Transforming building operations with new self-correcting controls technology

October 26, 2022

Buildings are core to our lives, climate, and economy

90%

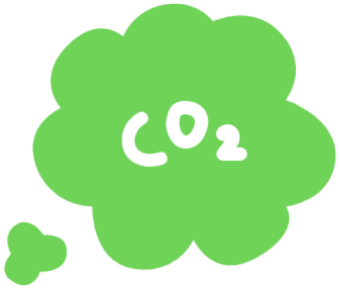
of our time indoors

17%

GDP in real estate and construction

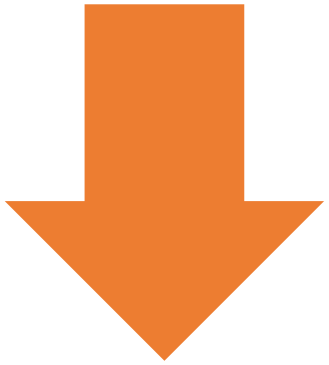
34%

GHG emissions



Commercial building controls routinely fall out of tune

Emissions
Utility bills



Comfort
Equipment Life
B2G Coordination

29%

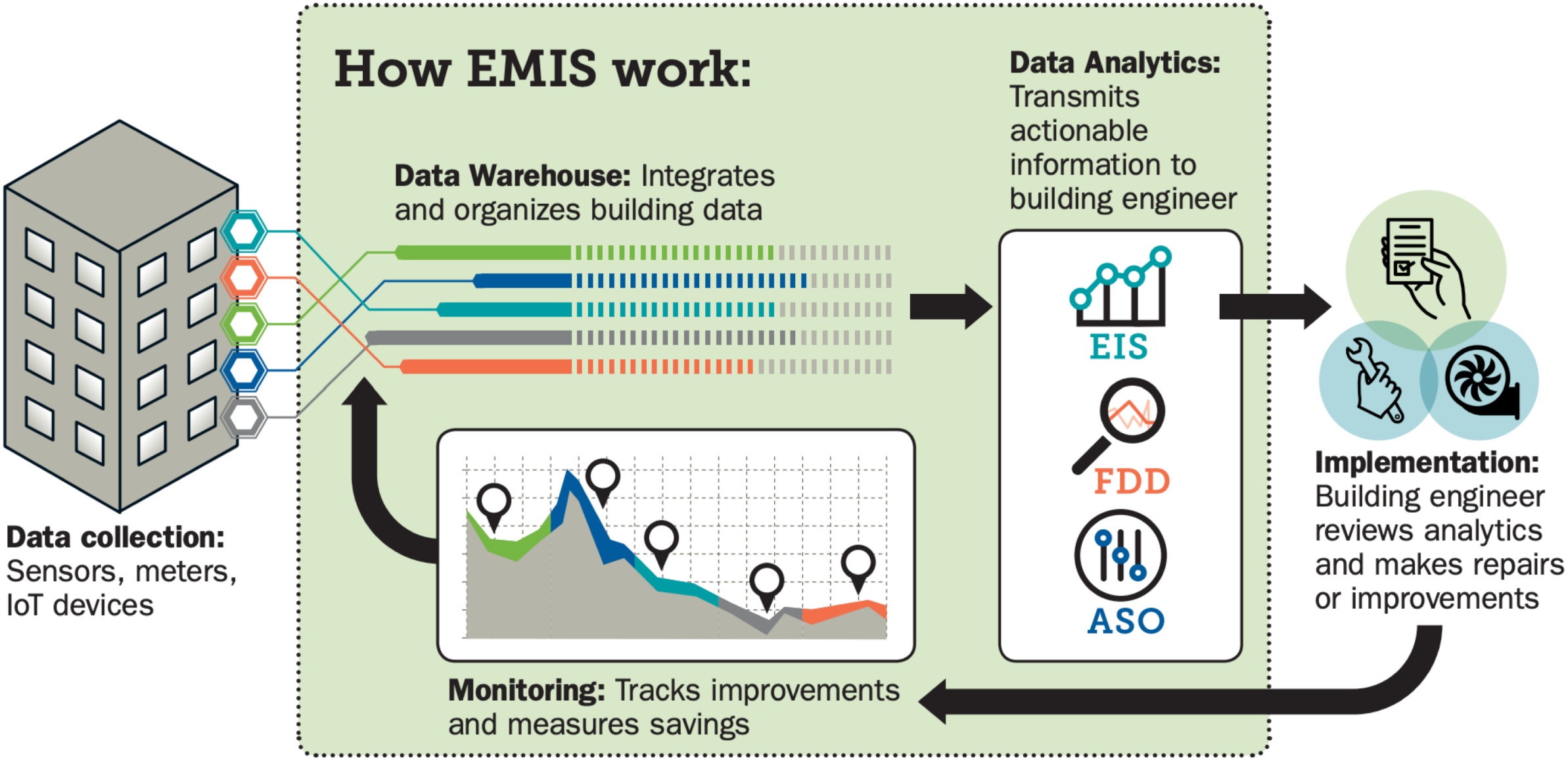
Energy savings potential

19%

Peak load shed potential

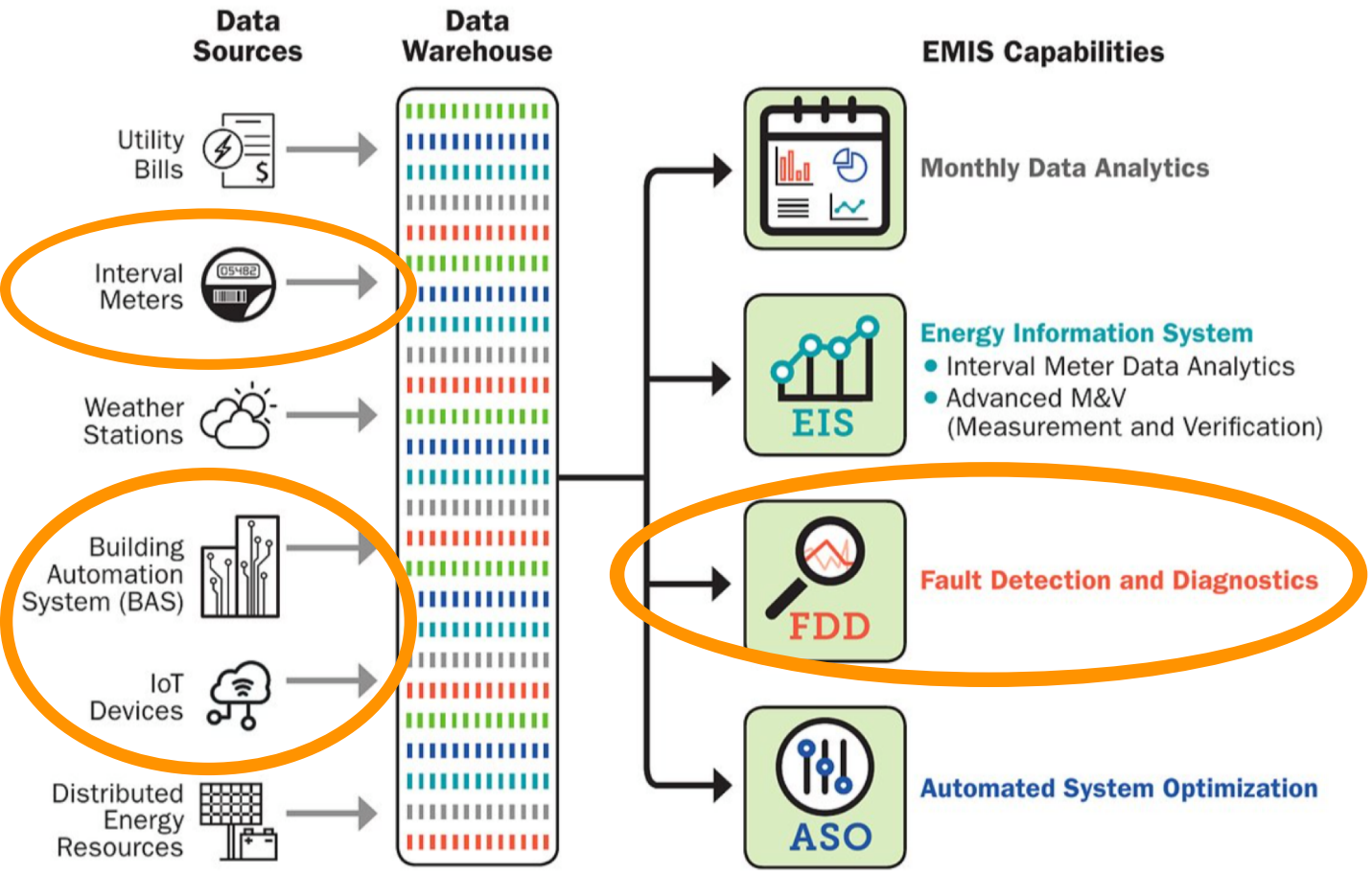
$17B

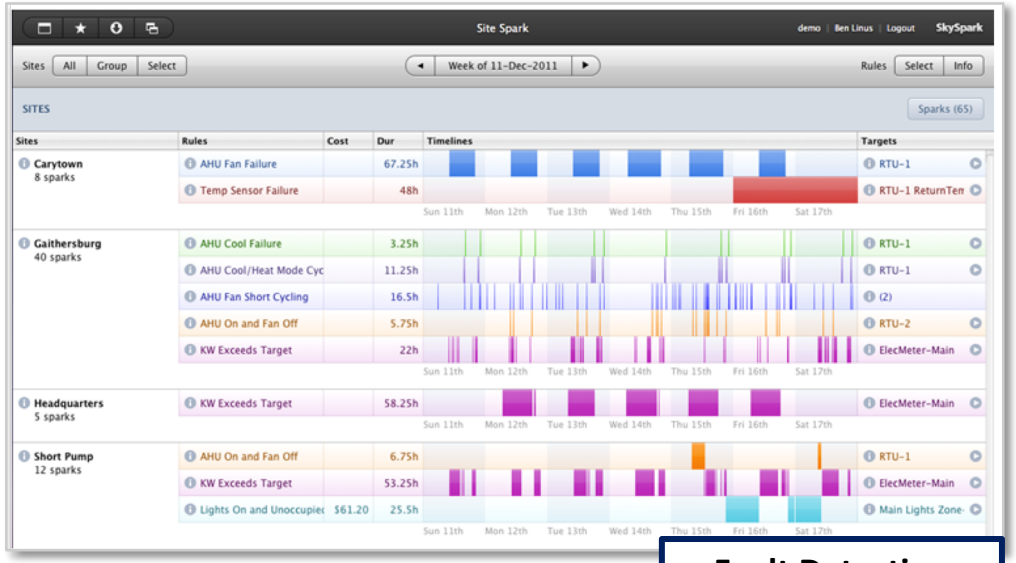
Business cost savings potential

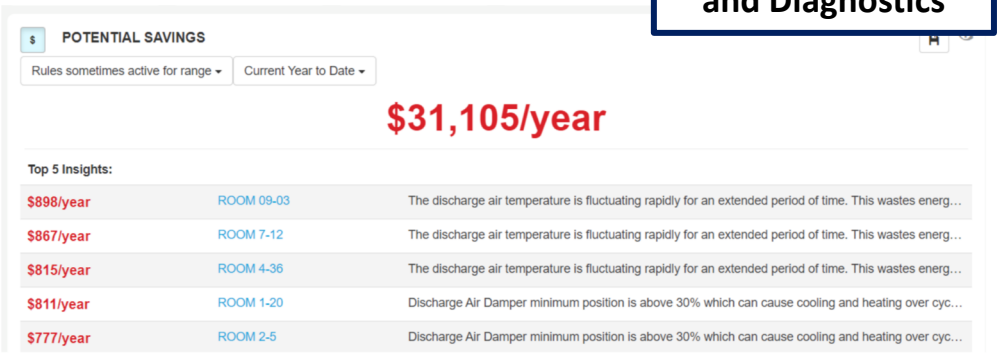


EMIS TOOLS: Energy information systems (**EIS**) help find energy waste using smart meter data. Fault detection and diagnostic tools (**FDD**) detect and prioritize HVAC system faults. Automated system optimization (**ASO**) includes control algorithms to minimize energy use across systems.

