ENVELOPE

Decarbonization and Optimization through Cloud-Based Data Harvesting

Presented by: Peter Wolff

Harvesting – From Old to New. From Micro to Macro

Residential Applications and features – Job to be done

Analog

$ vs $$$

- Furnace + AC | E-Heat | Heat Pump
- Hardwired to Equipment
- Sense Temp
- Run Equipment

Digital

- Furnace + AC | E-Heat | Heat Pump
- Hardwired to Equipment
- Sense Temp | Motion
- Run Equipment

Residential Applications value creation at-a-glance

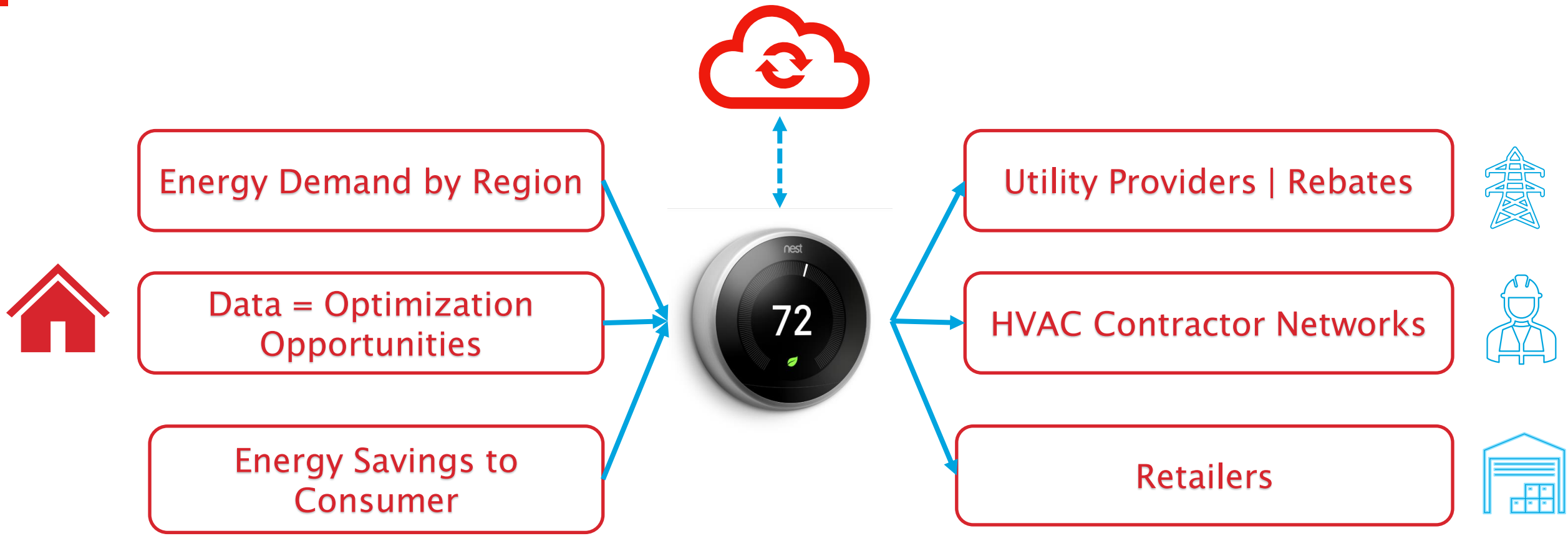
Analog

- No records of previous operation
- On / Off Proportional Control
- Completely Disconnected
- Energy assesed via utility bill

Digital

- Data Logs upload to Cloud
- Learns and adapts comfort using sensors
- Enhanced UX + Mobile UX + Connected
- Analytics | Energy optimization+ Savings

Value of Data to extend Ecosystem



Connects Consumers with Providers through data ←→ Win –Win - Win

Ecosystem Scope Expansion beyond HVAC | Open Connectivity

Why are Smart buildings lagging the Smart home movement?

Serial Network Architectures

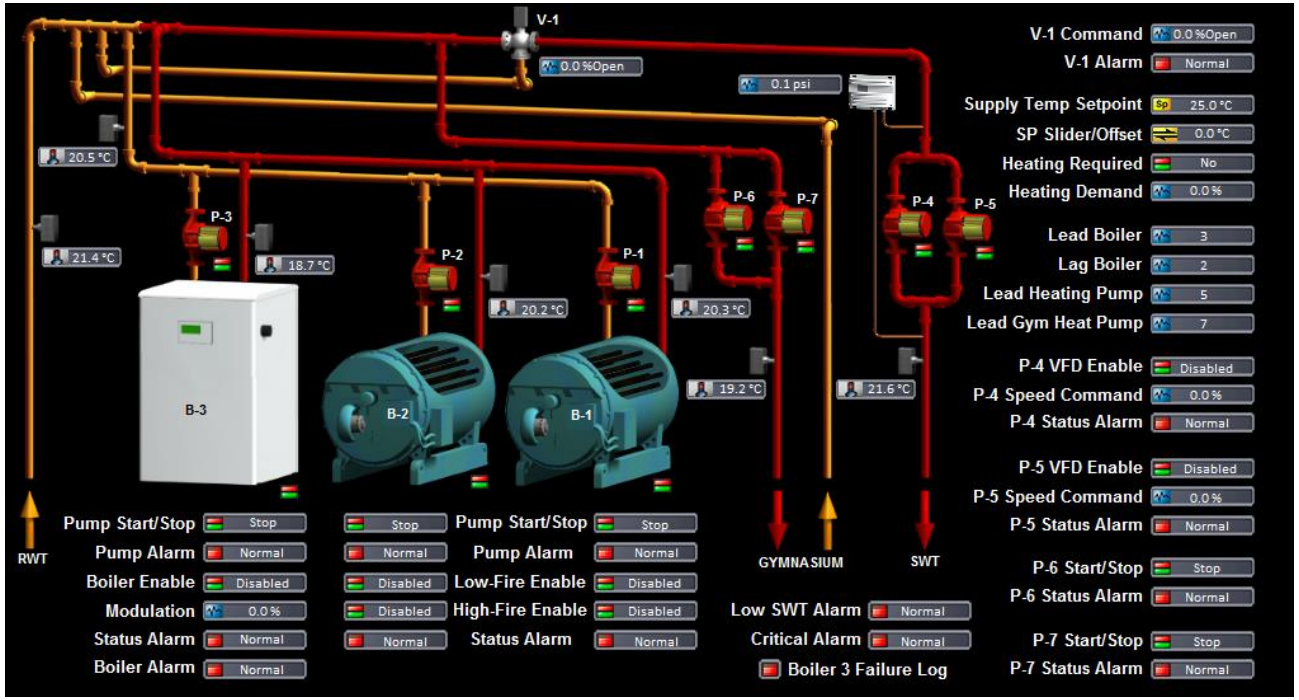
Traditional Set point control
Lacking systems modeling

Slow Adoption of
IoT Tech | Cloud Computing

Proprietary SW | HW
Separate Lifecycle HW and SW

Hardware-Independent
Engineering

How about the Building Automations System (BAS) data?



Typically used as an information dashboard and very often offers reactive response

Who wants to use the BAS Data ?

BRAINBOX AI

SkyFoundry

Optimum Insights

CopperTree Analytics

HaiLin Controls

ECOENERGY INSIGHTS

ATRIUS

BuildPulse

NERVA ENERGY

Google

GridPoint

THTF

How about the market incumbents?

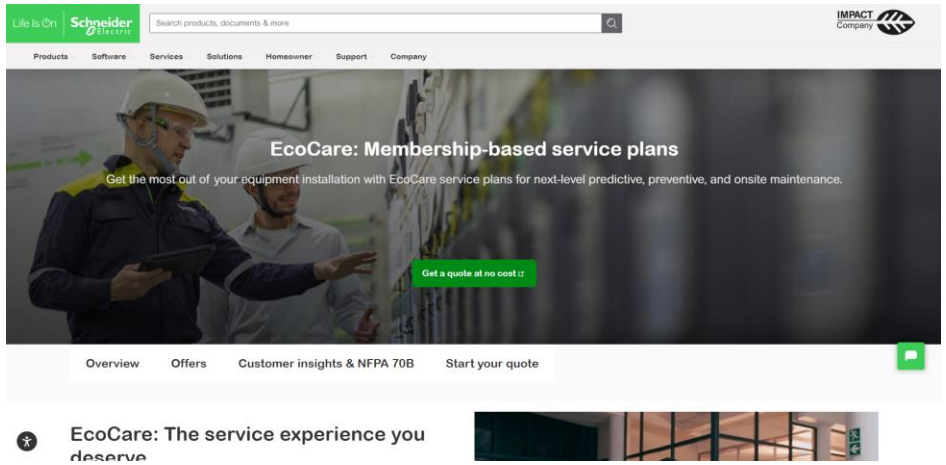
HONEYWELL FORGE

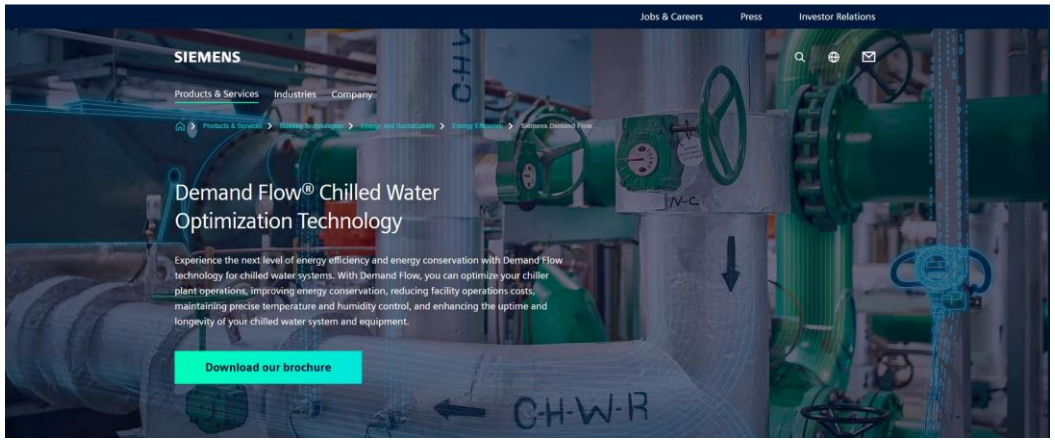
OpenBlue

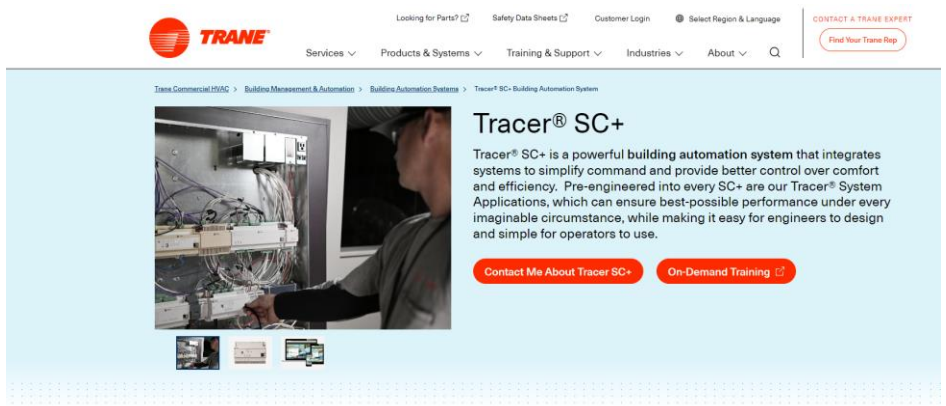
ABOUND

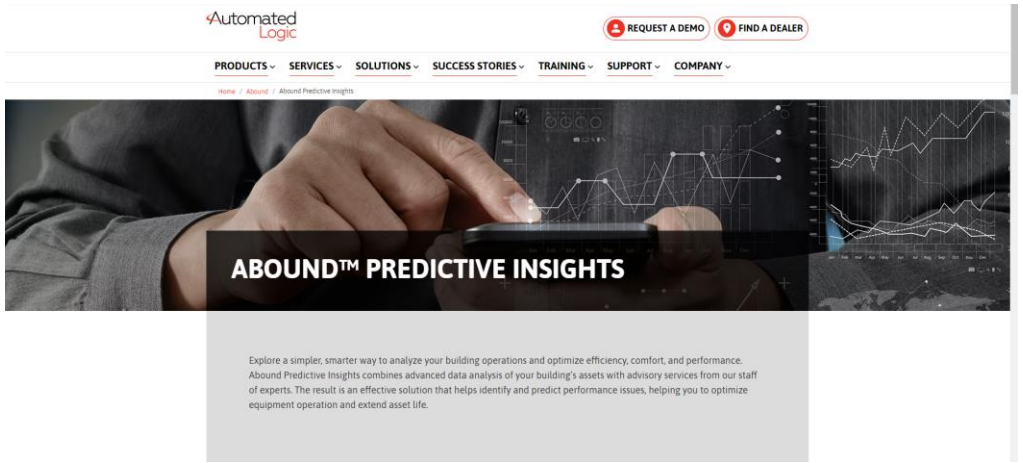
SIEMENS

BAS Companies Edging into Cloud Analytics









Why everyone is after the Building Data where is the opportunity?

