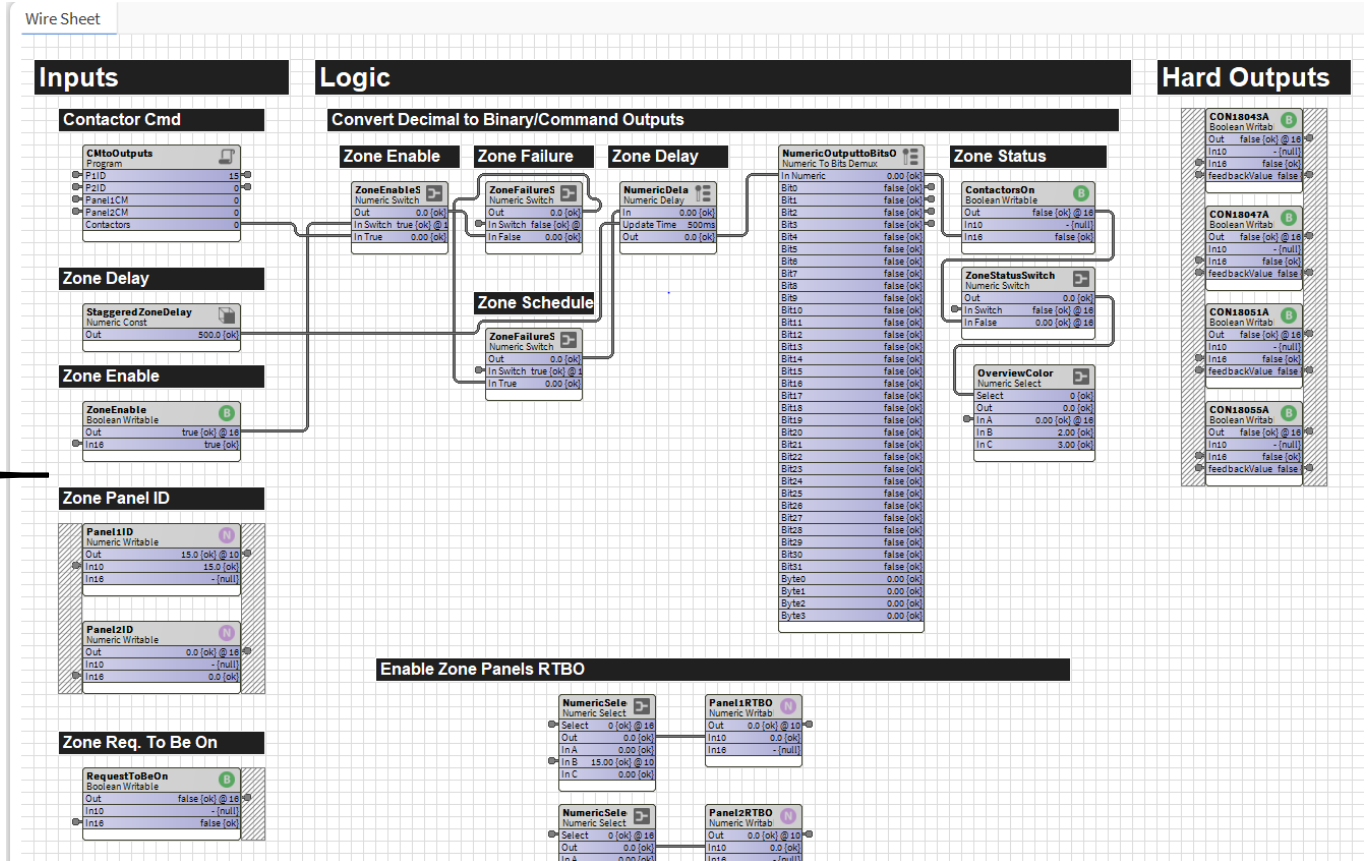
Direct Digital Control (DDC) Systems



Hard-wired
I/O



ModBus
(and other)
“softcomms”
I/O

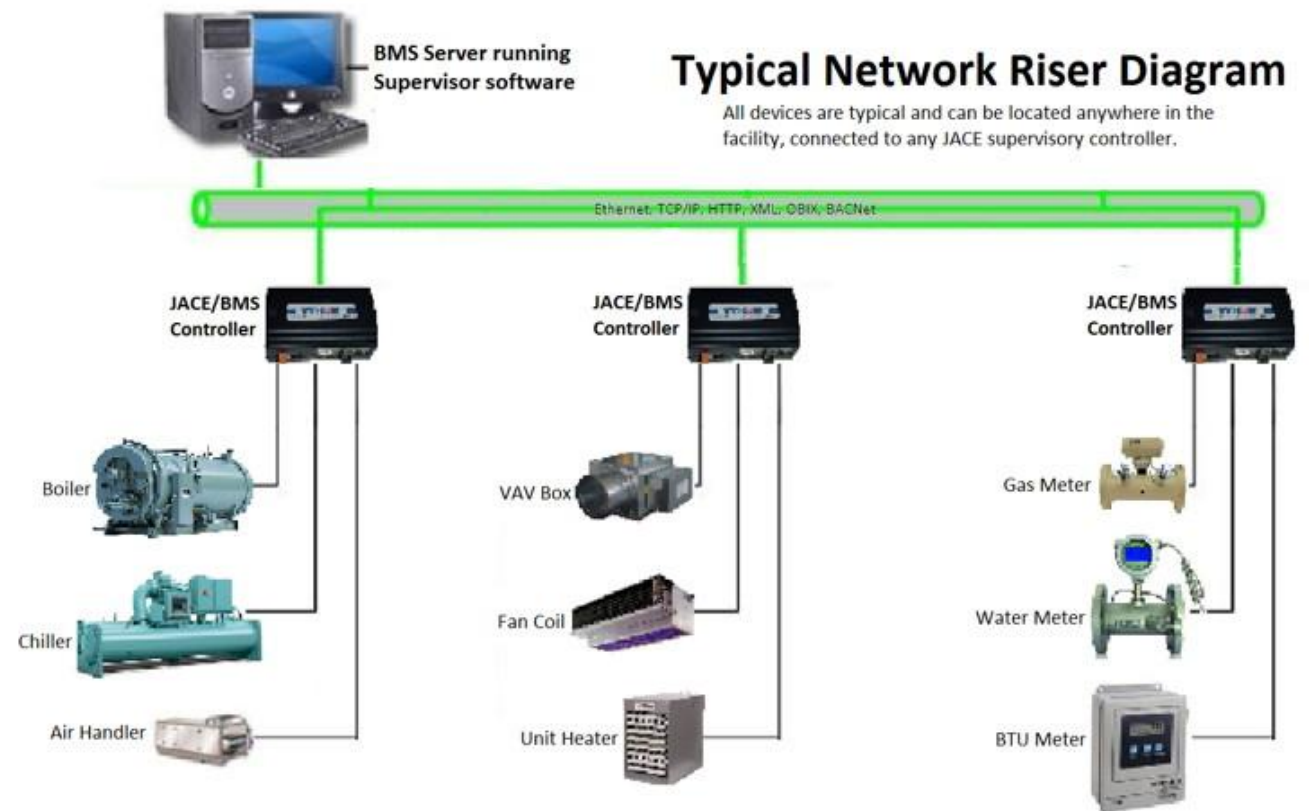