FDD analyze control and equipment faults

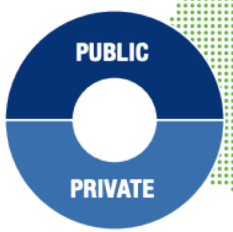






Top: SkyFoundry SkySpark
Bottom: CopperTree Kaizen

Largest Dataset Documents the Costs and Benefits of EMIS



104 ORGANIZATIONS

6,500 BUILDINGS

567 MILLION SQUARE FEET

EMIS SOFTWARE REPRESENTING **40** DIFFERENT EMIS VENDORS HAVE BEEN INSTALLED

ENERGY SAVINGS FOR ORGANIZATIONS WITH EMIS:

3% EIS

9% FDD

$95 million PROJECTED ANNUAL SAVINGS *for all organizations*

$3 million ANNUAL SAVINGS *for the median portfolio (15 million sq ft)*

FIRST-YEAR INSTALLATION AND SOFTWARE COSTS:

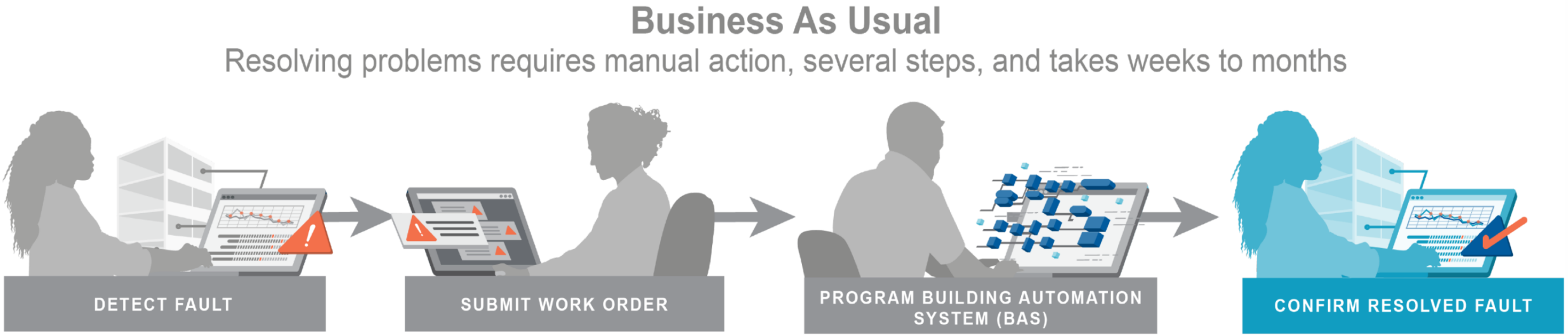
EIS **$0.02/sq ft**

FDD **$0.08/sq ft**

INVESTMENT PAYBACK:

2 years

FDD software IDs problems, people fix them



Advancing Market Solutions for Self-Correcting, Optimized Controls

Leapfrogging the status quo, the U.S. Department of Energy and Berkeley Lab have joined forces with the smart buildings industry to deliver the first-ever technology to automatically find and correct controls problems.

CLOCKWORKS ANALYTICS

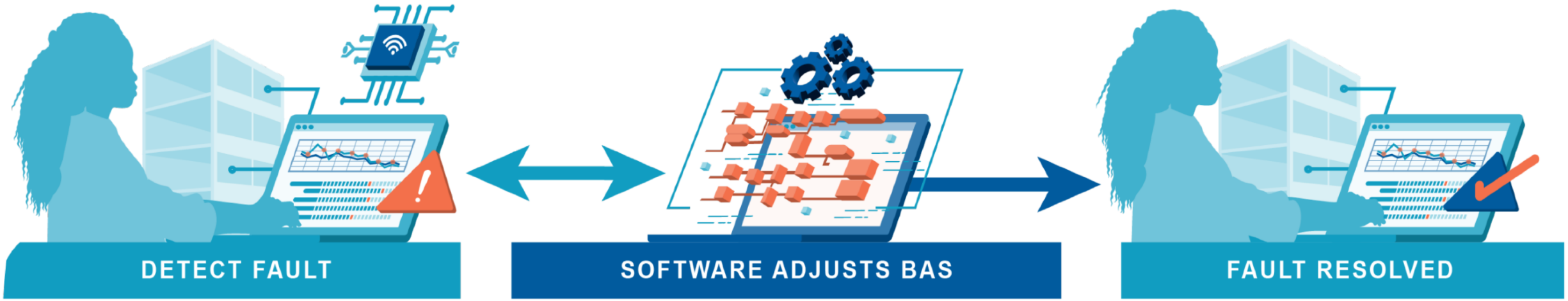
CopperTree Analytics

SkySpark EVERYWHERE

SUSTAINABLE BERKELEY LAB

Automated Control Correction

Control faults are automatically resolved within hours

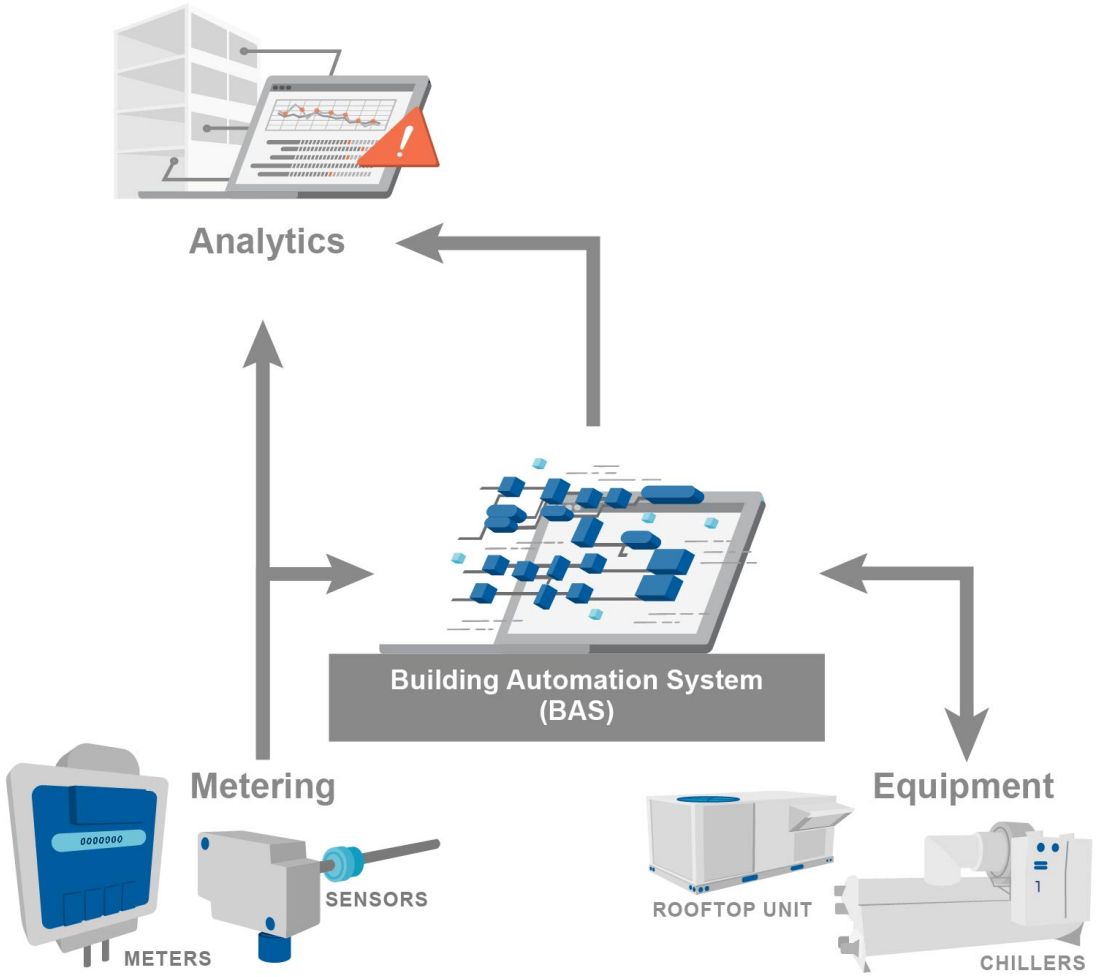


By integrating optimal control and fault diagnostics capabilities we can now:

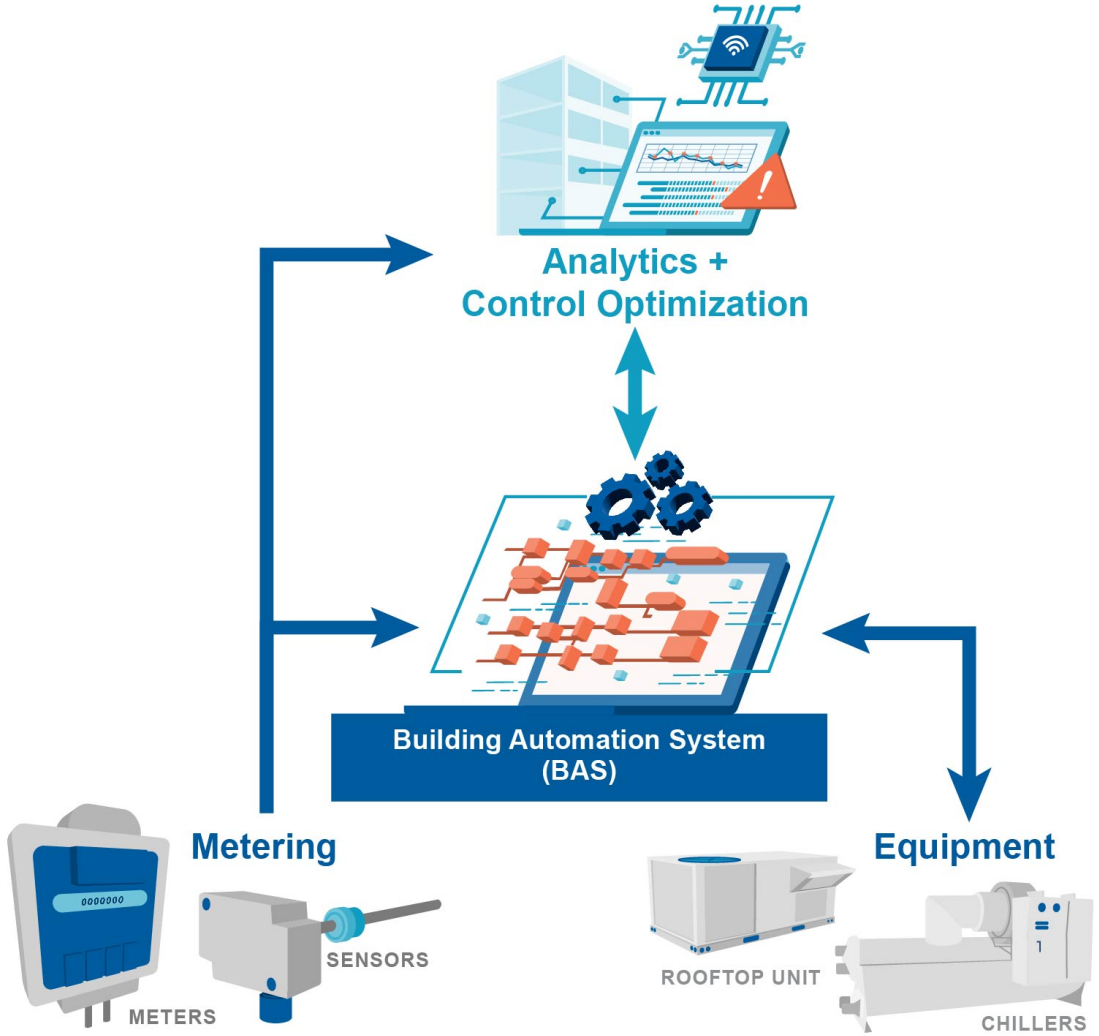
Reserve operations and maintenance staff expertise for the hardest problems

Maintain efficient, in-tune building operations

Scale the delivery of low-carbon demand-flexible buildings through software-based product infrastructure



Historically, FDD products have offered analytics capabilities, ‘reading’ data from the BAS and other sensors and meters



By adding BAS ‘write’ capability and additional corrective logic, FDD products can now fix the problems they detect

Self-correcting capabilities

We have developed solutions to automatically resolve the most common, impactful building controls problems. This new technology capability is applicable to smaller buildings with packaged heating ventilation and air-conditioning (HVAC) systems, as well as large buildings with built-up systems.

- Optimized economizer high lockout temperature setpoint
- Correction of incorrectly programmed HVAC schedules
- Release of unnecessary control overrides
- Correction of biased temperature sensors
- Automated loop tuning
- Implementation of best practice reset strategies
- Mitigation of rogue zones
- Optimized zone temperature setpoint setback

Field testing at 3 locations, across 4 BAS

CopperTree Analytics

Implemented at:

EMORY UNIVERSITY

Delta CONTROLS

CLOCKWORKS ANALYTICS

Implemented at:

Schneider Electric

EcoStruxure

SkyFoundry

Implemented at:

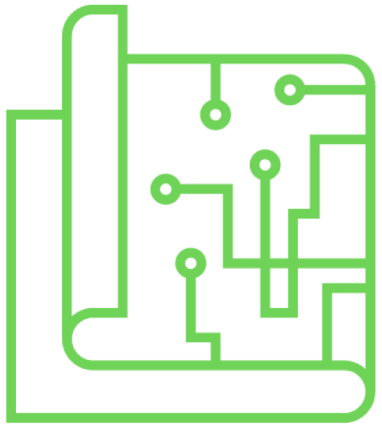
BERKELEY LAB

Automated Logic

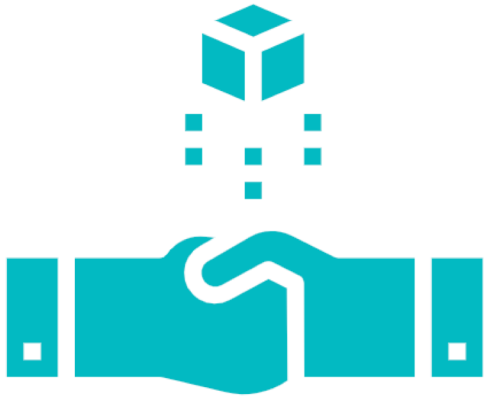
METASYS

Next up

Partners' results



Future directions

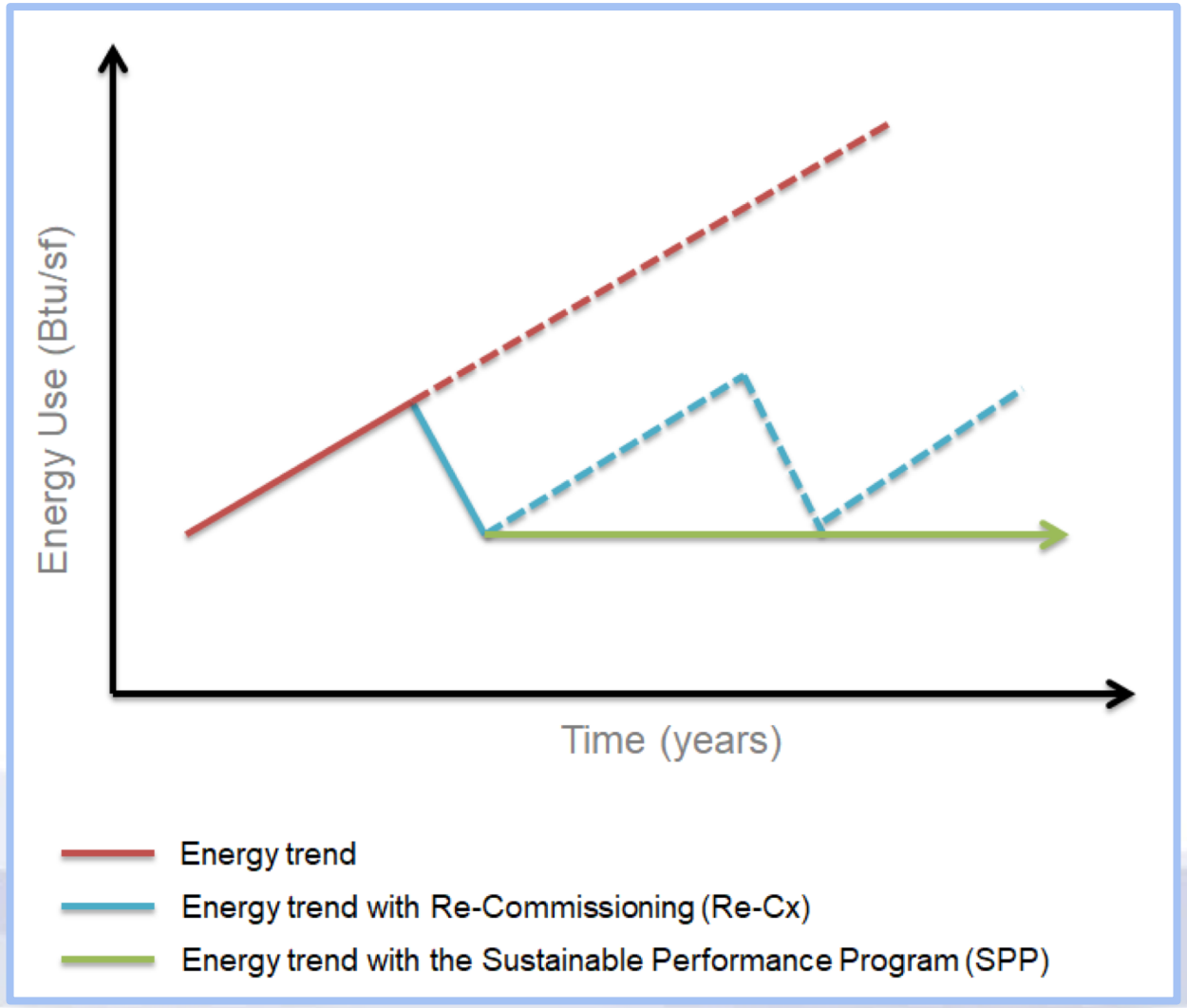


Call to collaborate

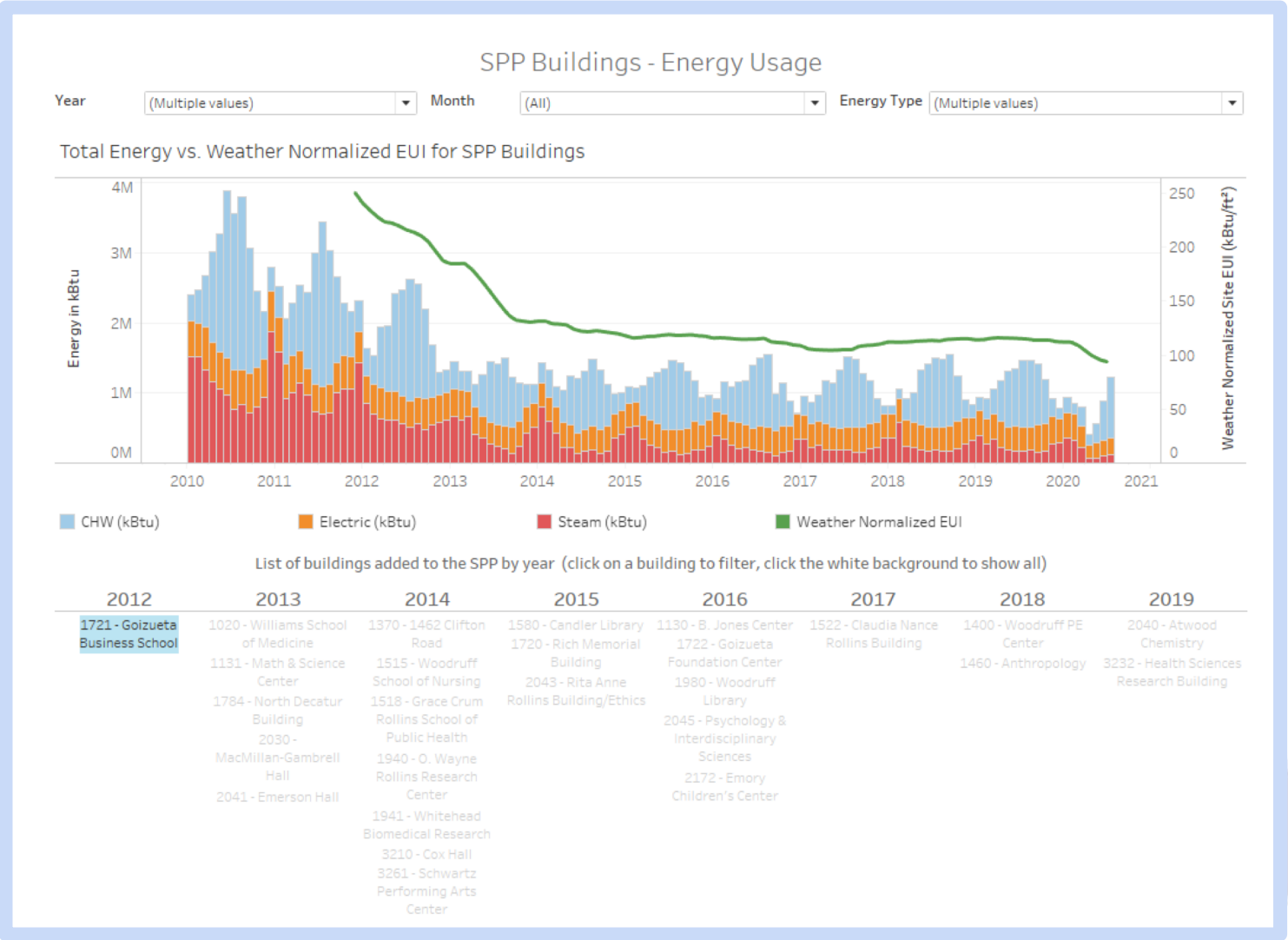
Questions so far?