1 Identify RCx Opportunity

2 Energy Analytics

3 Energy Upgrade

Opportunities in retrofit and renovation of existing buildings

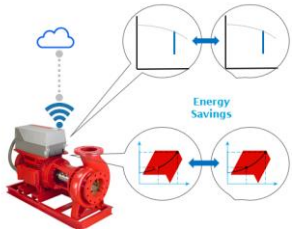
Addressing commercial typology trends, organizational commitments, levers of transformation and decarbonization technologies, the report covers a lot of ground. The section "Retrofit and Renovation" discusses how making our existing building stock greener and more energy-efficient will help us reach climate goals:

> "Retro-commissioning (RCx) is a valuable tool for identifying and maximizing potential energy savings. For example, every 1% of retro-commissioning market penetration results in energy savings of almost four billion kBtu, the equivalent of over 830,000 metric tons of CO2 e per year—more than the average of two U.S. natural gas-fired power plants operating for an entire year."

Source: U.S Green Building Council, https://www.usgbc.org/articles/state-decarbonization-report-spotlight-retrofitting

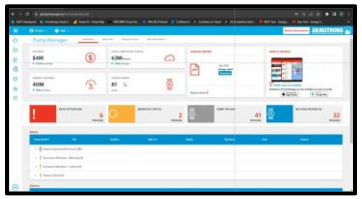
Performance Improvement through connectivity and data analytics

1 Connect



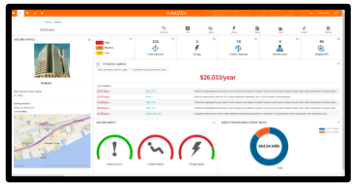
- Connect smart plant equipment to web at startup or at recommissioning
- Upgrade or retrofit older plant to be able to connect

2 Manage



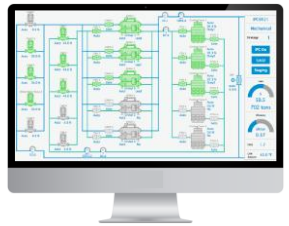
- Proactive performance management meetings to discuss findings
- Process to address issues
- Advise savings being accrued

3 Analyze



- Apply whole plant analytics and AFDD
  - Application of learnings can save full plant energy reduction
  - AFDD can lead to reduction in maintenance costs

4 Optimize



- Full Plant optimization
- ~30% Plant energy reduction
- Energy upgrades can be delivered with confidence

Assets + Smart Services | **Follow ups** | **AFDD + Case for Optimization** | **Enterprise Energy Upgrades**

What is the Size of this opportunity?

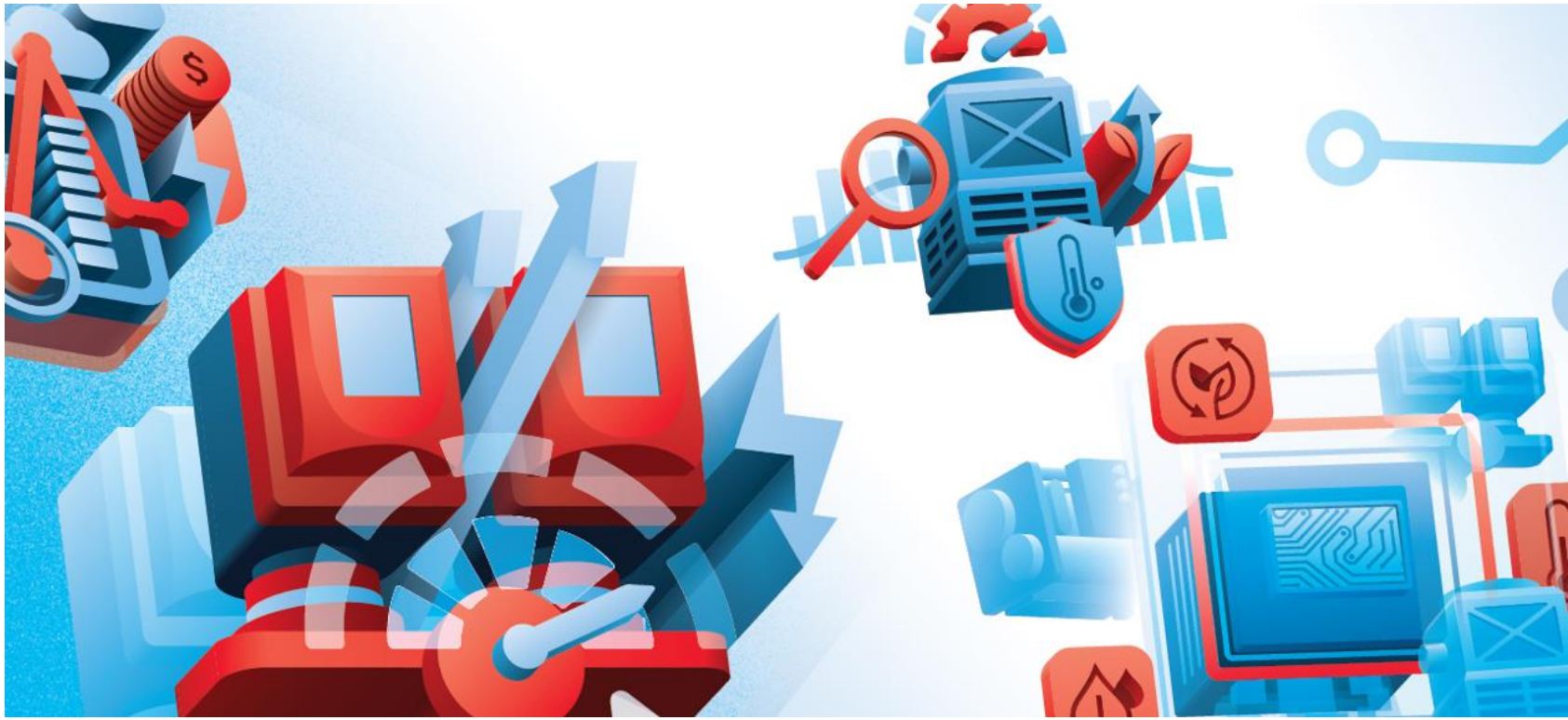
"IRA amendments to the commercial building incentive known as Section 179D update the financial benefits for energy efficiency retrofits to existing buildings," shares the report, explaining that buildings constructed before 1980 that have not been renovated since 2000 make up 37% of the national gross commercial floor area—and 47% of the tax deductions provided under Section 179D are tied to these buildings.

"If all existing commercial buildings in the United States were retrofitted with energy efficiency upgrades in compliance with their respective states' current energy code, $314B of tax deductions could be recognized, resulting in $66B in net total tax savings," estimates the report.

~$300B+

Source: U.S Green Building Council, https://www.usgbc.org/articles/state-decarbonization-report-spotlight-retrofitting

Research Results on Analyzing Data to Deliver Persistent High Efficiency



ASHRAE Journal Article December 2019 on Persistence – Its Findings

Commissioning and retro-commissioning (RCx) are critical steps to ensure that a building performs at its best. But commissioning and RCx are truly effective only if their impacts last over time, which cannot be taken for granted. We took a deep dive into dozens of RCx projects in Illinois to determine long-term persistence of savings from RCx and what drives that persistence.

BY SARANYA GUNASINGH; SCOTT HACKEL, MEMBER ASHRAE; XIAOHUI ZHOU, PH.D., P.E., MEMBER ASHRAE

ASHRAE Journal Article December 2019 on Persistence – Its Findings

RCx Training. Training site engineering staff to operate and maintain RCx measures is critical to preserve savings from installed measures. Our analysis showed that staff who received training immediately following the RCx process were more knowledgeable about RCx measures and made continuous efforts to preserve energy savings. It is important to incorporate post RCx building operation training as part of the RCx process.

ner
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e.g.,

water) would be good candidates for this approach.

Major Retrofits. When significant retrofit activity or building additions followed RCx, persistence suffered. After major retrofits, buildings were often zoned differently, had variations in space use or occupancy. All these factors made the building operation deviate from the post-RCx building management plan, causing a loss in RCx savings. Outreach discussions could identify when building retrofit, significant HVAC equipment retrofit, or BAS hardware or software retrofit are occurring.

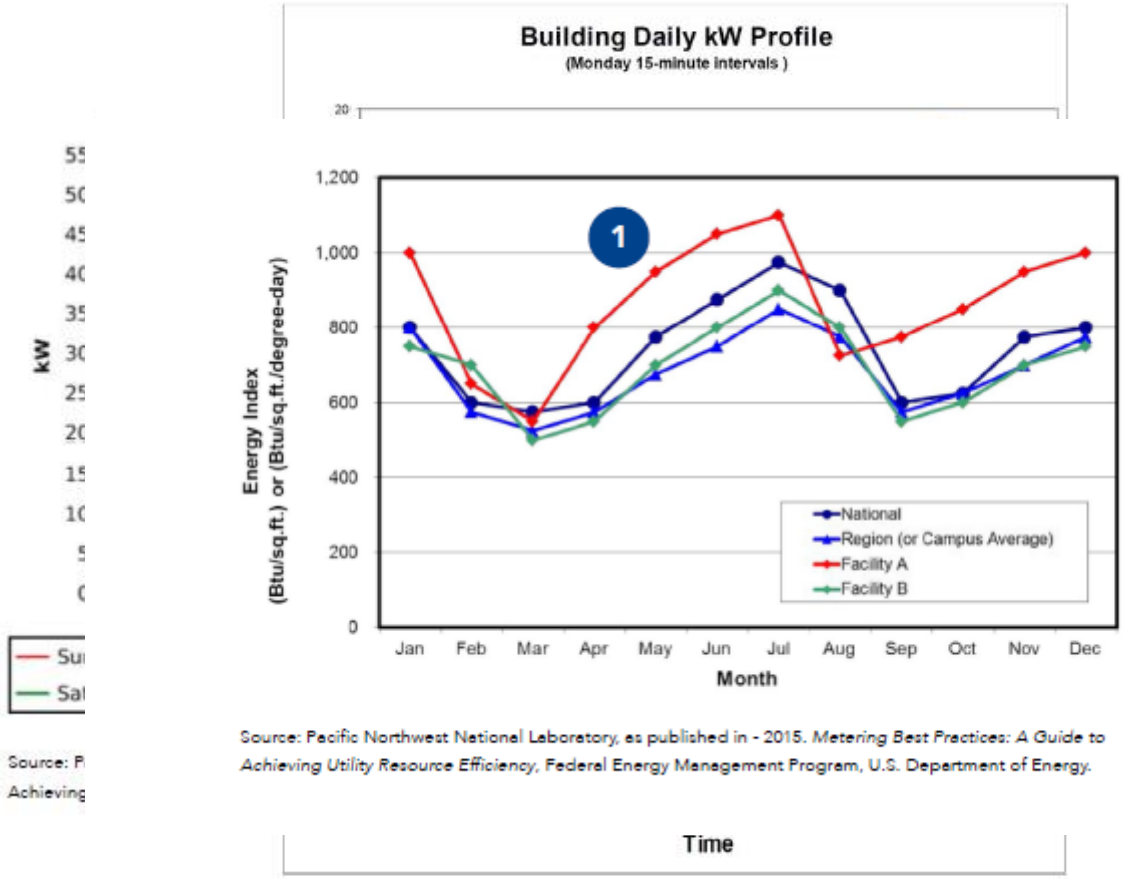
Beyond BAS – Energy Management Information Systems (EMIS)

Better Buildings®
U.S. DEPARTMENT OF ENERGY

Using EMIS to Identify Top Opportunities for Commercial Building Efficiency

MAY 2017

U.S. DEPARTMENT OF ENERGY



Source: Pacific Northwest National Laboratory, as published in - 2015. *Metering Best Practices: A Guide to Achieving Utility Resource Efficiency*, Federal Energy Management Program, U.S. Department of Energy.