Direct Digital Control (DDC) Systems

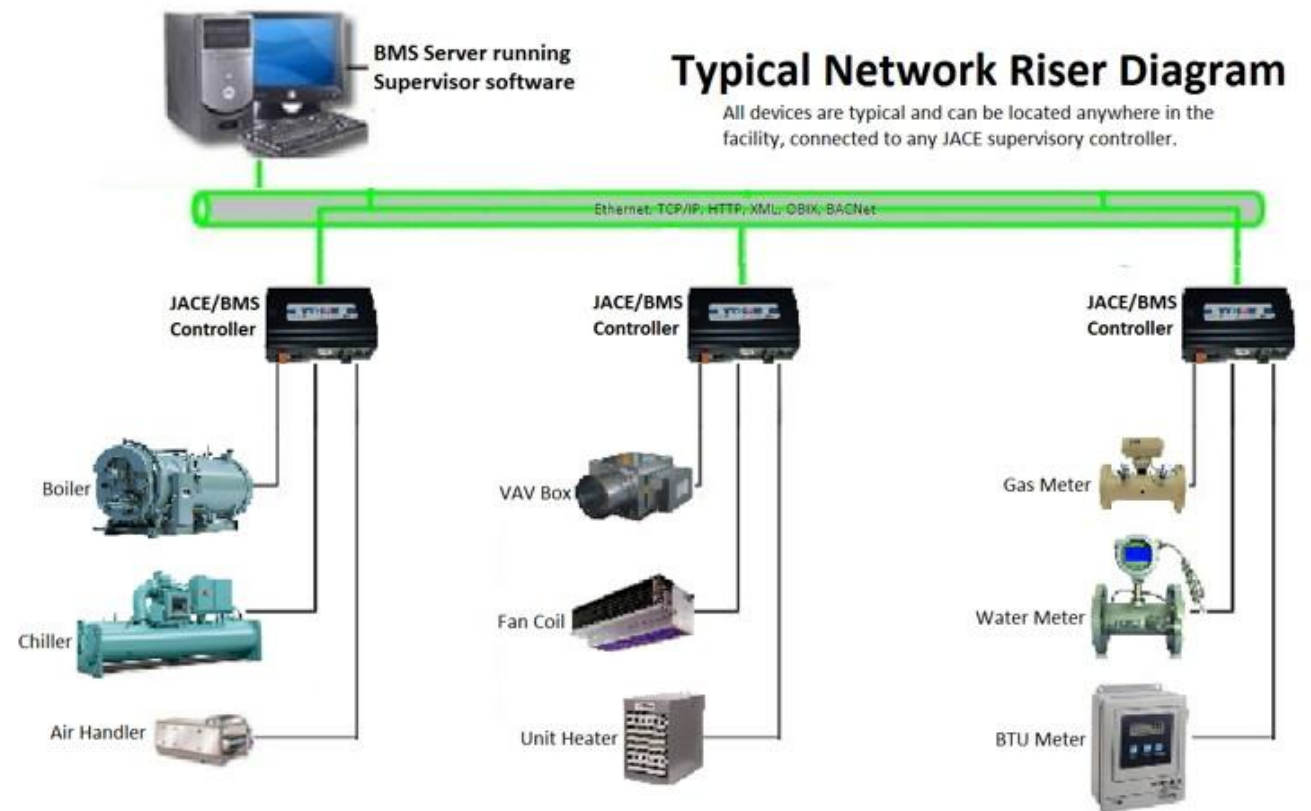


DDC HVAC Control & WAGES Monitoring

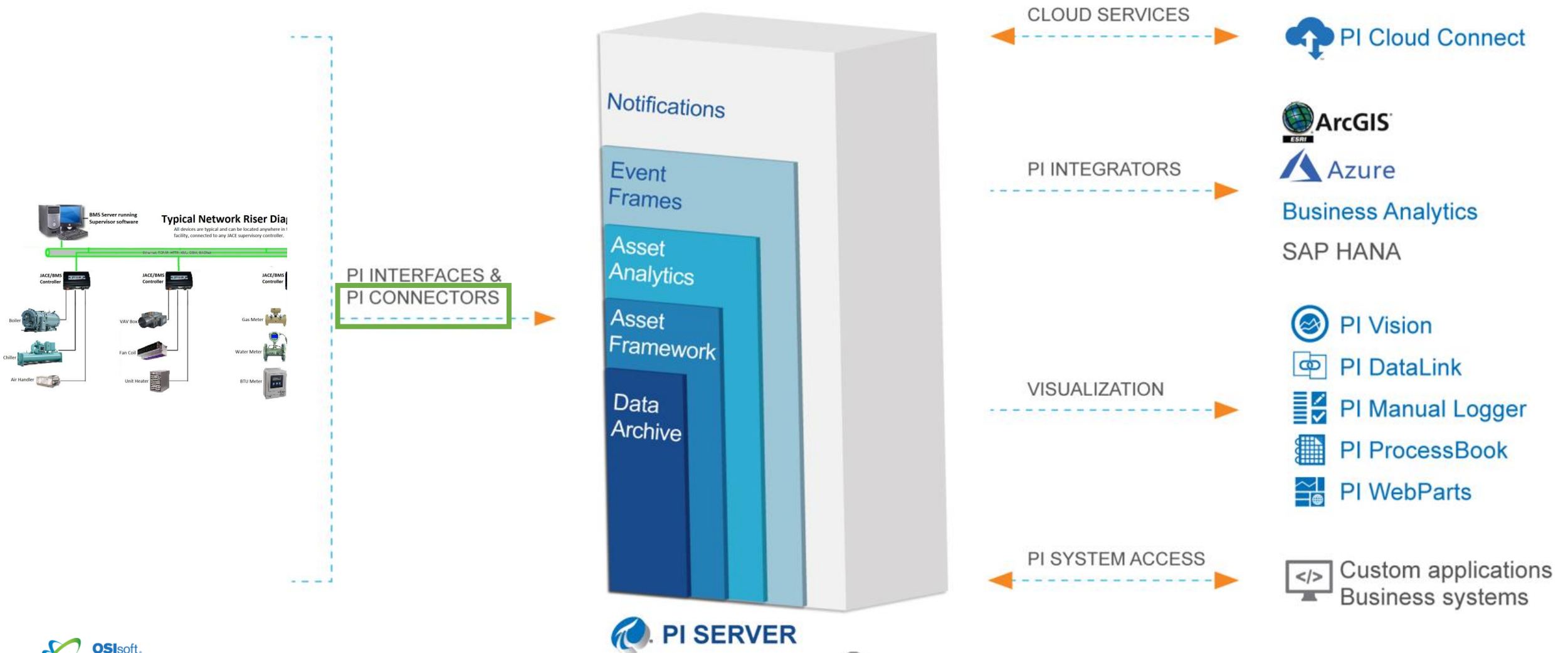
- Examples of DDC systems
 - Open Protocol
 - Johnson Controls
 - Siemens
 - Alerton
 - Automated Logic
 - Open Integration
 - Tridium
 - Distech
 - Phoenix Contact