Emory's Sustainable Performance Program

Sustainable Performance Program



Sustainable Performance Program



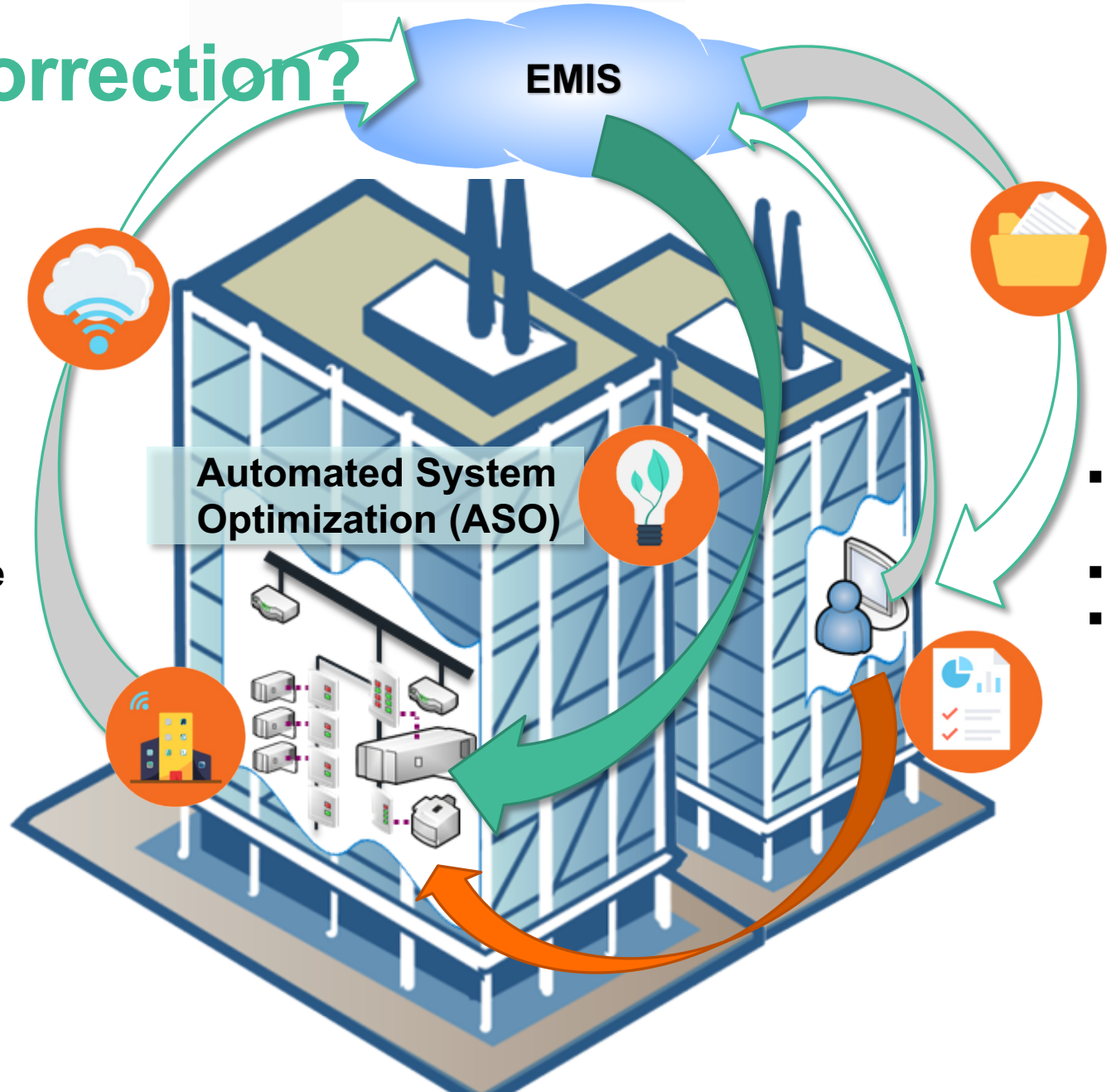
CopperTree Analytics

Who we are

- Founded in 2012 with a long history in building automation and energy management
- Canadian-based developer of KAIZEN – a data acquisition, analytics, and reporting platform for building energy monitoring, fault detection and diagnostics, and system performance auditing
- KAIZEN is currently deployed in over 2,800 client buildings on four continents
- Each day, KAIZEN intakes ~1.2 billion data samples into our servers for analysis and reporting

Why Self-correction?

- Building Automation System (BAS)
- Metering Infrastructure
- IoT/Cloud Data Source



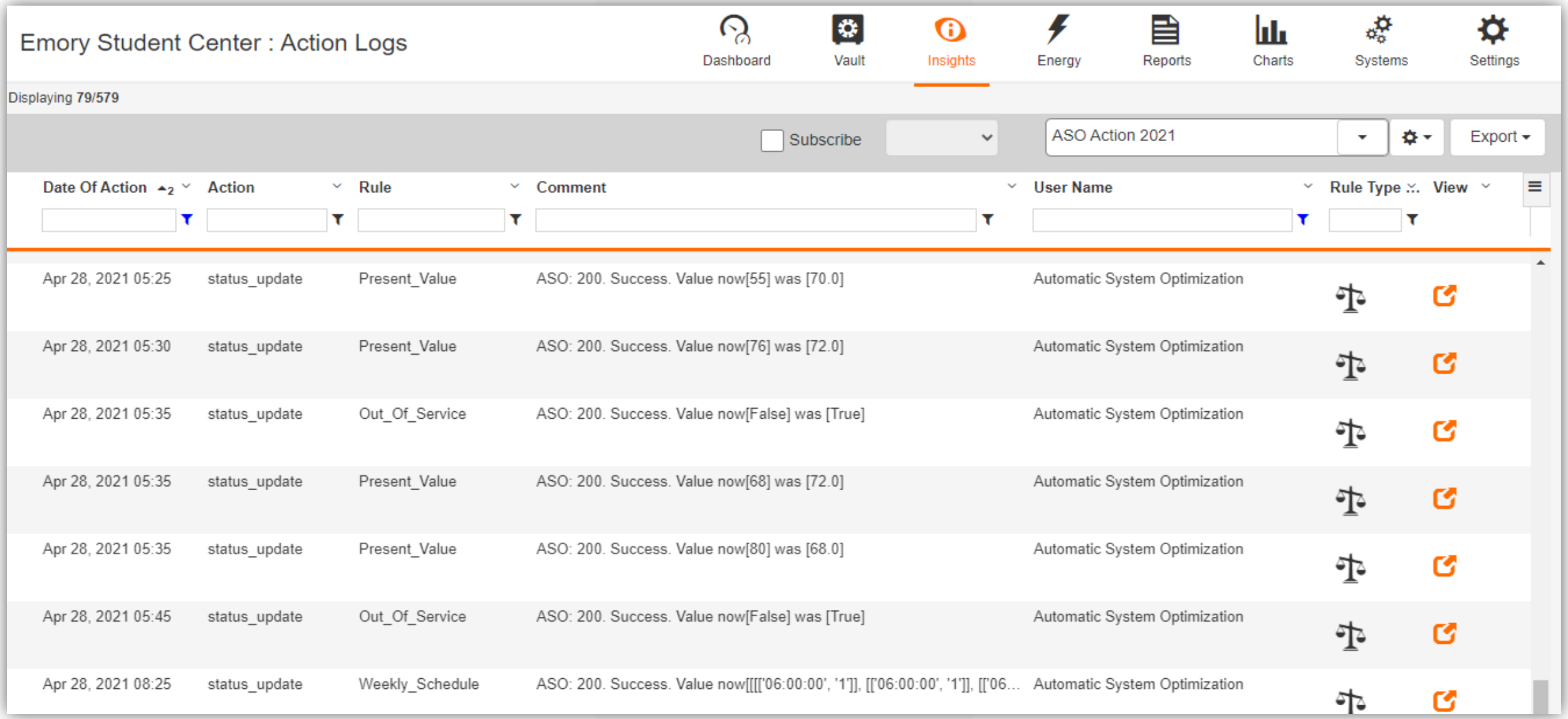
- Energy Performance
- Fault-Detection
- System Optimization