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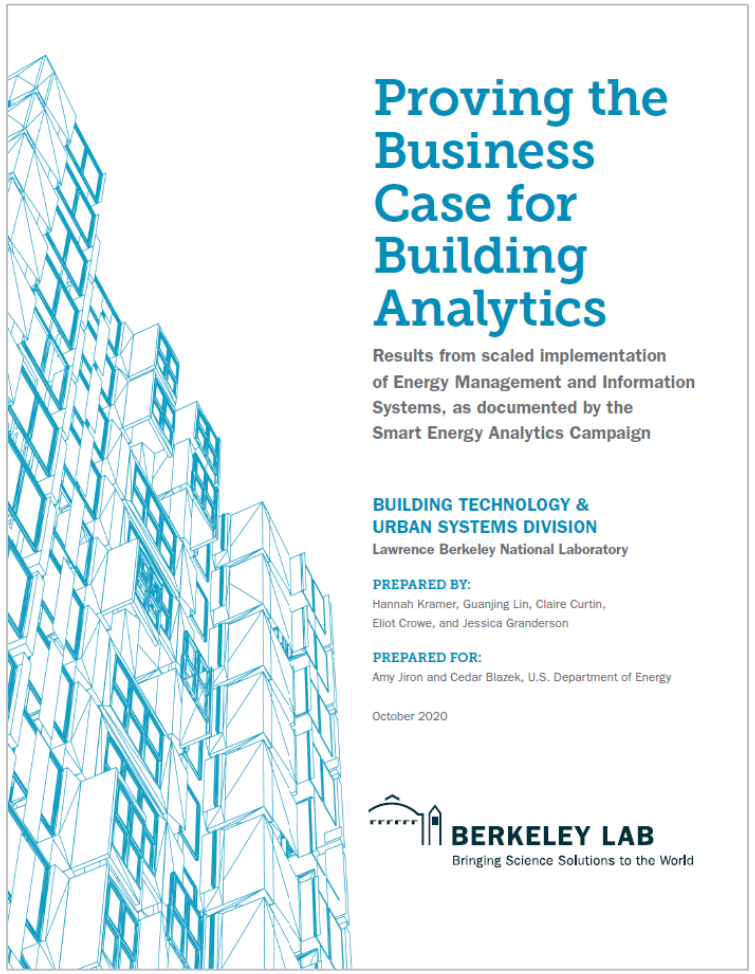
Jessica Granderson, Guangjng Lin, Rupam Singla, Lawrence Berkeley National Laboratory 2017

Beyond BAS – Fault Detection and Diagnostics (FDD)



SECTION 5:

A Maturing Market for Analytics

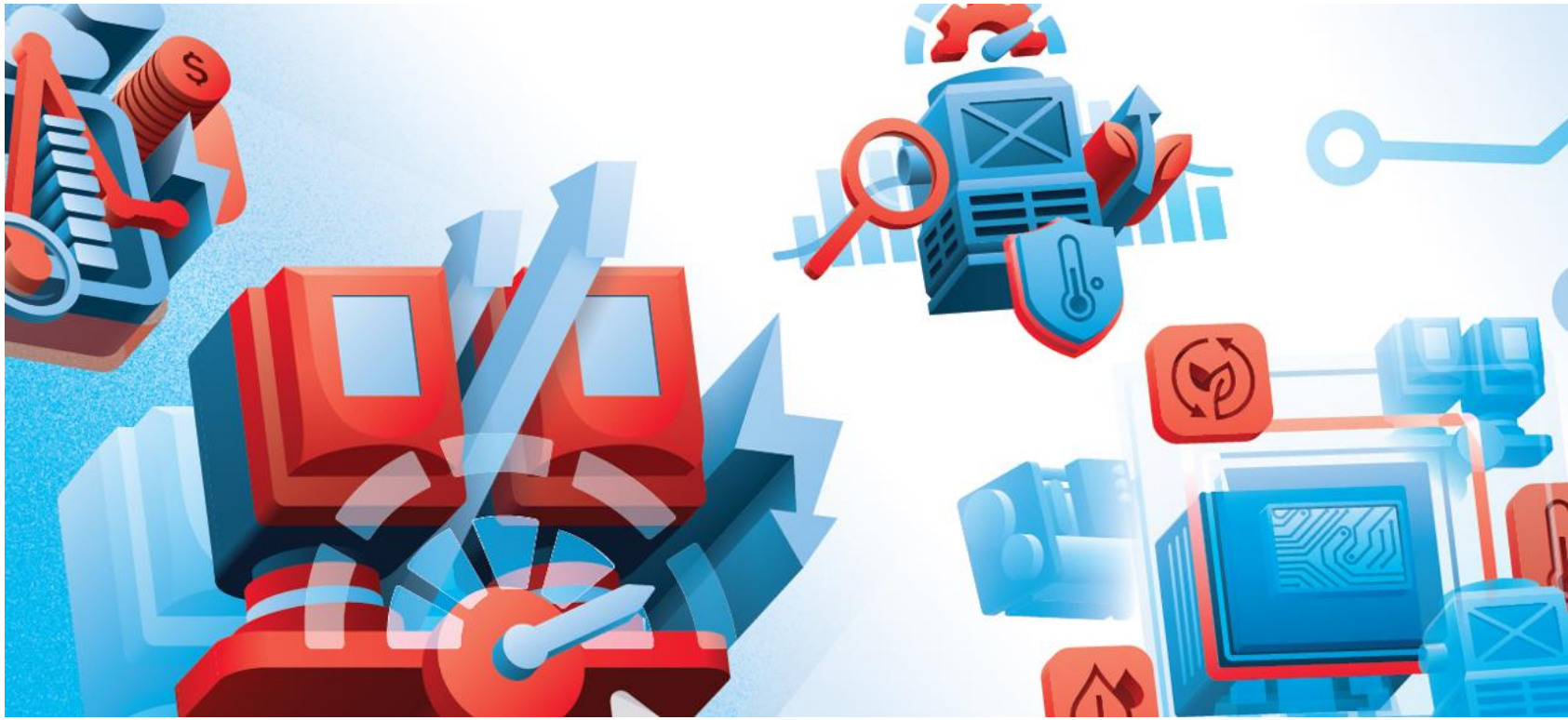
HIGHLIGHTS:

- **Smart Energy Analytics Campaign data reinforces and enhances prior research on EMIS benefits**
- **EIS and FDD offer complementary capabilities when deployed in parallel**
- **Organizations with FDD achieved greater savings than EIS but at a greater cost; overall both EIS and FDD showed a two-year simple payback**

Proving the Business Case for Building Analytics Hannah Kramer, Claire Curtin, Eliot Crowe and Jessica Granderson. Lawrence Berkeley National Laboratory October 2020

What route would you like to take?

Analytics at Work on Buildings

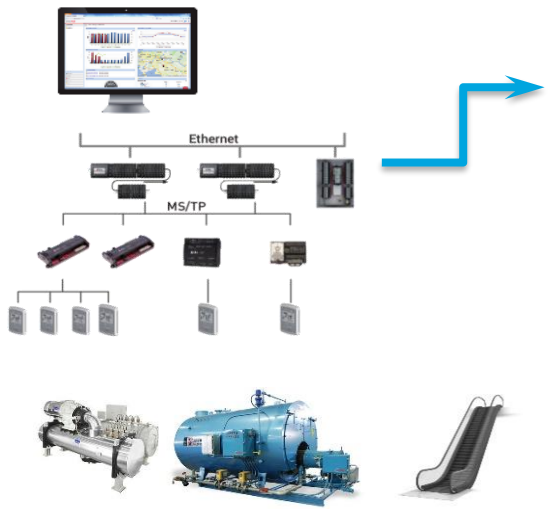


How Does It Work?

Weather Data

Onsite device acquires and prepares data for delivery

Existing Metering & HVAC Control System



Edge Device

Cloud server analyzes the data & gives access to analytics, charts and reports.

Notifications are delivered via the web and mobile

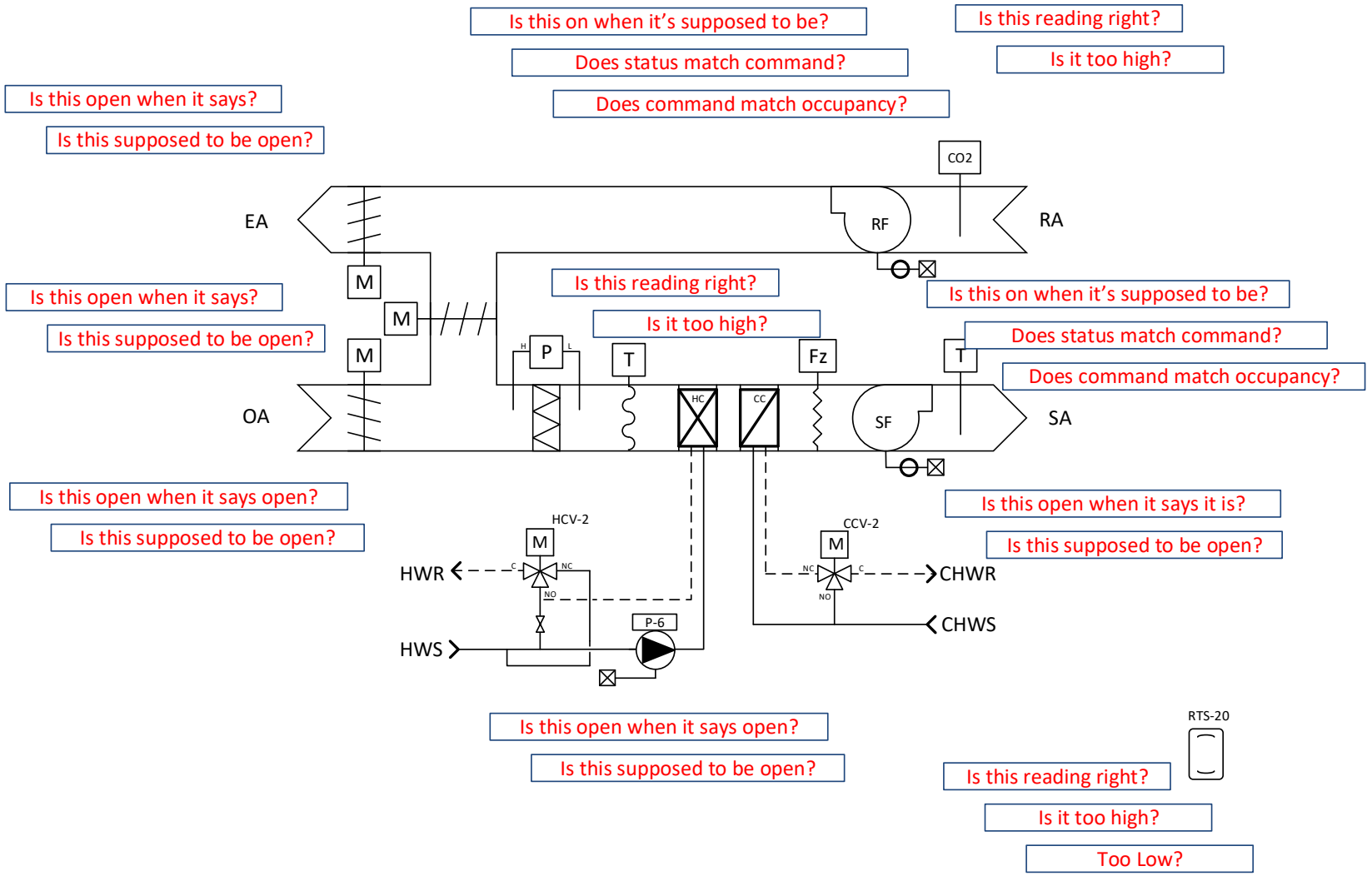
HVAC Zone, Plant & Auxiliary Equip.