DDC HVAC Control & WAGES Monitoring



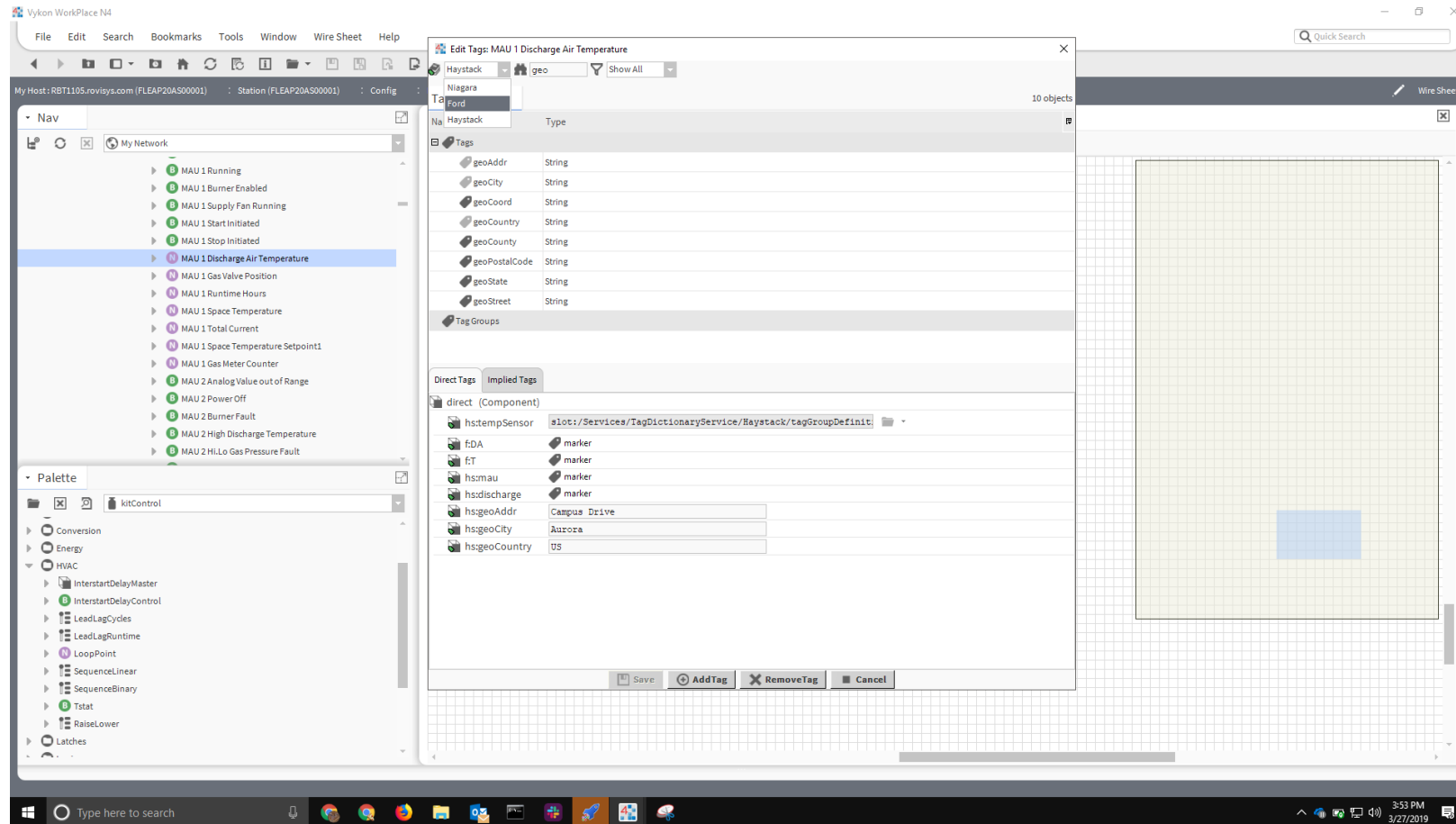
DDC Data Into PI



Tridium Niagara → OSIsoft PI Connector

- Automatically build PI-AF hierarchy