CopperTree Analytics

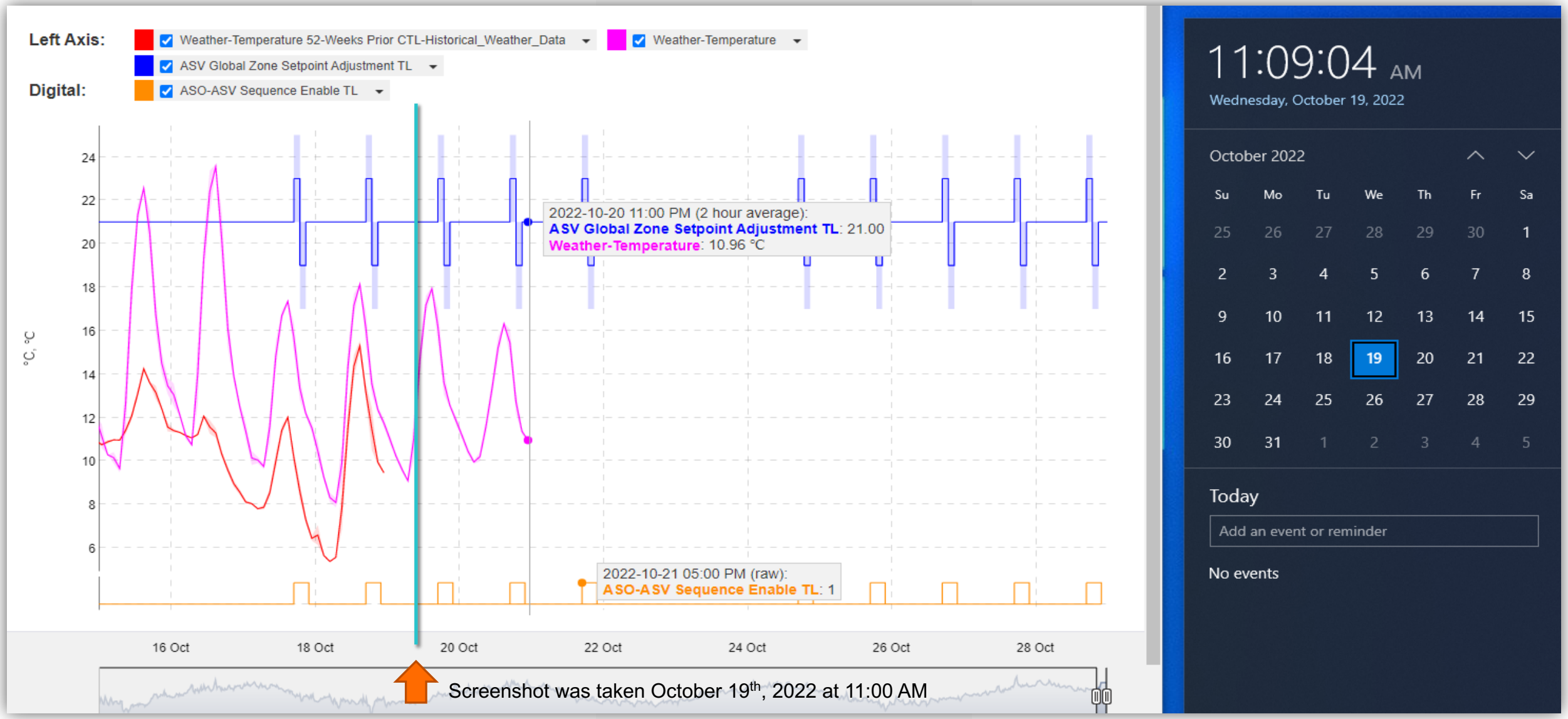
Strategies Tested & Field Results

Ref.	Application	Self-correction Algorithm	Field Results
1	HVAC	Schedules are incorrectly programmed (not as intended)	Successful implementation. Schedule change is detected and the operator can automatically revert it back to the schedule's "commissioned" values
2	HVAC	Override manual control	Successful implementation. Override is detected and the operator can automatically revert it back to automatic control
6	HVAC	Rogue zone (for ASHRAE G36 control sequence)	Implementation (phase 2) in progress
9	HVAC	Improve economizer lockout setpoint	Implementation (phase 2) in progress
10	HVAC	Improve zone temperature setpoint setback	Successful implementation. Incorrect setpoint is detected and the operator can automatically revert it back to the setpoint's commissioned value

Automated Action Logs



Automated Optimization & Verification



Screenshot was taken October 19th, 2022 at 11:00 AM

EMIS Automated Fault Correction & Optimization

Challenges

- Disparate building technologies, including BAS protocols and infrastructure
- Inadequacy of integrated workflows in facility management
- Unclear delineation of roles between operational and supervisory building energy management systems

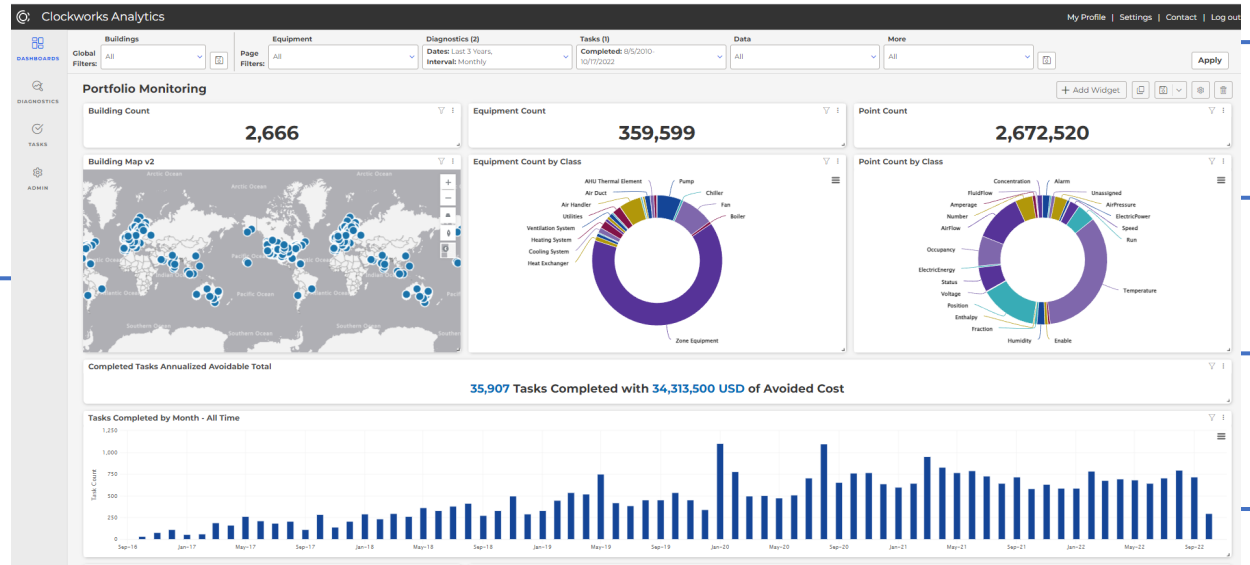
Opportunities

- Automated processes help facility management focus on more strategic tasks
- Energy and operational savings increase as soft faults are quickly fixed and system performance continuously improved
- 2-way interfaces are the foundation for smart buildings' adaptive controls, ongoing commissioning and optimization, and grid interactivity

OBJECTIVE

To simplify and reduce costs of ‘fixing’ faults for large portfolios with constrained resources

For facilities teams and service providers, to fix many faults at the push of a button to achieve energy savings, extended asset life, and better performance



Building 1

Building 2

Building 3

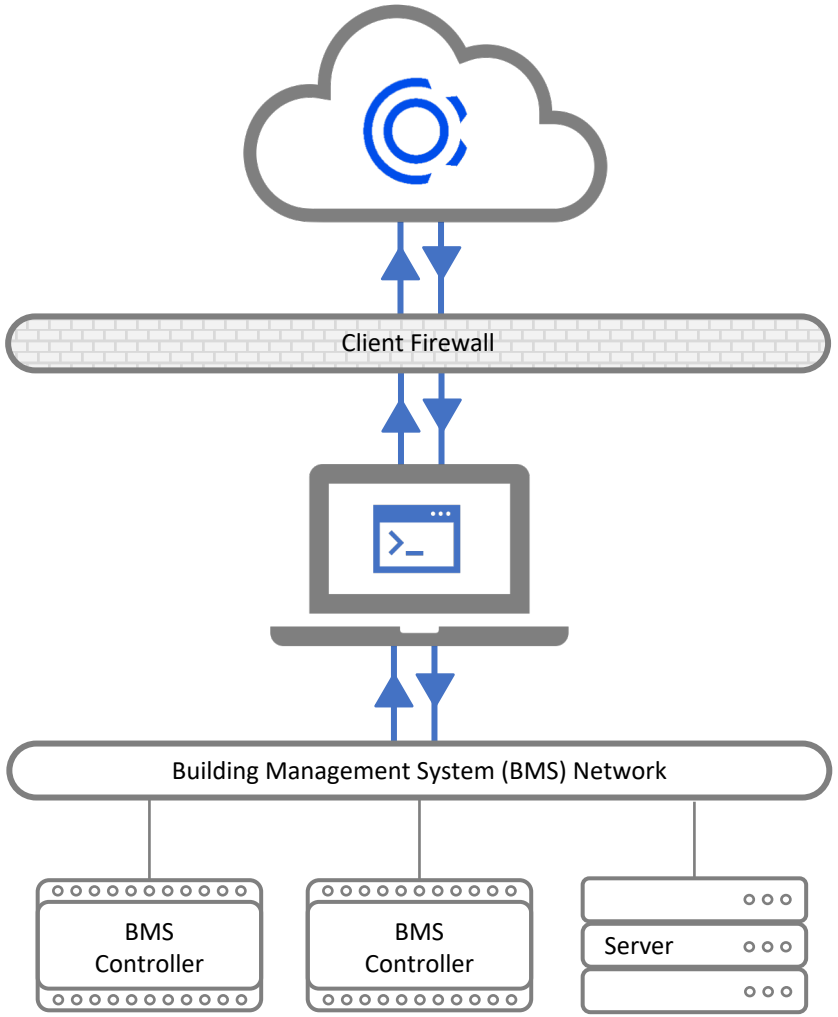
Building 4

CLOCKWORKS AUTOMATED FAULT CORRECTION

Data push to the cloud API request for updates

Software Gateway installed on local workstation, server, or virtual machine

Reads BMS data from IP devices or server via supported protocols



REST API response with correctable issues

User interface for validation and acknowledgement

Sends commands to BMS devices

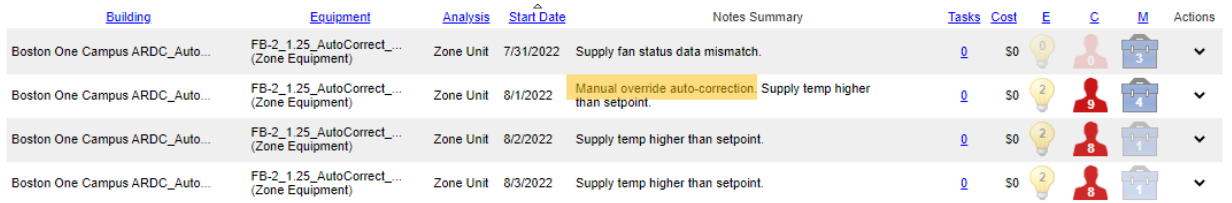
BACnet

FIELD TEST

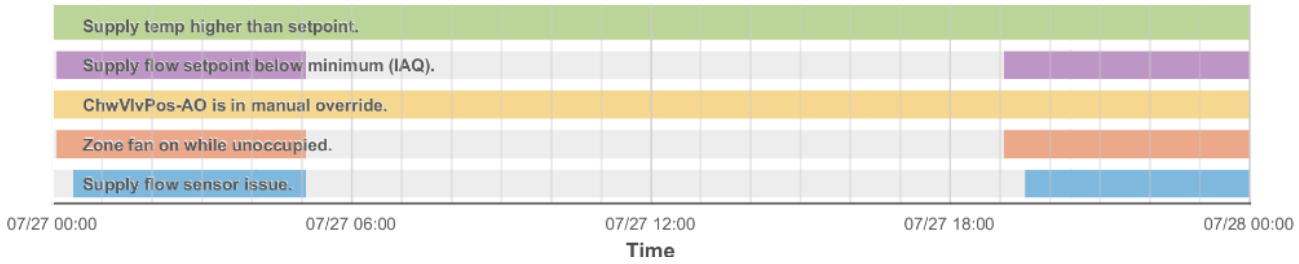
Implemented automated fault correction routines for a mid-size commercial office building