Analytics Server

Alerts & Reports

Mobile & PC

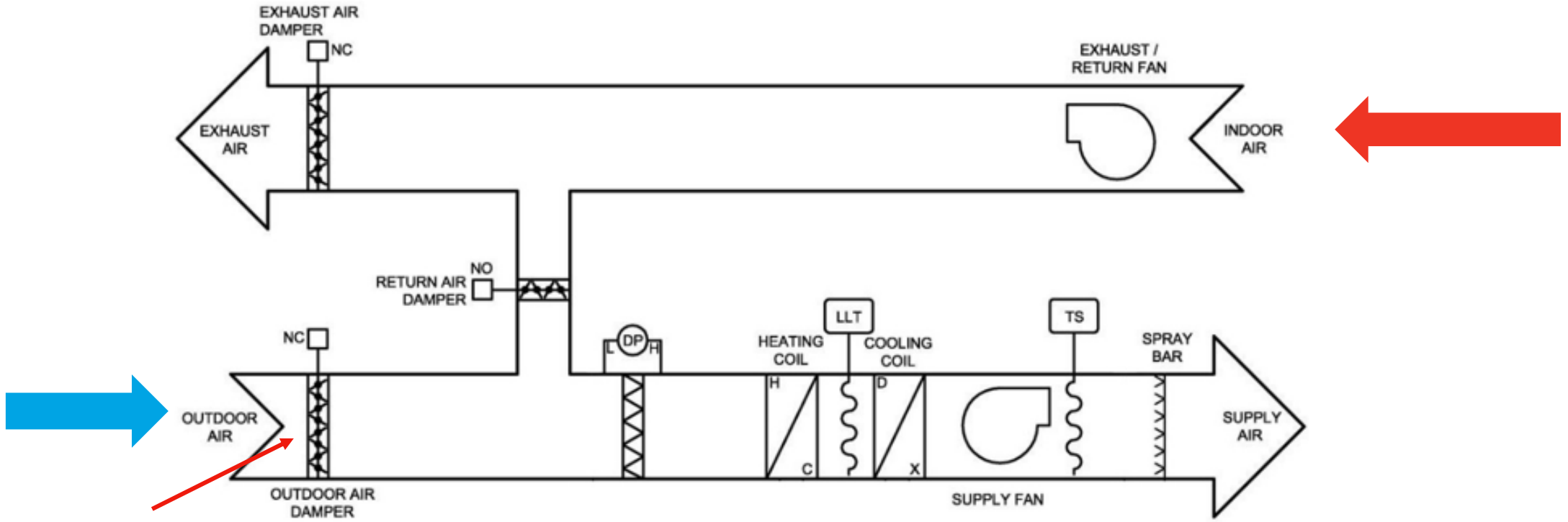
AHU with Fault Detection and Diagnostics (FDD) Applied (1)



Data Collection and Analysis of an Air Handling Unit (2)

Harvesting Airside Data from a Single Dataset to Diagnose AHU Fault (3)

Outside Air Damper is Leaking (mechanical fault)



Leaking Damper!

Unnecessary heating

AHU Fault – Leaking Damper Algorithm (4)

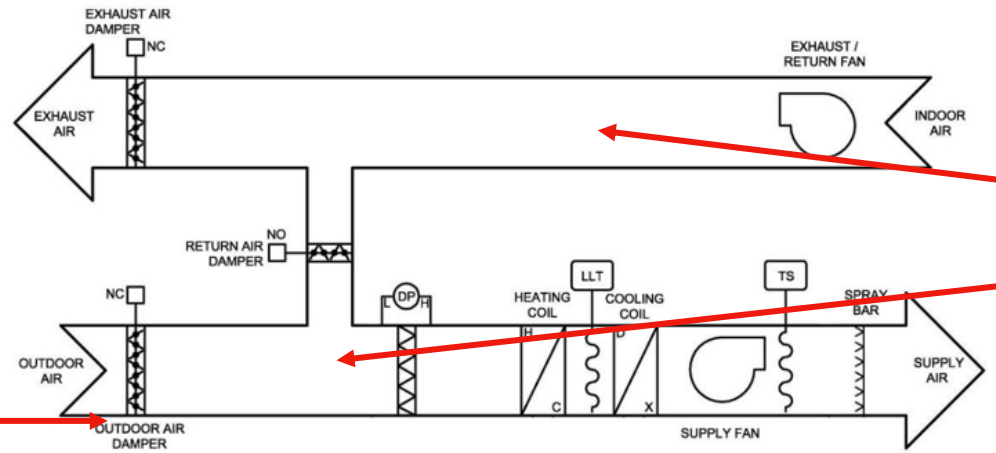
Insight notification triggers only when all these parameters are TRUE:

Outside air damper says that it is closed (0%)

Mixed air and return air temperature sensor delta T > 2 degrees

These conditions have all been true for > 6 total occupied hours in a week

With this algorithm, once a week the data is analyzed and fault reports (if any) sent to interested parties



Delta T >2 degrees?

Damper closed?

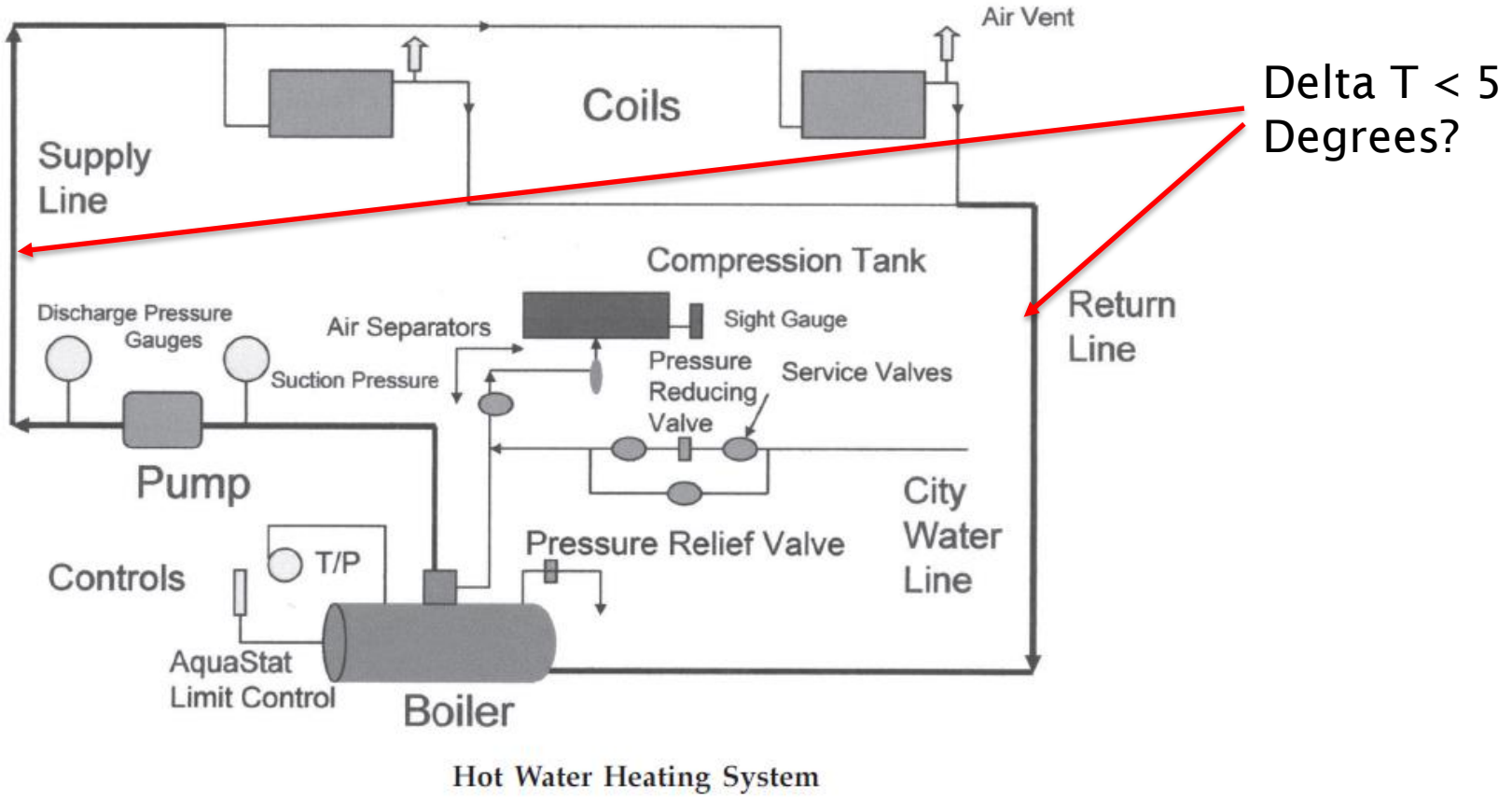
Hot Water Supply – Delta T Algorithm (1)

Insight notification triggers only when all these parameters are TRUE:

Boiler is Enabled

Flow and Return water temperature Delta T < 5 degrees

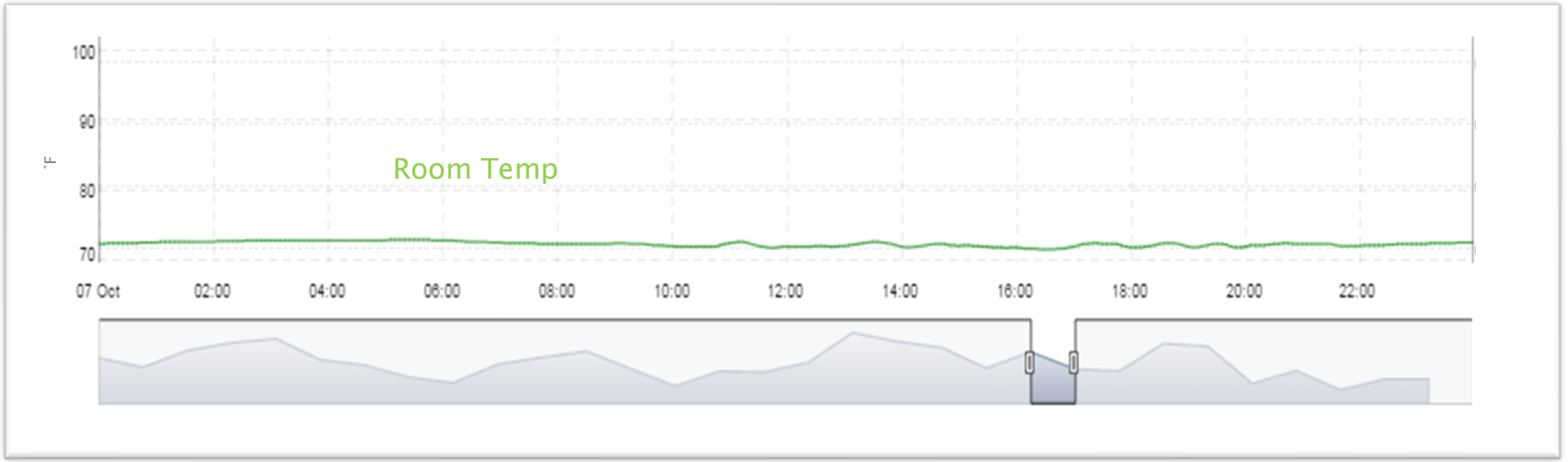
Conditions true for > 8 hours total per week