- Poll all device meta-data, values, and hierarchies from Niagara
- Write data from PI → Niagara

#Tagging

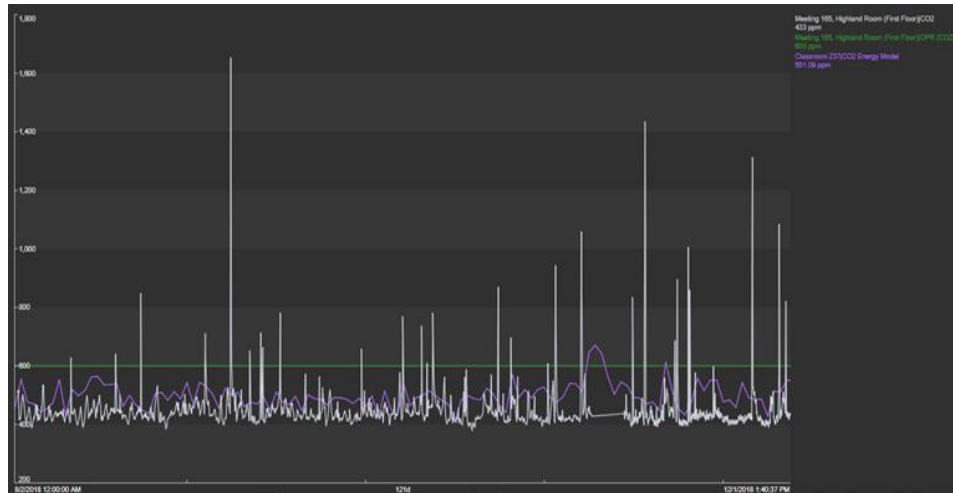
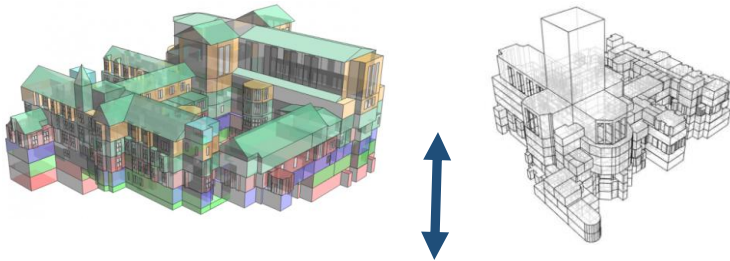