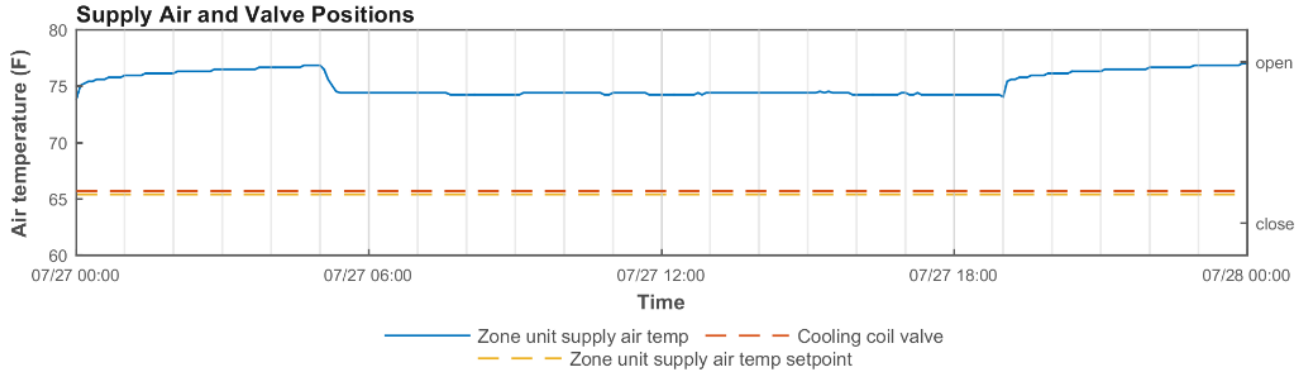
For example, relinquishing a controls override on a chilled beam's chilled water valve

- Clockworks identifies a chilled water valve override on a fan powered box
- Override is visible in the fault data



Building	Equipment	Analysis	Start Date	Notes Summary	Tasks	Cost	E	C	M	Actions
Boston One Campus ARDC_Auto...	FB-2_1.25_AutoCorrect_... (Zone Equipment)	Zone Unit	7/31/2022	Supply fan status data mismatch.	0	$0	0	0	3	
Boston One Campus ARDC_Auto...	FB-2_1.25_AutoCorrect_... (Zone Equipment)	Zone Unit	8/1/2022	Manual override auto-correction. Supply temp higher than setpoint.	0	$0	2	9	4	
Boston One Campus ARDC_Auto...	FB-2_1.25_AutoCorrect_... (Zone Equipment)	Zone Unit	8/2/2022	Supply temp higher than setpoint.	0	$0	2	8	1	
Boston One Campus ARDC_Auto...	FB-2_1.25_AutoCorrect_... (Zone Equipment)	Zone Unit	8/3/2022	Supply temp higher than setpoint.	0	$0	2	8	1	



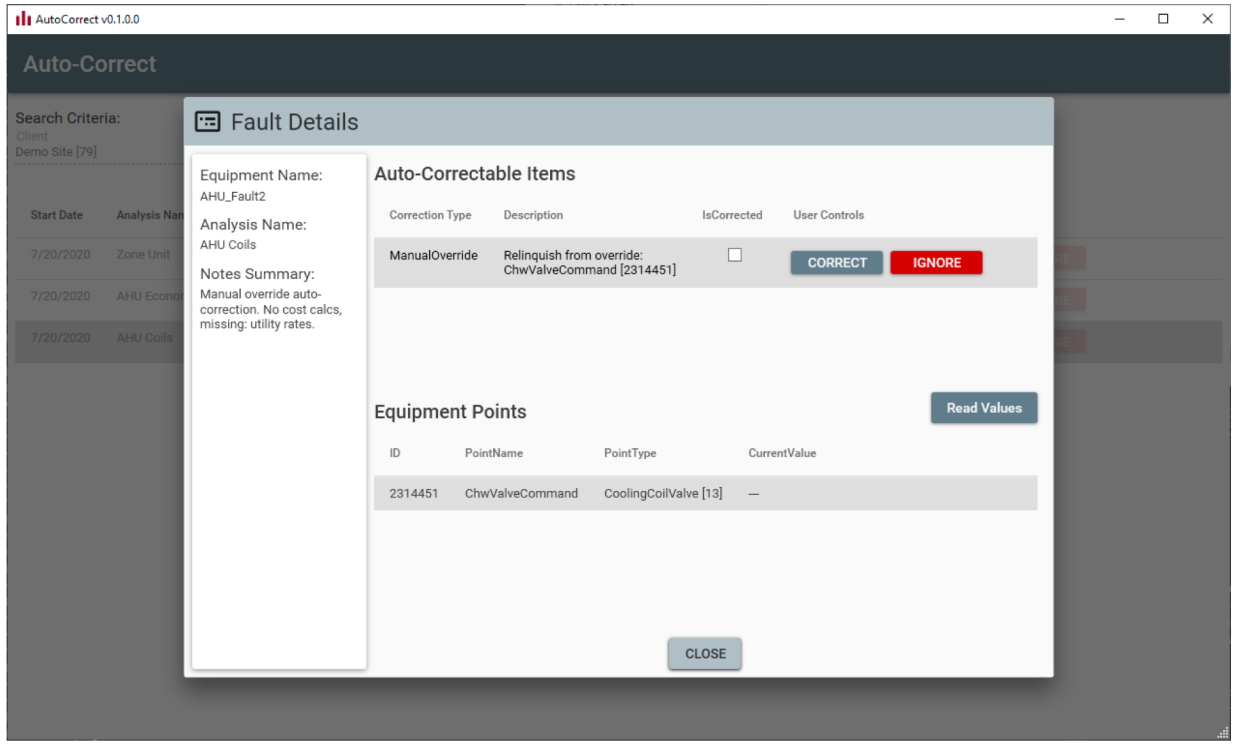


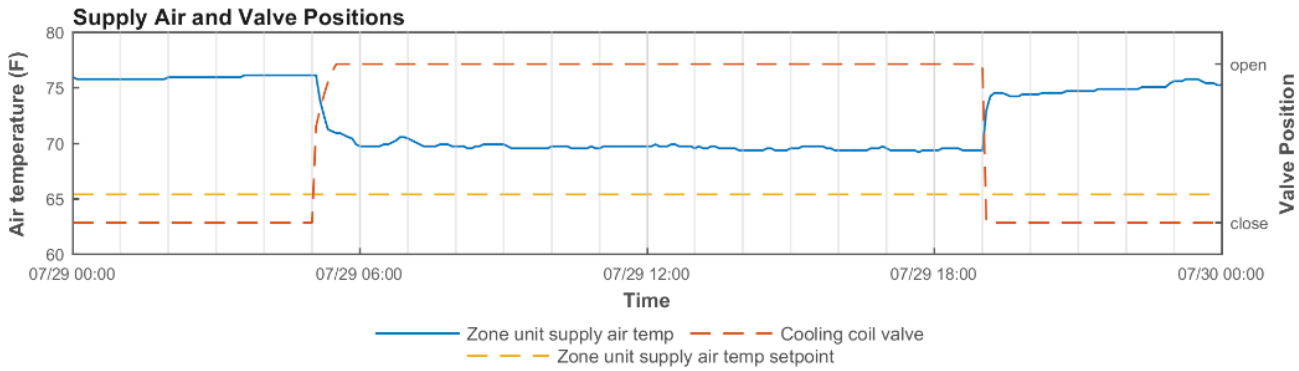
FIELD TEST

Implemented automated fault correction routines for a mid-size commercial office building

For example, relinquishing a controls override on a chilled beam's chilled water valve

- Clockworks identifies a chilled water valve override on a fan powered box
- Override is visible in the fault data
- User acknowledges the need for automated fault correction (optional step in the future)
- Data shows chilled water valve returned to normal operation





FEEDBACK

Majority of customers want to see automated fault correction in action asap. They have resource constraints to fix the issues they want fixed, and this is a welcome solution.

- Some customers want assurance they won't 'have to' do it. They worry about cybersecurity, regulatory requirements, and change control processes.

One healthcare organization, one system integrator, and one higher education facility have expressed interest to deploy automated fault correction in their facilities

The boundary between automated fault correction, control optimization, and building automation programming blurs on some issues, such as supply air temperature or static pressure control loops, and partners and customers have different views on the technical architecture for such interventions.

NEXT STEPS

Expand the number of issues that can be automatically fixed

- Adjustments to economizer control sequence
- Adjustments to existing hydronic loop reset schedules
- Additional methods in which overrides can be applied and corrected