Hot Water Heating System

The Building Operator's Perspective (2)

Room Temperature Average 15 Minute Trend



BAS is not generating alarms because average temperatures are within range

Occupants complain nonetheless

No evidence of incorrect room temperatures or faulty mechanical equipment

Supply Air Temperature Analysis (3)

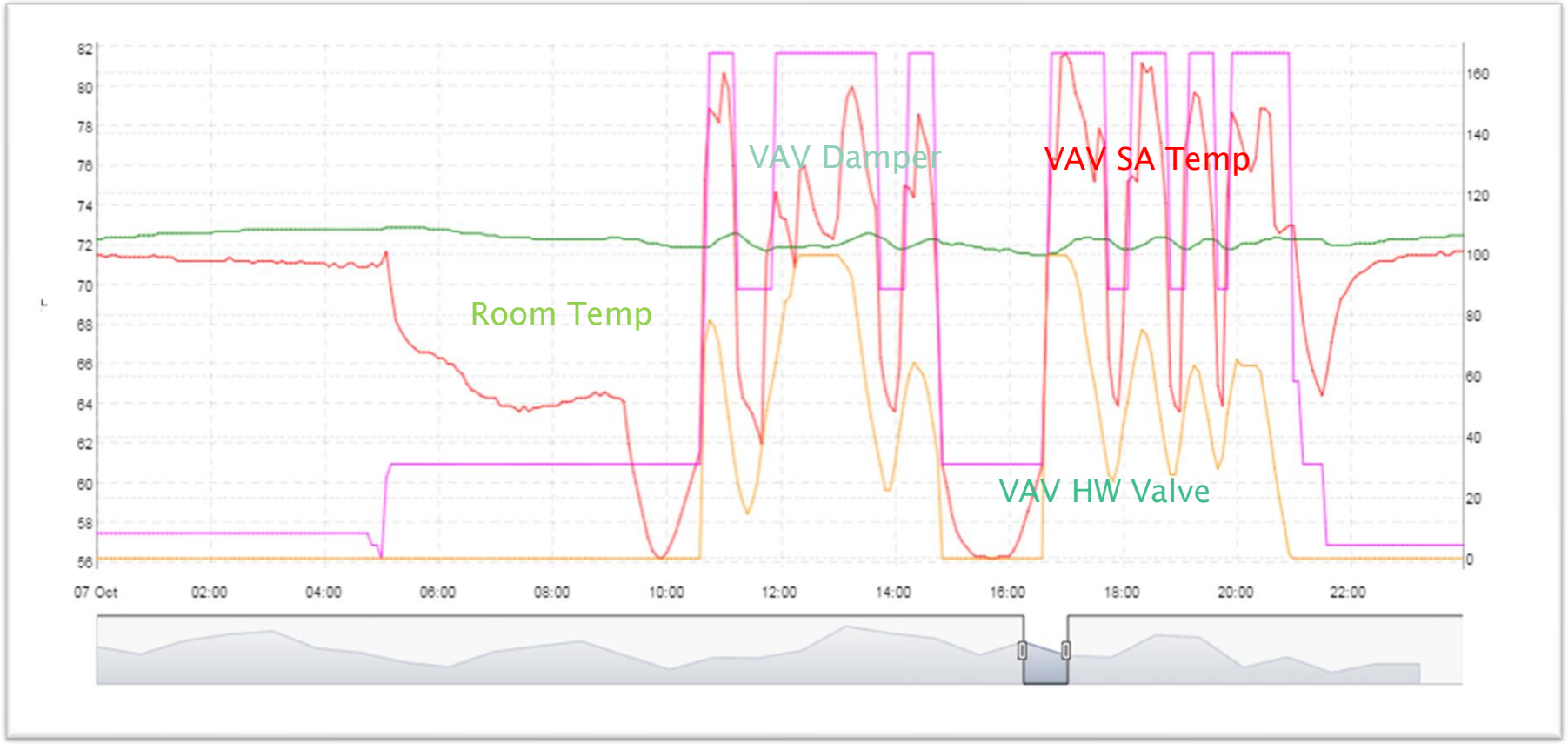
Room Temperature Average 15 Minute Trend

Supply air temperature swinging up to 25 degrees F either way

Occupants sitting close to diffusers would feel this.

However, 15 minute average room temperatures remain in range

Zone System Mechanical Analysis (4)



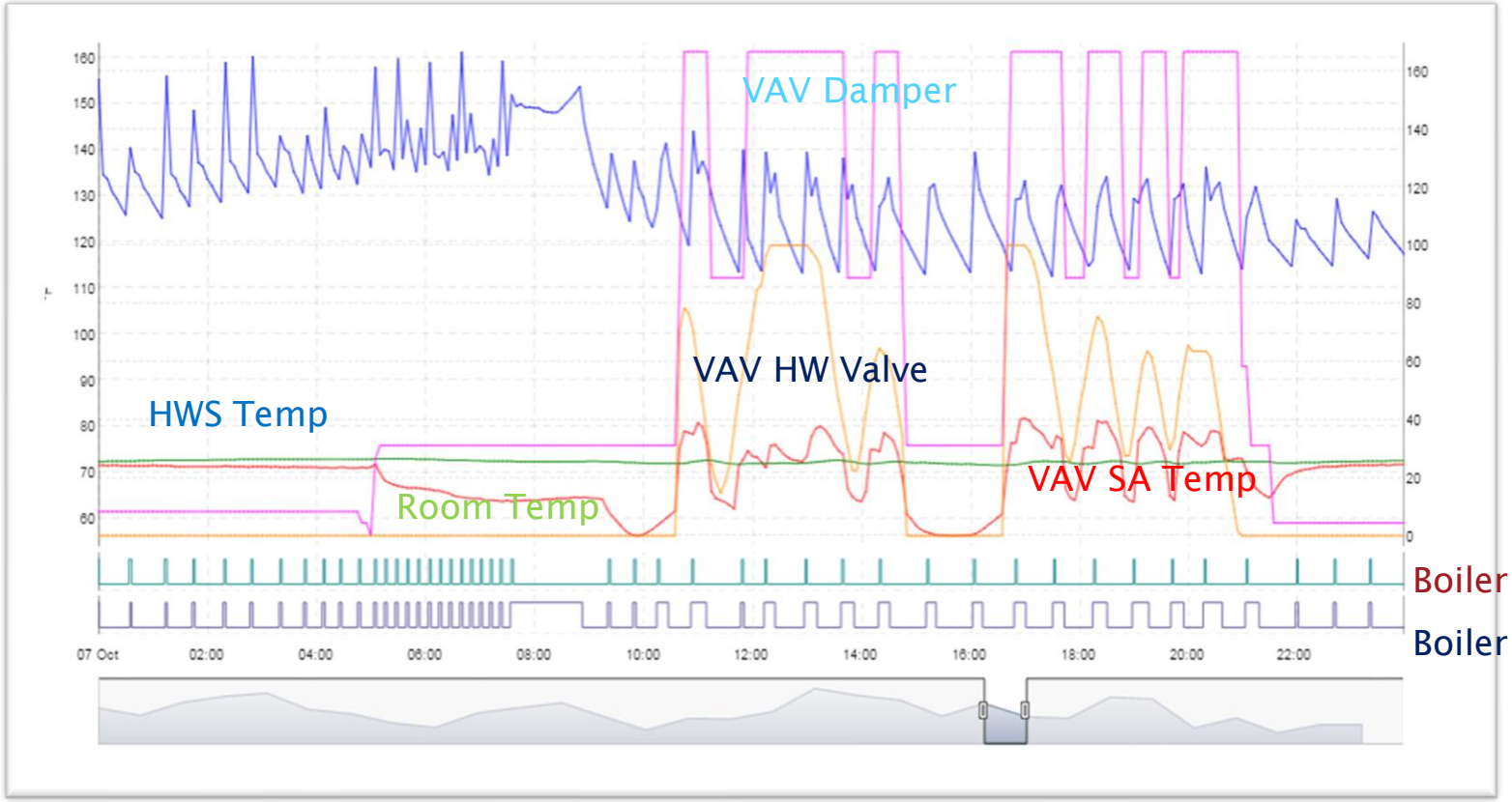
VAV dampers are actuating and hunting wildly

VAV hot water valves are hunting wildly

Leading to excessive wear and tear on these plant items

Harvesting Waterside Data from a Single Dataset to Diagnose Fault (5)

Root Cause: Boiler Sequence Analysis

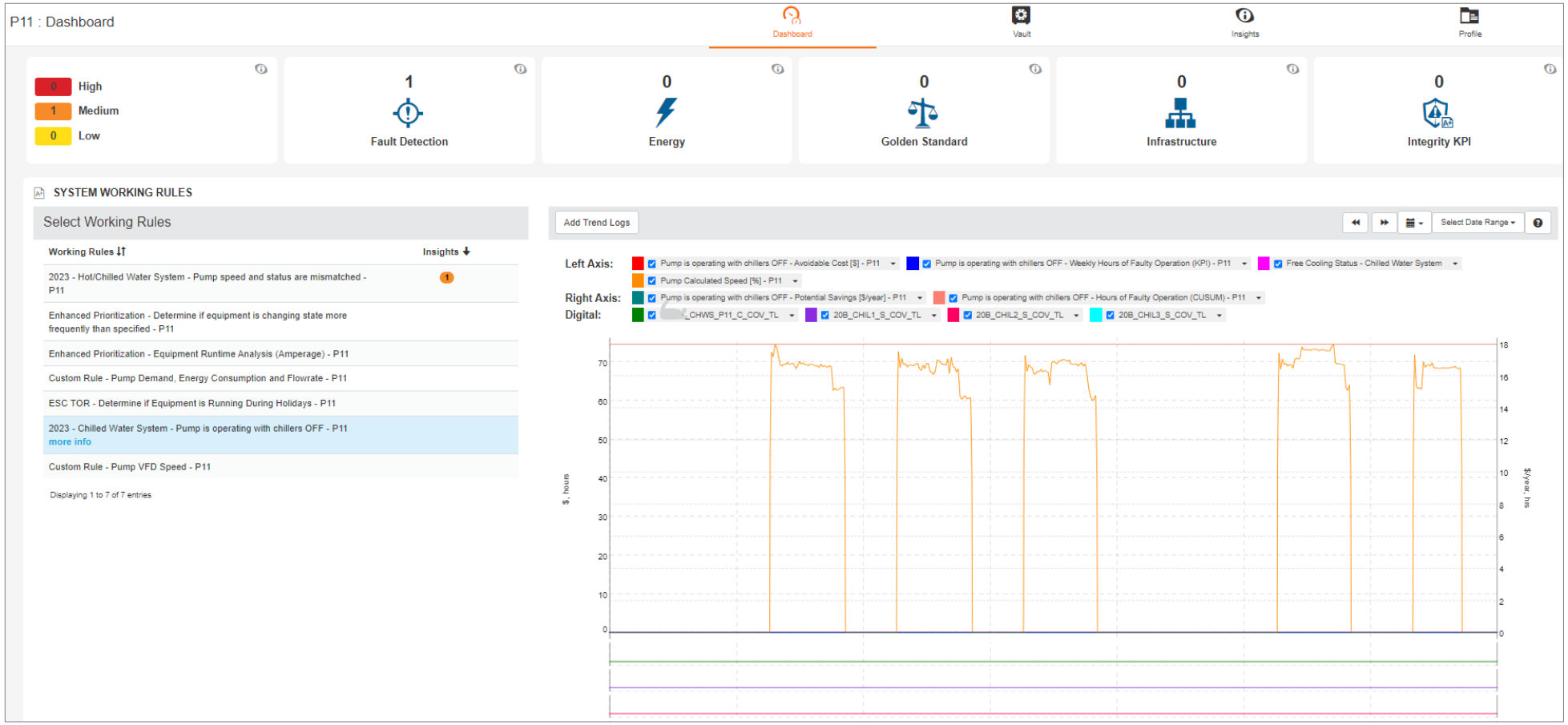


The boilers were designed to be lead/lag sequenced

But the analysis above shows them lead/lead sequenced – both operating together

Overshooting setpoints

A pump related rule – Pumps in operation when chillers are off – wasting money and energy