Building Performance Against Target/Design

AUROS360™ TECHNOLOGY SOLUTION

EVIDENCE-BASED PERFORMANCE

DIGITAL SIMULATION



CLOSING PERFORMANCE GAPS DURING OPERATIONS

AUROS360 Data Flow Diagram

BUILDING PERFORMANCE

Smart Building Infrastructure
Data Source

Primary Source Digital Utility Meters



BAS-BMS Integration



Indoor Air Quality
Sensors



Outdoor Climate Station
and
Weather Station

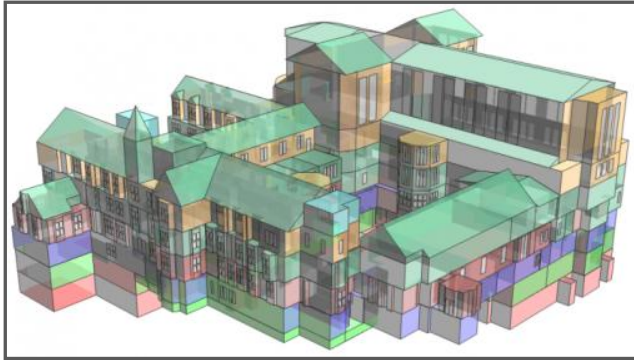


Monitoring-based
Commissioning
&
Interrogation-based
Commissioning

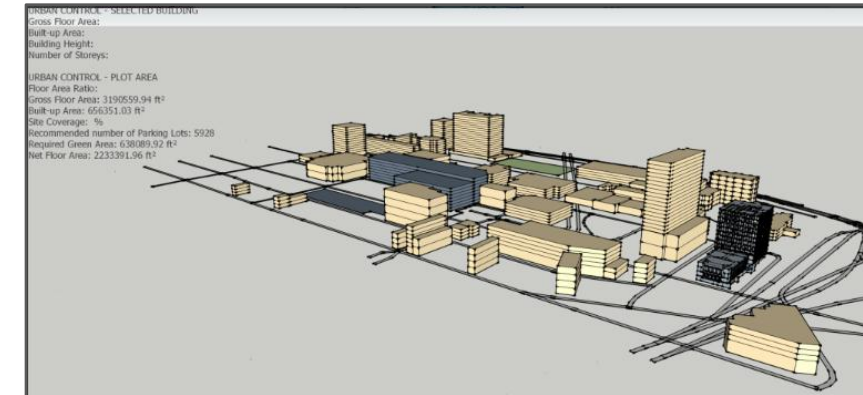
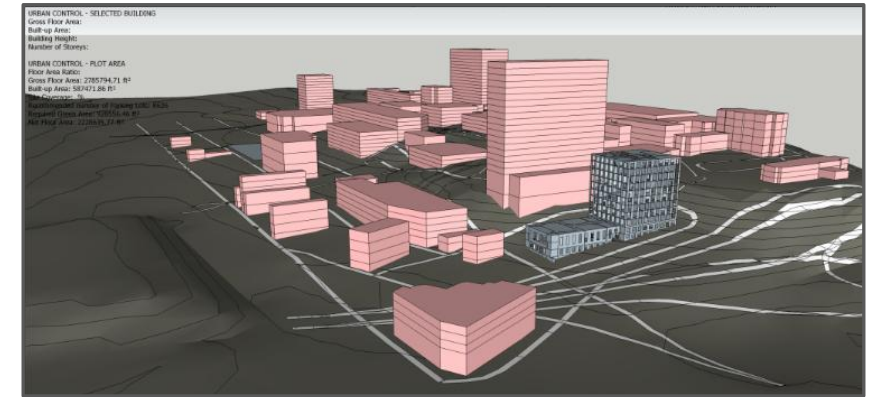