Expand field testing and user experience testing

Automated Fault Correction at Berkeley Lab

Optimizing for Deeper Energy Savings

SUSTAINABLE BERKELEY LAB • sbl.lbl.gov

BERKELEY LAB

October 26, 2022 - Chris Weyandt, Ongoing Cx Lead

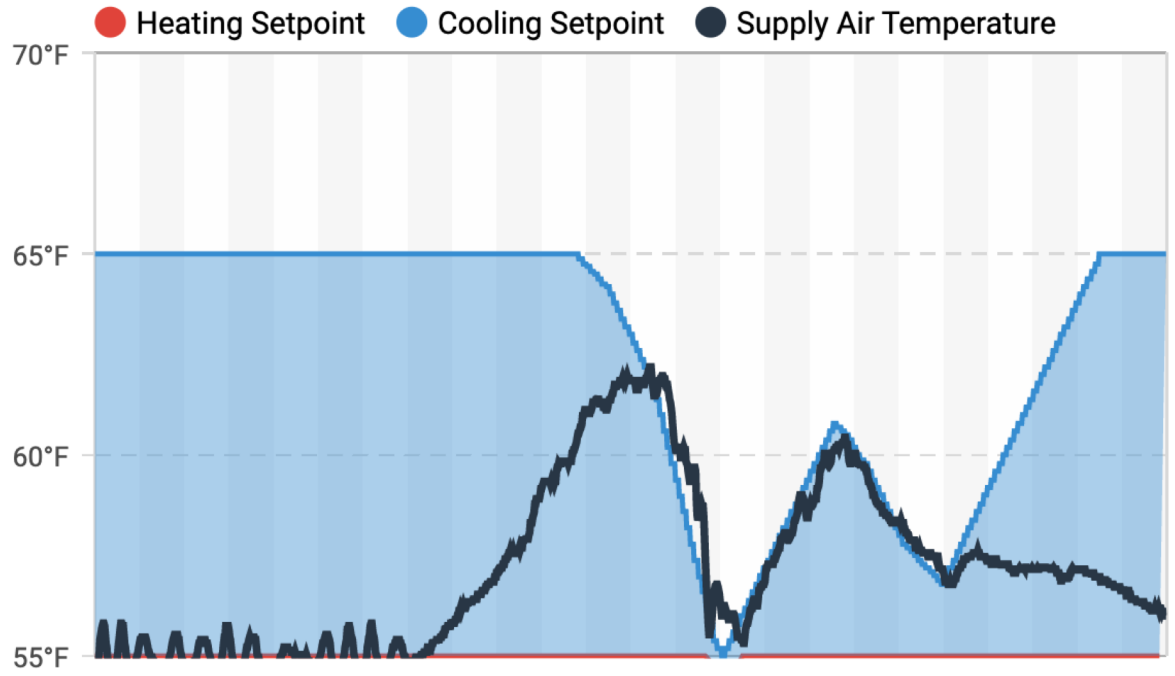
Automated Fault Correction Implemented

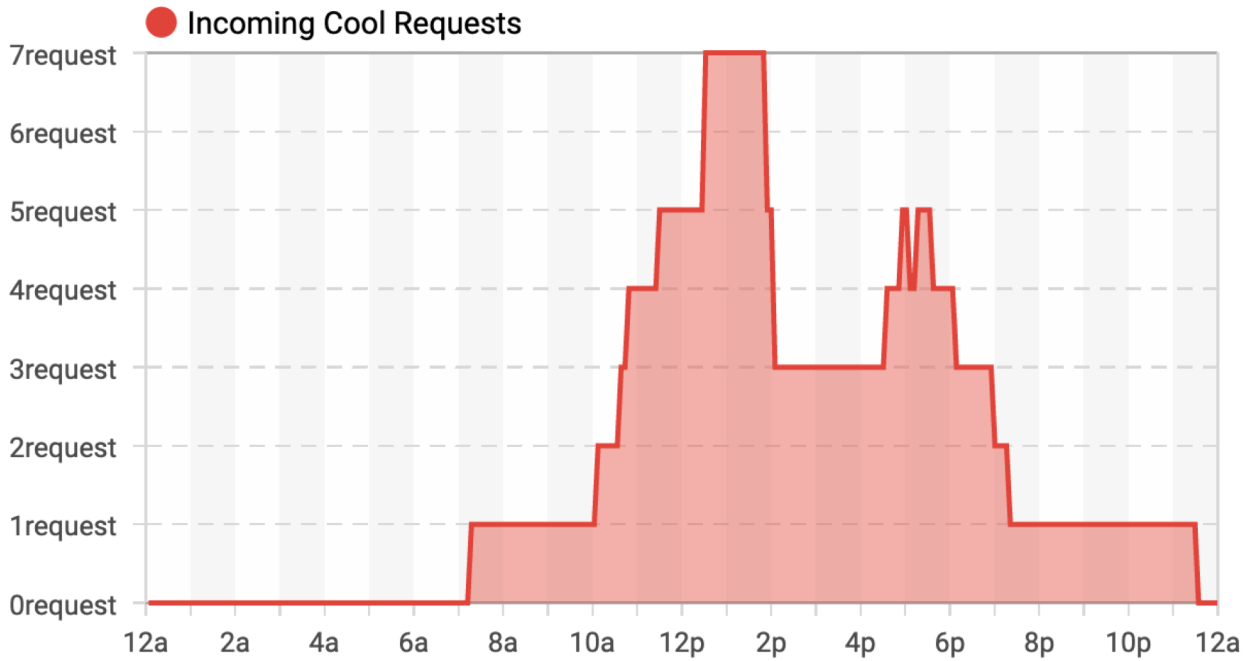
AHU Setpoint Optimization:	Applies modern, energy saving strategies to outdated HVAC control systems.
Rogue Zone Suppression:	Enhances existing logic by dynamically ignoring invalid requests from zones.
Automated Loop Tuning:	Extends equipment life and stabilizes distributed systems by reducing control hunting faults.

Supply Air Temperature and Pressure Resets

Optimizes air handling unit (AHU) supply air temperature and pressure setpoints based on zone-level equipment operating conditions.

Implements ASHRAE Guideline 36 standardized Trim and Respond calculations with minimal modification to existing BAS logic.



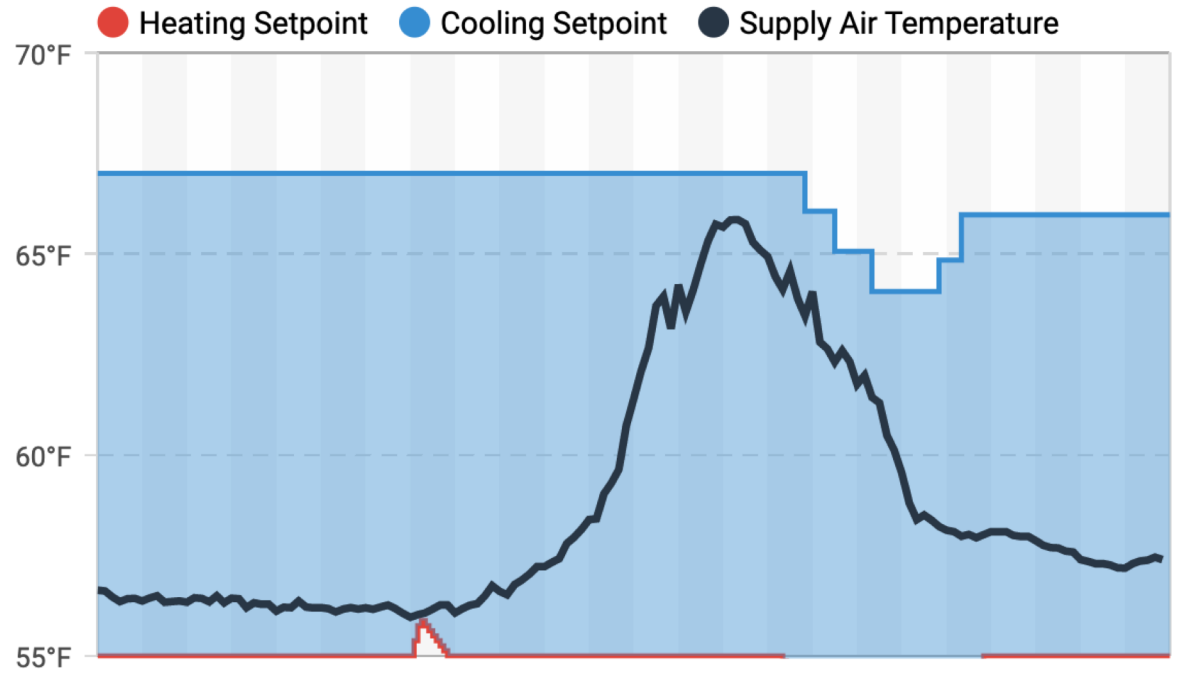


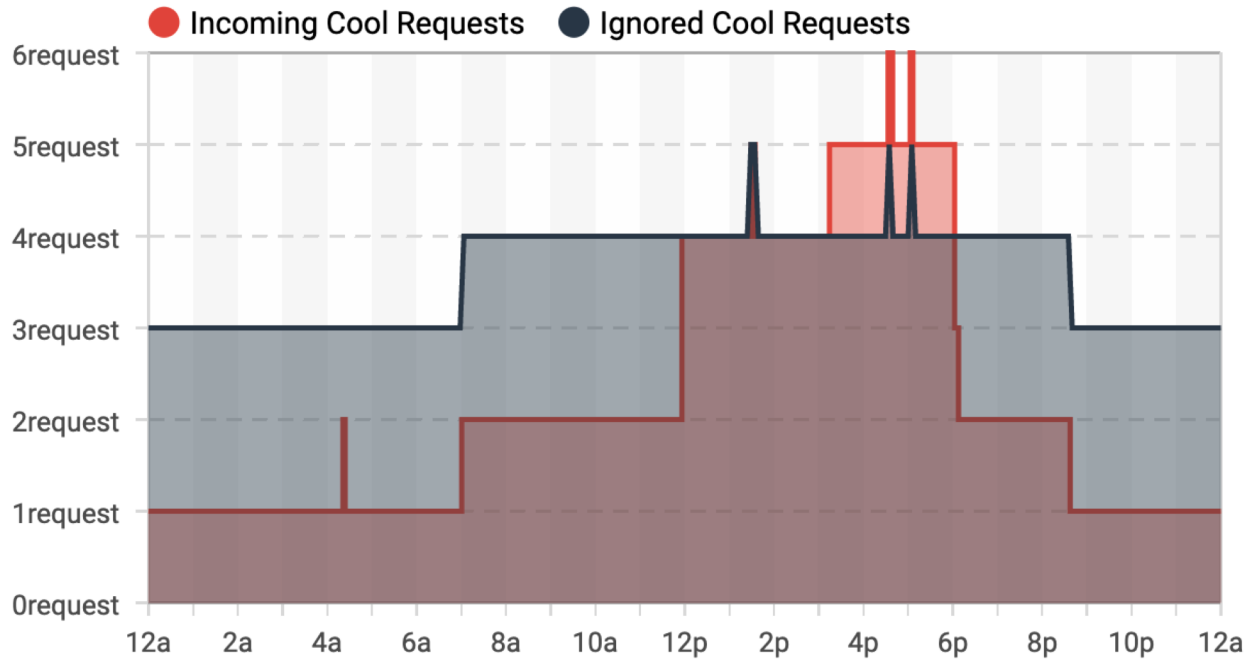
Identify and Ignore Rogue Zone Requests

Instructs the BAS to ignore requests (i.e. for colder supply air) from zones that are unsatisfied due to local equipment issues.