Other Common Faults That Can Be Highlighted by Analytics

General

- Controls set to “hand” operation => $
- Systems running outside intended schedule
- Control program incorrectly implemented
- Incorrect or inefficiency sequencing

Chilled Water Systems

- Low delta T warning with cost $ implication
- kW/ton CHW plant efficiency (chillers, tower fans, pumps) year on year, by % load=>$
- Excess chiller power consumption, compensating for tower degradation, cumulative, YOY $
- Valves and dampers leaking; hunting and PID tuning issues
- Heat input to building vs OAT and vs WB, normalized by occupant #, year on year, $

How are pumps connected to the cloud

Why is it done?

What does it deliver?

HMI Upgrade

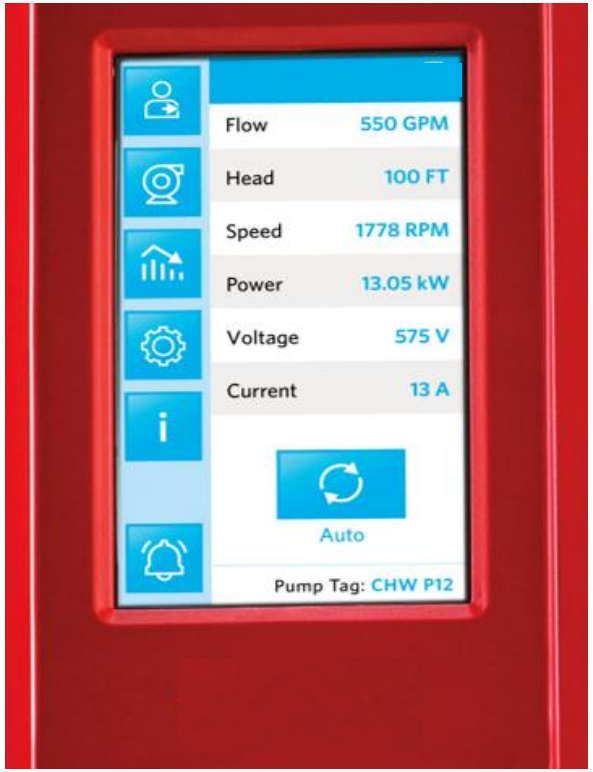
Before

After

Updated Pump Controller – The Headline Benefits

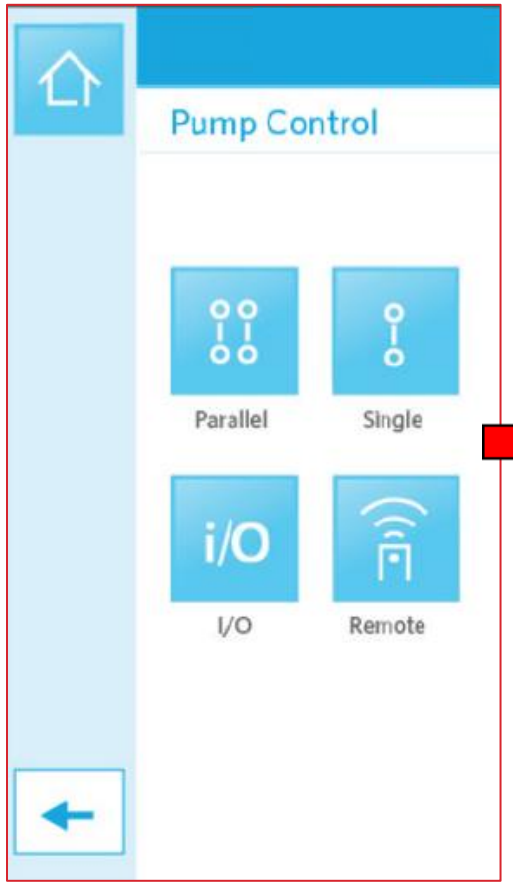
- Expired Warranty
- Push-button monochrome screen
- Complex parameter list
- Flow display? Unlikely
- No maintenance prediction
- No analytics of performance

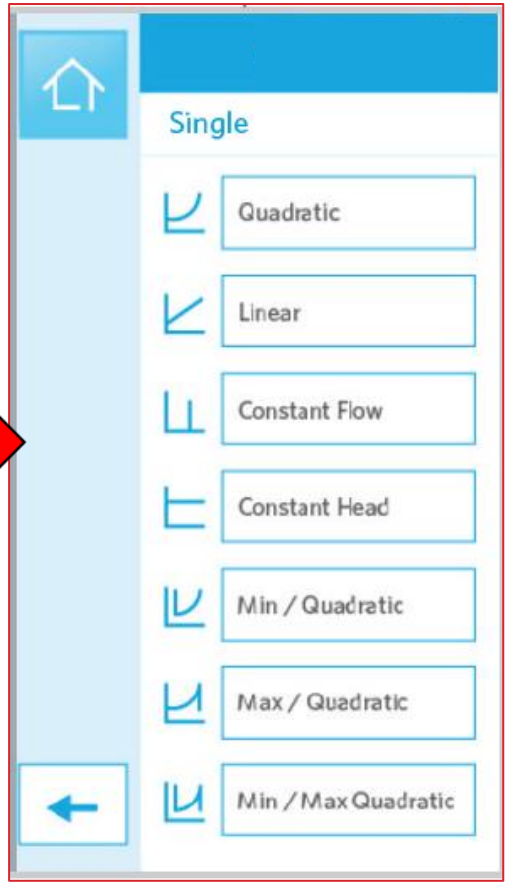
- 12 Month Warranty – Parts and Labour
- Colour touch screen
- Intuitive icon-led adjustment
- Flow rate at top of display
- Early warning of maintenance needs
- In-depth analytics - from cloud manager

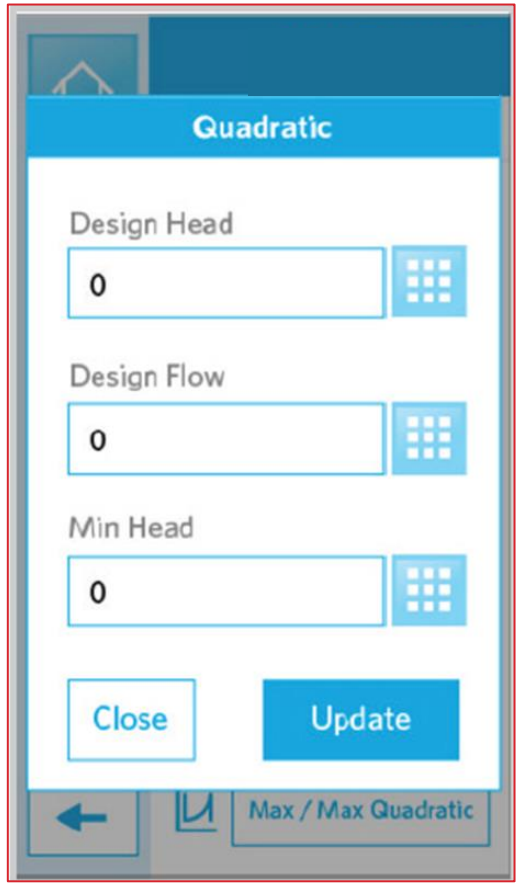


In detail - What a modern pump controller delivers

Simple intuitive set up specific for pumps





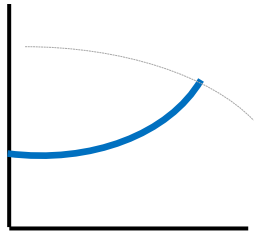


Pump and Valve Control Bundles Included

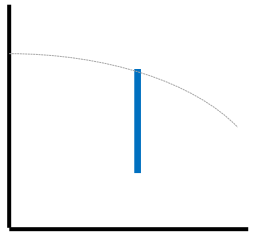
Control Bundles		Functions included
Sensorless Bundle		• Quadratic Pressure Control- Secondary loop • Flow Metering • Constant Flow- typical in Primary and cooling tower loops • Constant Pressure
Parallel Sensorless		• Parallel Sensorless Control (headered piping)
Energy Performance Bundle		• Auto-Flow Balancing • Maximum Flow Control
Protection Bundle		• Minimum Flow Control • System Bypass Valve Control for a Chiller
Dual Season Setup		• Summer Cooling and Winter Heating

Smart Pump Speed Control Capabilities

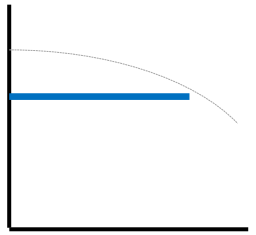
- **Quadratic Pressure Control**
- emulates performance of one remotely mounted DP sensor,
- Friction losses vary to the square of system flow



- **Constant Flow Control** – (Primary, Cooling Tower)
- Maintains pre-set flow rate
- Irrespective of pressure head change
- Great for multiple condenser pumps piped into common header