Niagara N4, JACE 8000
Controller

CONNECTING DESIGN TO OPERATIONS



**Single Buildings,
Groups of
Buildings,
and
Groups of
Campuses**

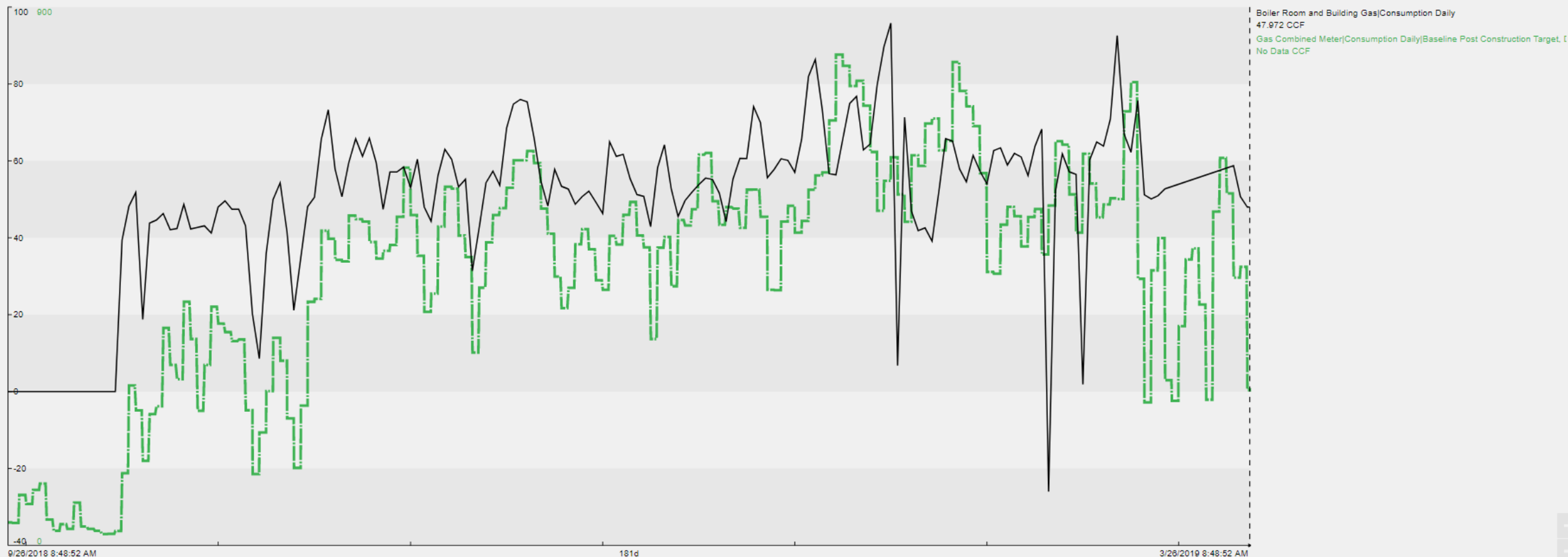


Early goal setting for buildings connected to building operations



ELPC - Gas Meters

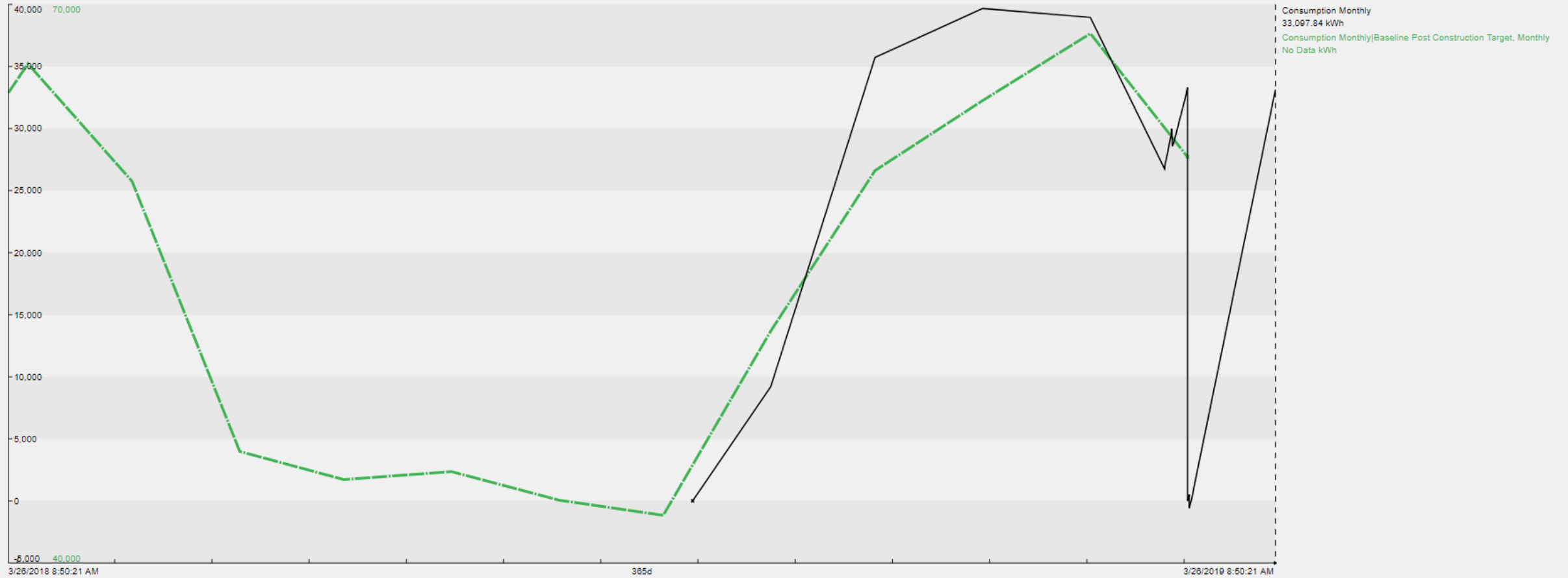
Year Month Day Hour
Boiler Room and Building Gas Consumption Daily