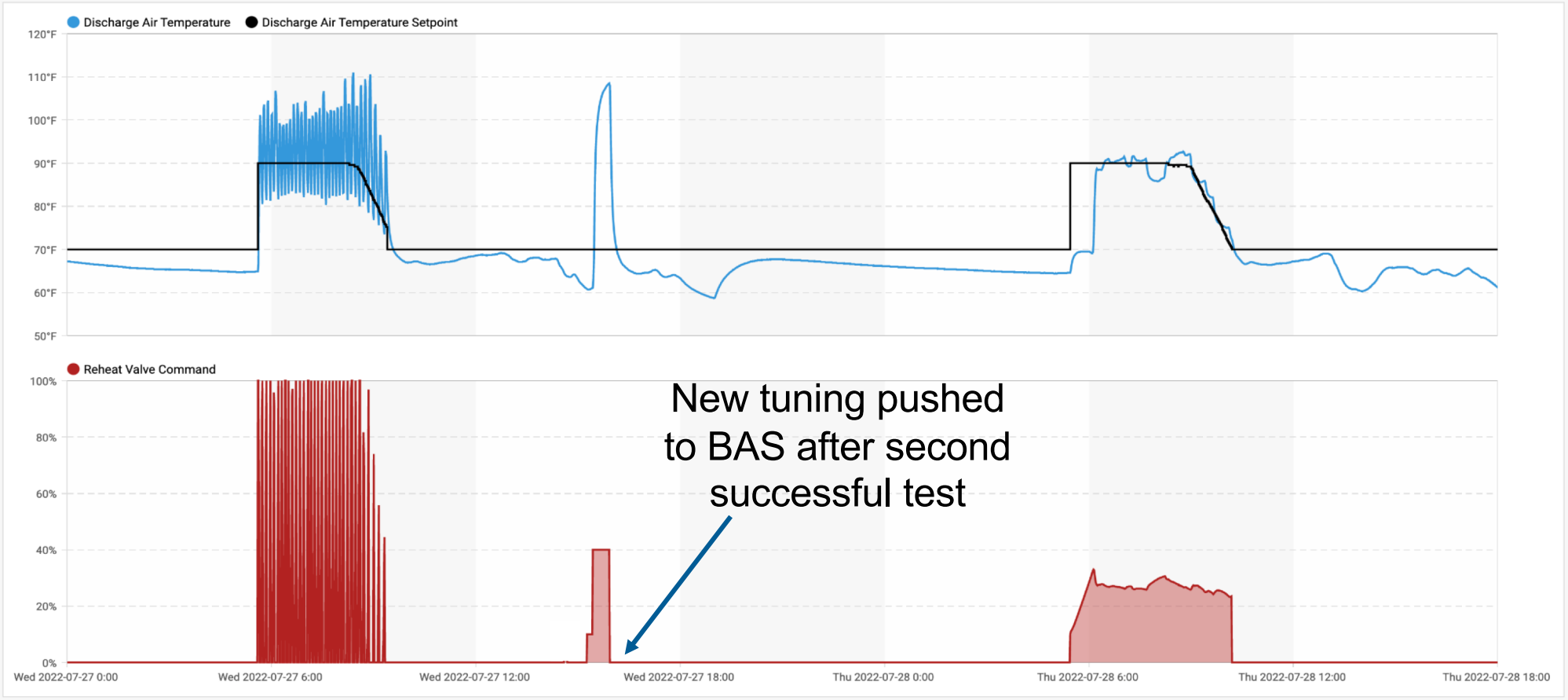
Faults causing disqualification:

1. Leaky reheat valve
2. Airflow setpoint not met
3. Cooling setpoint too low

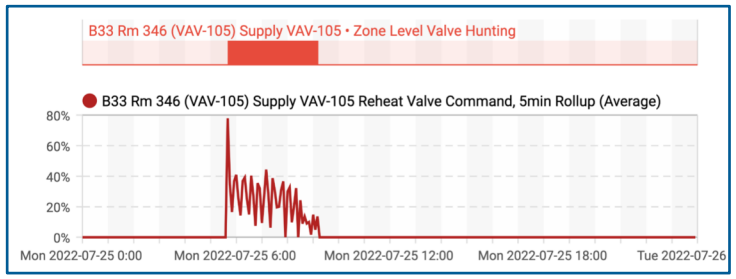




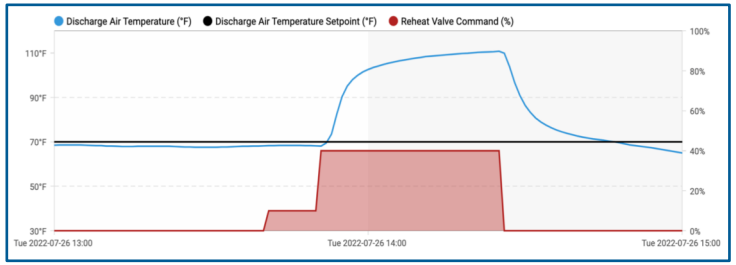
Automated Loop Tuning with Active Testing



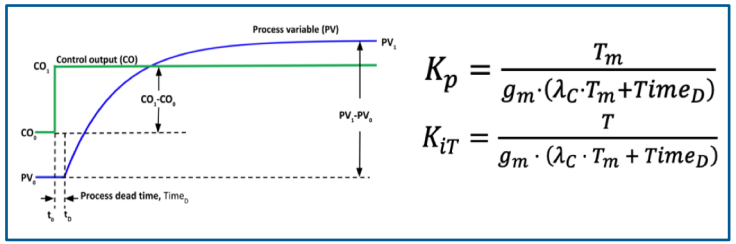
Process for Active Testing and Tuning with FDD



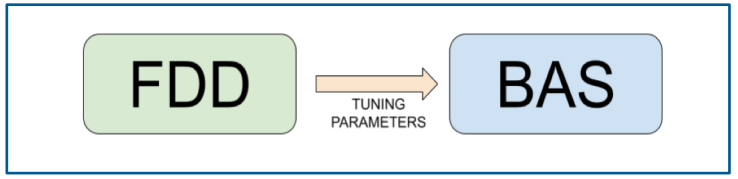
1. Identify control hunting with FDD.



2. Perturb system and measure response.



3. Calculate improved tuning parameters.



4. Push updated tuning parameters to BAS.

Benefits to Operations at Berkeley Lab

Optimizes delivery of conditioned air in buildings to:

- Save energy, expense, and emissions.
- Improve the reliability of HVAC equipment.

Reduces barriers to implementation of new strategies by:

- Extending the capabilities of legacy systems.
- Centralizing and standardizing control algorithms.

Questions of any presenters?

EMIS are core to the future of buildings

- Historic investments in retrofits and electrification
- Persistent performance, enduring value

EMIS are core to the future of buildings

- Historic investments in retrofits and electrification
- Retiring workforce, next gen. expects networked intelligent systems
- Persistent performance, enduring value
- Automation and modern tools for building O&M

EMIS are core to the future of buildings

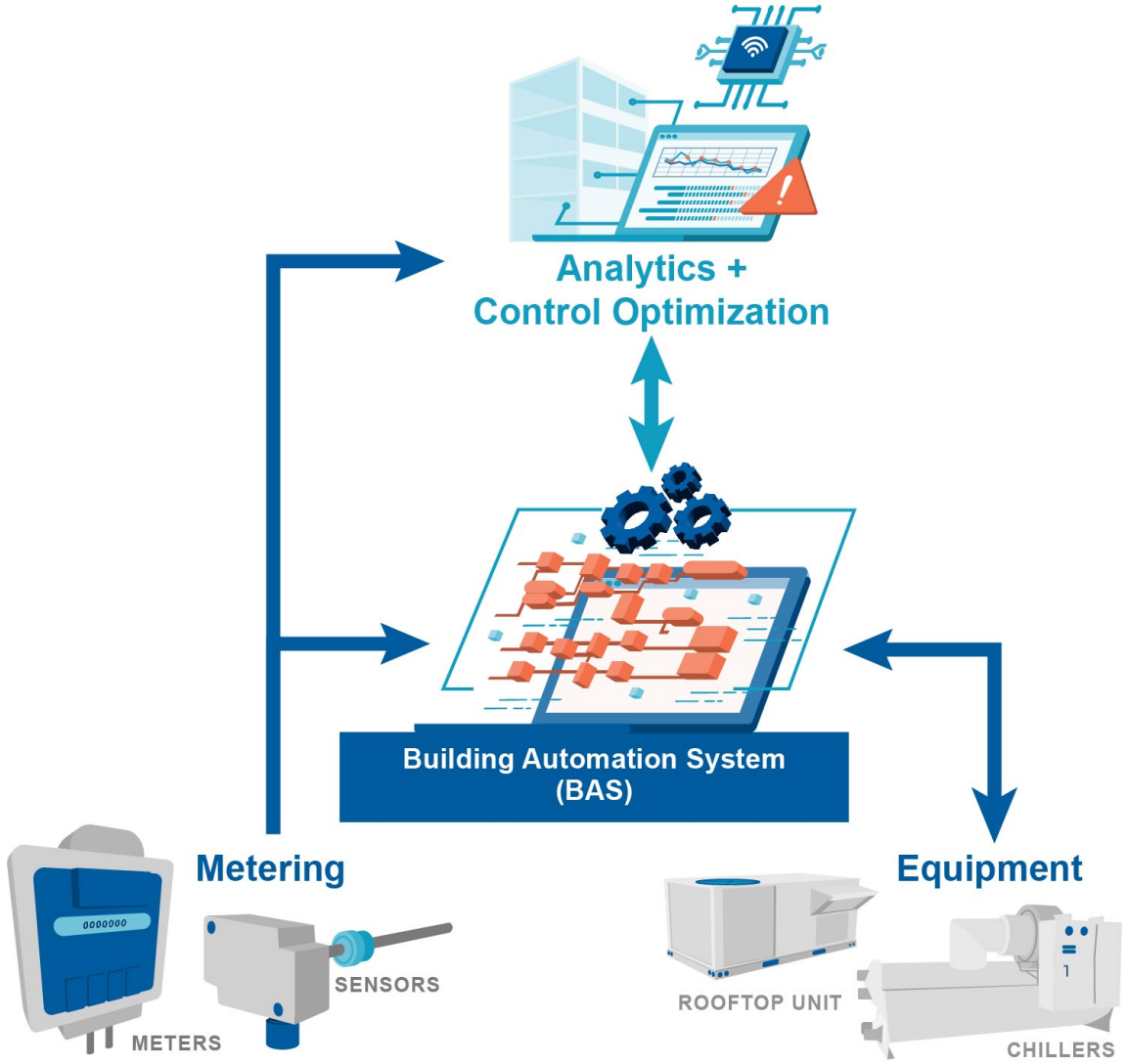
- Historic investments in retrofits and electrification
- Retiring workforce, next gen. expects networked intelligent systems
- Industry mobilization around speed and climate urgency
- Increasing asks of our buildings – health, grid, DERs, GHGs
- Persistent performance, enduring value
- Automation and modern tools for building O&M

EMIS are core to the future of buildings

- Historic investments in retrofits and electrification
- Retiring workforce, next gen. expects networked intelligent systems
- Industry mobilization around speed and climate urgency
- Increasing asks of our buildings – health, grid, DERs, IEA
- Persistent performance, enduring value
- Automation and modern tools for building O&M
- Mechanism to scale across systems, data models, equipt configurations
- Growing footprint of software-based infrastructure to rapidly deploy

Ongoing work

- More buildings and early users
- More technology partners
- Additional operational strategies
  - Demand flex/demand mgt
  - Automated functional testing



Berkeley Lab is excited to continue bringing these capabilities to our nation's buildings.

Building owners: Please contact us to learn more about how to acquire and use these technologies.

Software providers: Please contact us for assistance to incorporate these open-source corrective solutions into your products, and to extend the current library.

JGranderson@lbl.gov
https://transformingbuildingcontrols.lbl.gov

THANK YOU