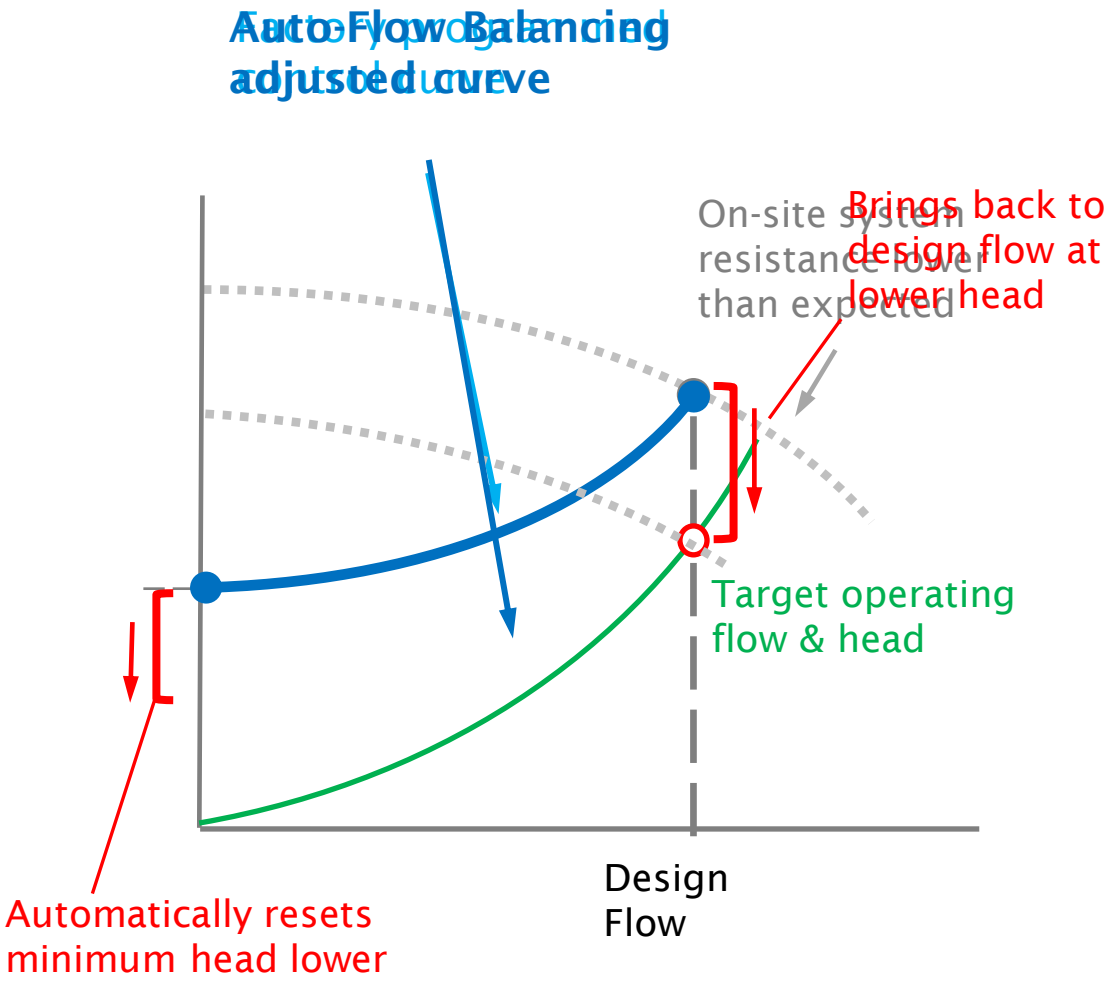


- **Constant Pressure Control**
- Emulates performance of a DP sensor mounted close to the pump
- Varies speed with system flow, maintaining constant pressure



Automatic Final Balancing – Start Delivering Value at Start-Up

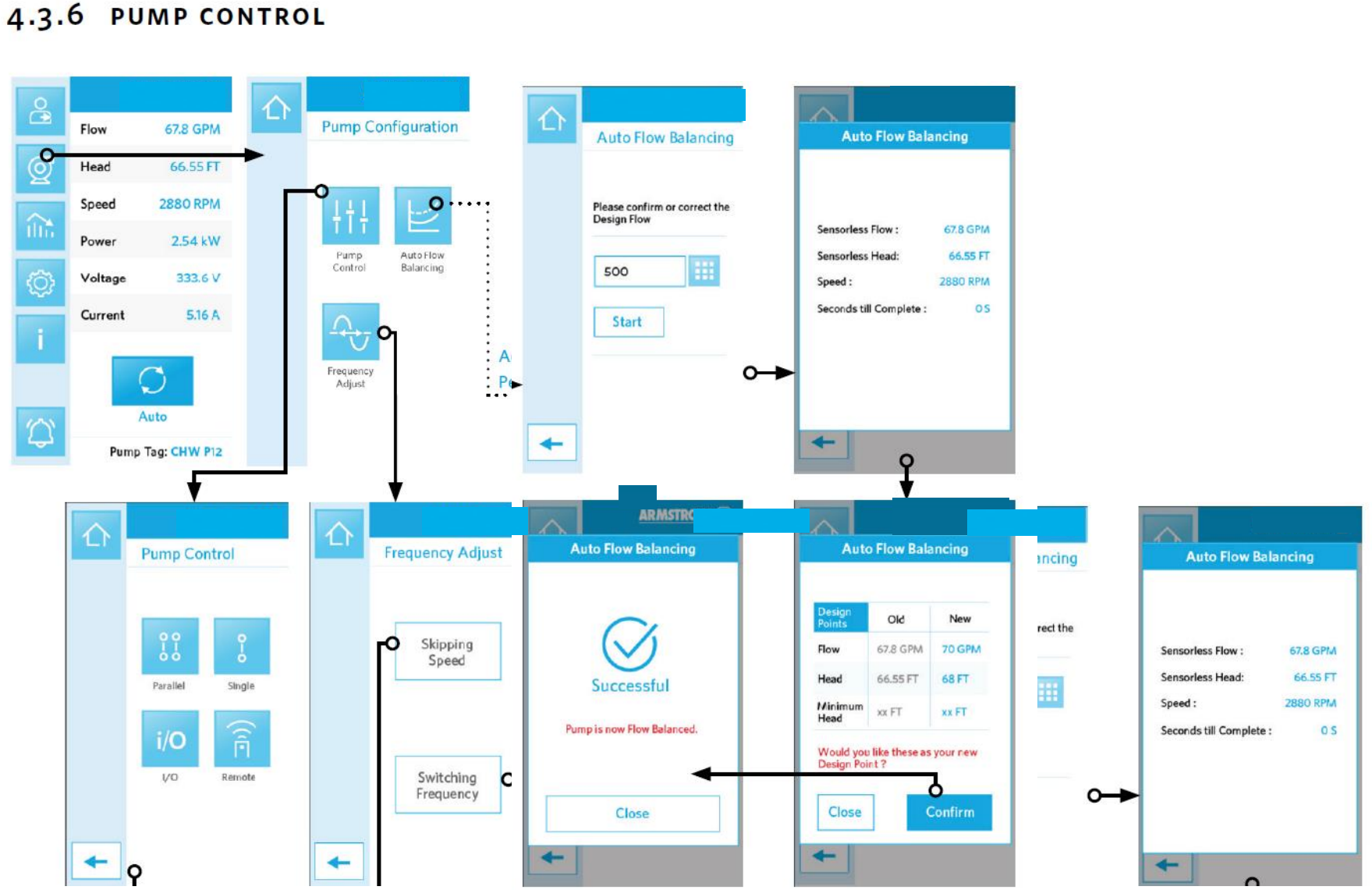
For simplified start-up, push the button



Up to **30%** energy savings

£00's T&B time

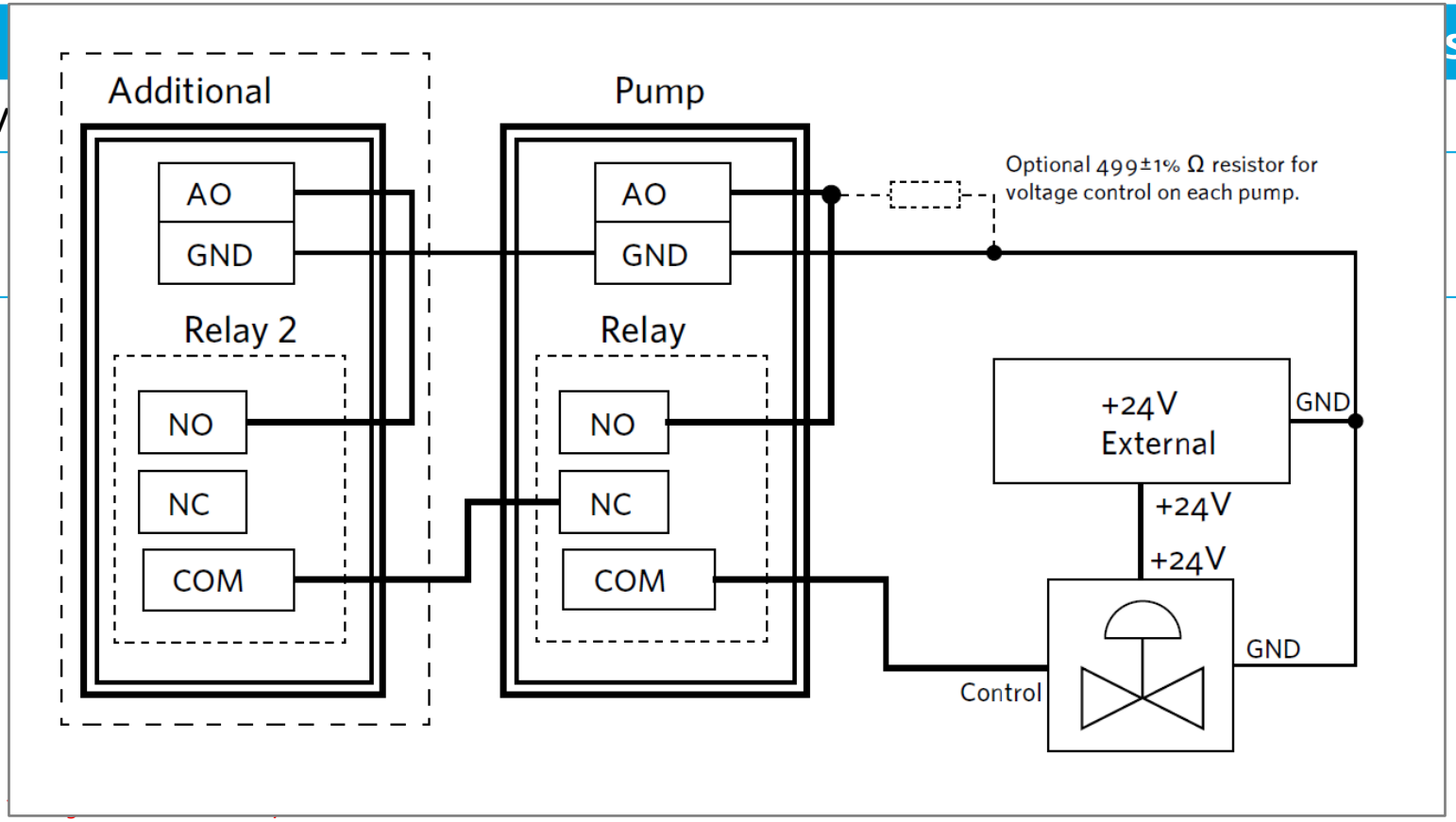
Auto-Flow Final Balancing



Protection Bundle

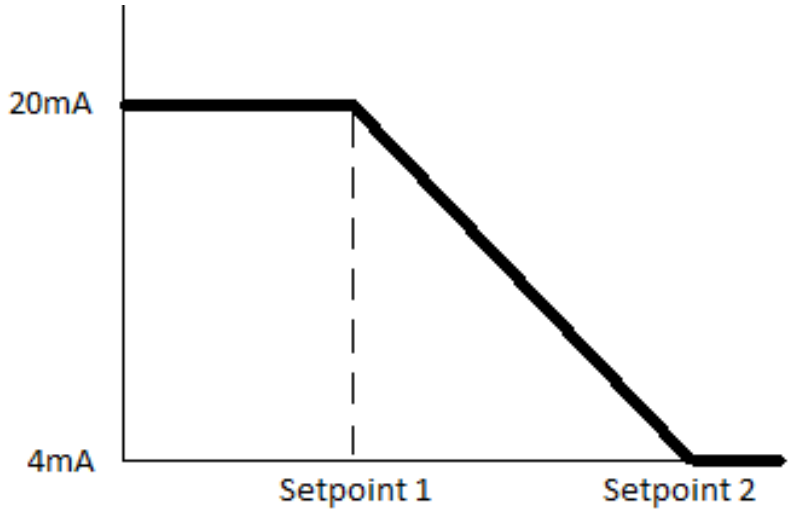
- **Bypass Valve Control** – actuates a bypass valve to protect flow sensitive equipment if pre-set minimum is reached