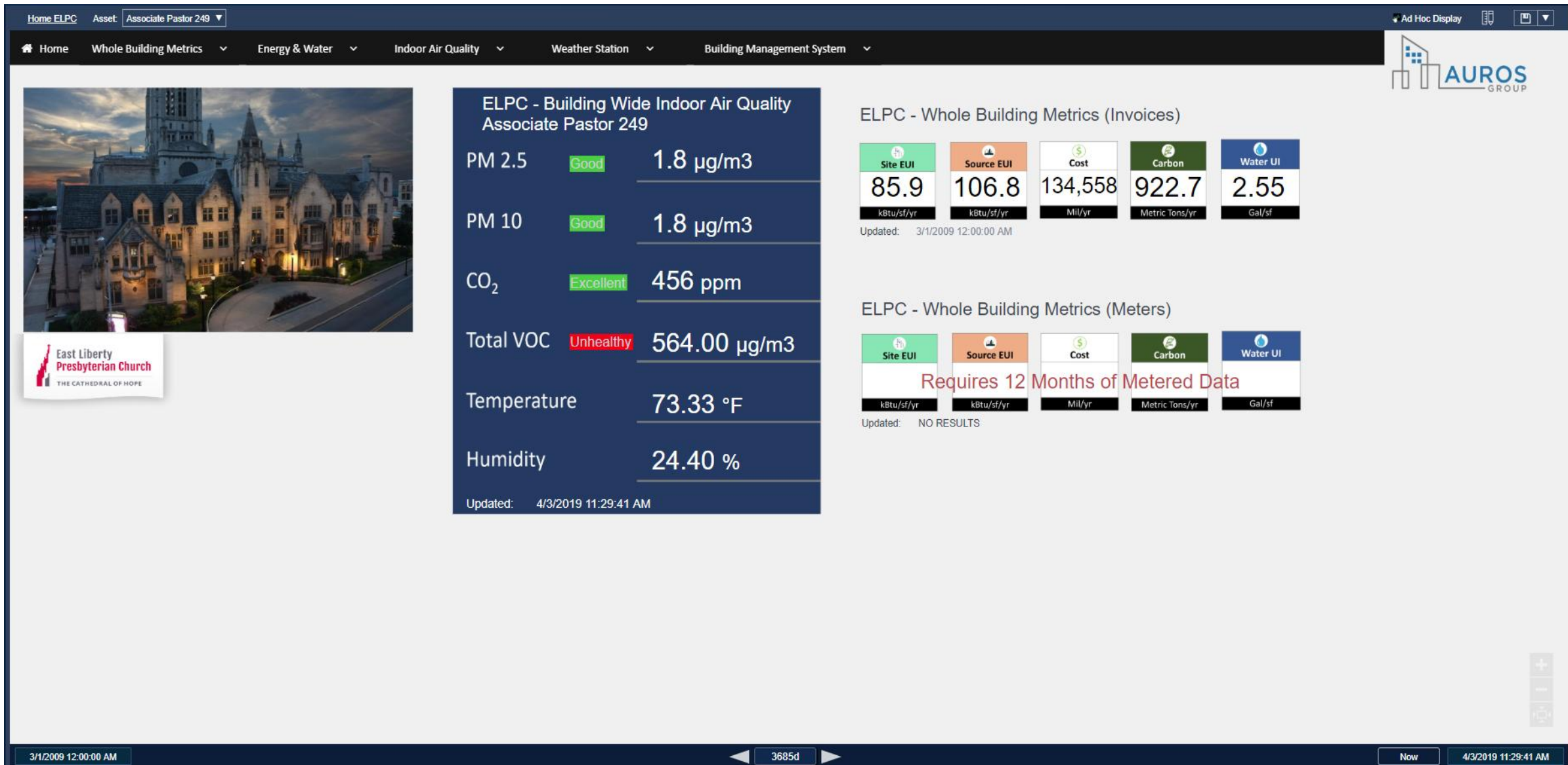




ELPC - Electric Meters

Year Month Day Hour
2000 Amp 208/120V MDP|Consumption Monthly





Take Aways

- Getting PLC data into PI is well established
- Getting DDC data is also important!
- Connector will make it easy to get DDC data
- This data can be used to:
 - Optimize existing underperforming systems (FDD)
 - Determine if building is performing to design (advanced modeling)