Function	s
Bypass Valv	



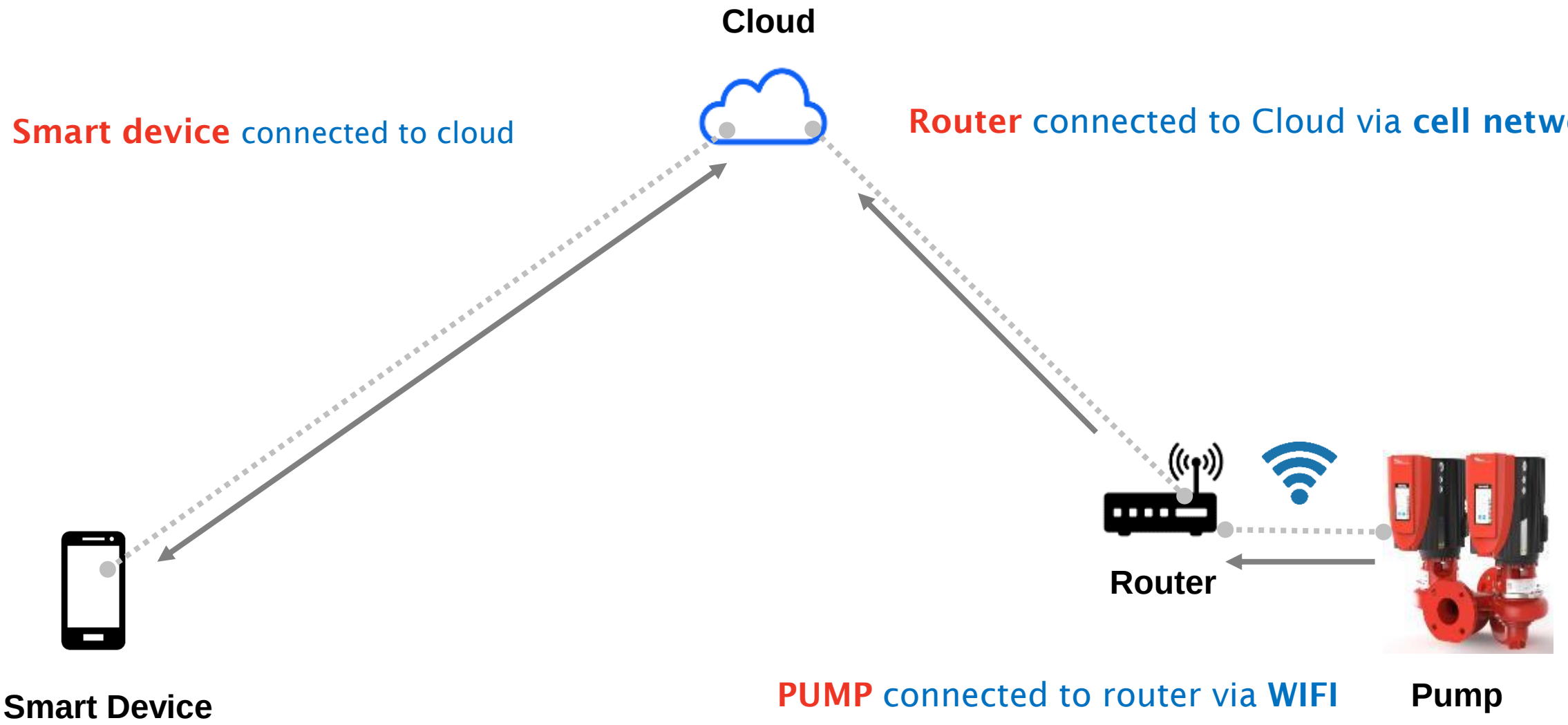
Protection Bundle

- **Minimum Flow Bypass Valve Control**:
  - Modulates the opening and closing of the by-pass valve
  - Valve chosen to have linear characteristic
  - Normally closed
  - 4-20mA

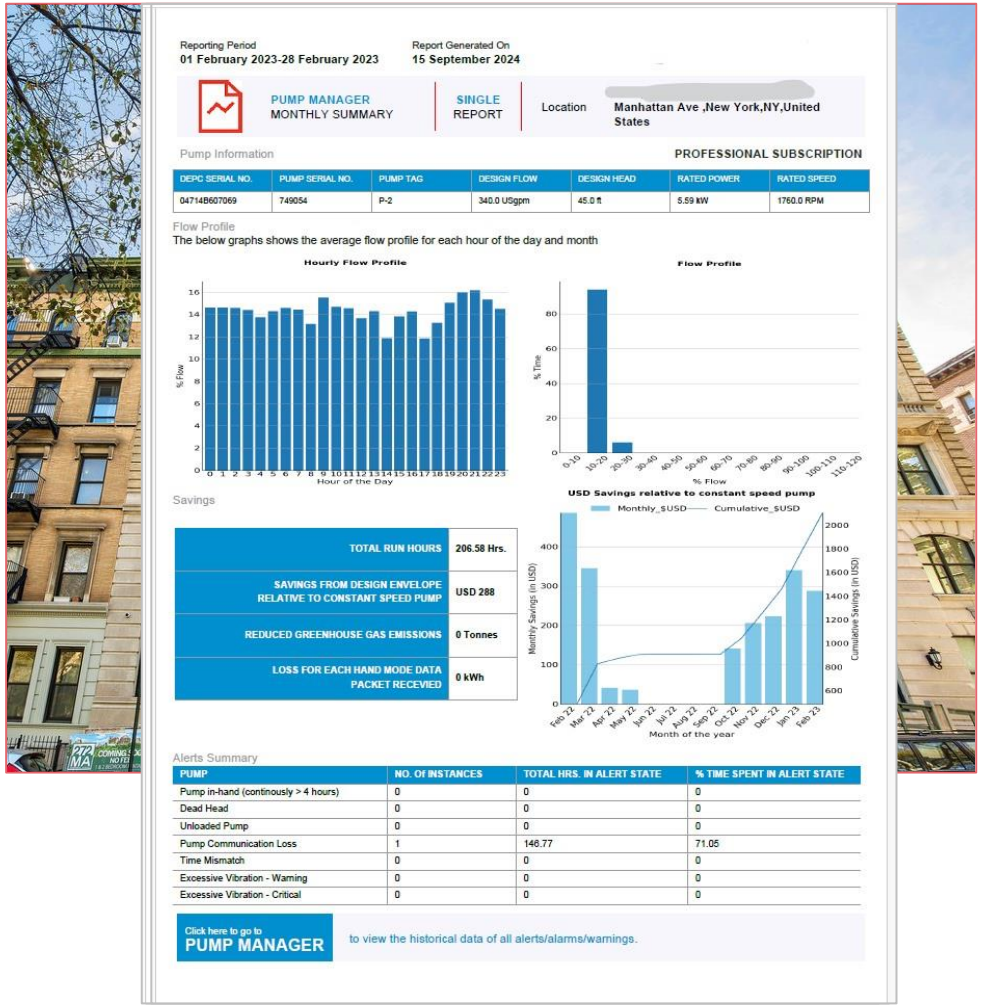


- If flow is less than Setpoint 1, DEPC sends 20mA signal to open valve
- If flow is greater than Setpoint 1, DEPC sends reduced mA to close valve
- Sufficient gap between Setpoint 1 and 2 Flows to prevent excess opening and closing

Connections to Cloud Analytics



Cloud Analytics Stories (1) – Oversized Pumps



Reporting Period
01 February 2023-28 February 2023

Report Generated On
15 September 2024

PUMP MANAGER
MONTHLY SUMMARY

SINGLE
REPORT

Location [redacted] Manhattan Ave ,New York,NY,United States

Pump Information

PROFESSIONAL SUBSCRIPTION

DEPC SERIAL NO.	PUMP SERIAL NO.	PUMP TAG	DESIGN FLOW	DESIGN HEAD	RATED POWER	RATED SPEED
04714B607069	749054	P-2	340.0 USgpm	45.0 ft	5.59 kW	1760.0 RPM

Flow Profile
The below graphs shows the average flow profile for each hour of the day and month

Hourly Flow Profile

Flow Profile

Savings

TOTAL RUN HOURS	206.58 Hrs.
SAVINGS FROM DESIGN ENVELOPE RELATIVE TO CONSTANT SPEED PUMP	USD 288
REDUCED GREENHOUSE GAS EMISSIONS	0 Tonnes
LOSS FOR EACH HAND MODE DATA PACKET RECEIVED	0 kWh

USD Savings relative to constant speed pump

Alerts Summary

PUMP	NO. OF INSTANCES	TOTAL HRS. IN ALERT STATE	% TIME SPENT IN ALERT STATE
Pump in-hand (continously > 4 hours)	0	0	0
Dead Head	0	0	0
Unloaded Pump	0	0	0
Pump Communication Loss	1	146.77	71.05
Time Mismatch	0	0	0
Excessive Vibration - Warning	0	0	0
Excessive Vibration - Critical	0	0	0

Click here to go to PUMP MANAGER to view the historical data of all alerts/alarms/warnings.

Project: Residential Building, Manhattan, US

- Building renovated and **new controller retro-fitted**
- Cloud analytics reported in 2021 pumps were operating in hand
- In 2022 cloud analytics was sending owner dead-heading alarms
- Reports for the same month over 3 years were reviewed
- Insights from the reports revealed over sized boiler and pump
- Customer declares to make detailed design reviews for future projects – to reduce Capex and Opex

Cloud Analytics Stories (2) – N/C By-Pass Valve Left Open

CDSB 2021-22 Budget

June 22, 2021

During the 2020-21 school year, the Board will undertake several facility renewal projects, which are designed to create a safe and more comfortable learning environment for our students and staff. Administration and the Board of Trustees will be reviewing the needs of the system and identifying specific projects for the coming year.

From time-to-time, schools may require portables or portapacks to alleviate enrolment pressures. Portables and portapacks are typically funded using the Board's temporary accommodations allocation and from time-to-time accumulated surplus, where necessary.

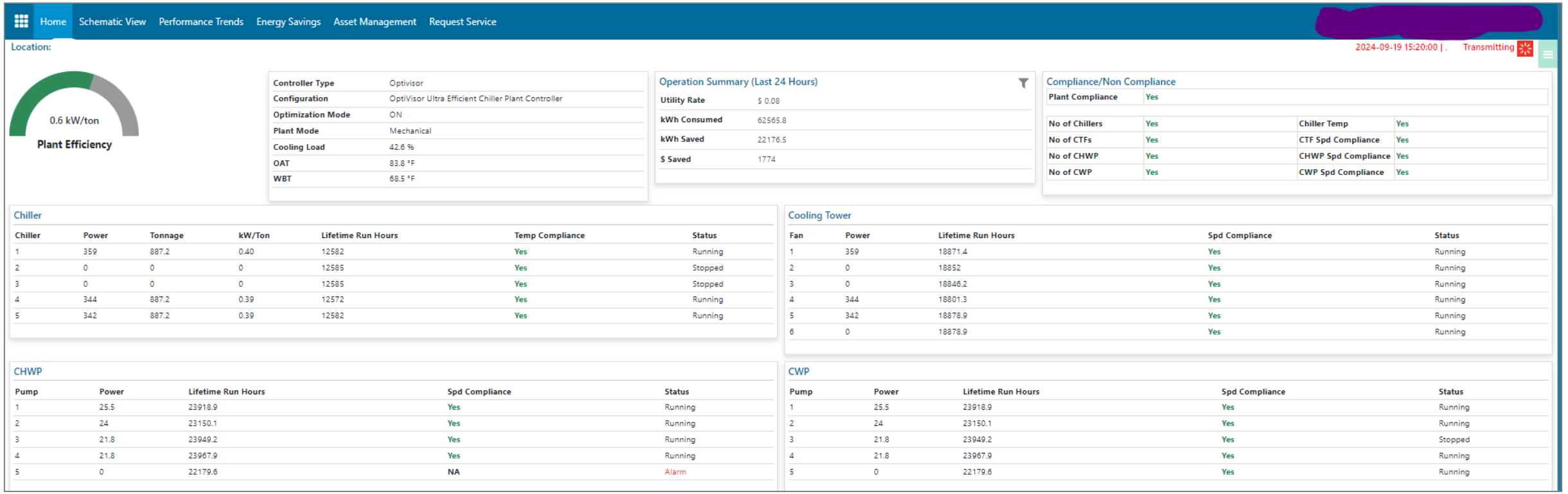
HVAC Upgrade

How is optimized chilled water plant connected to the cloud?

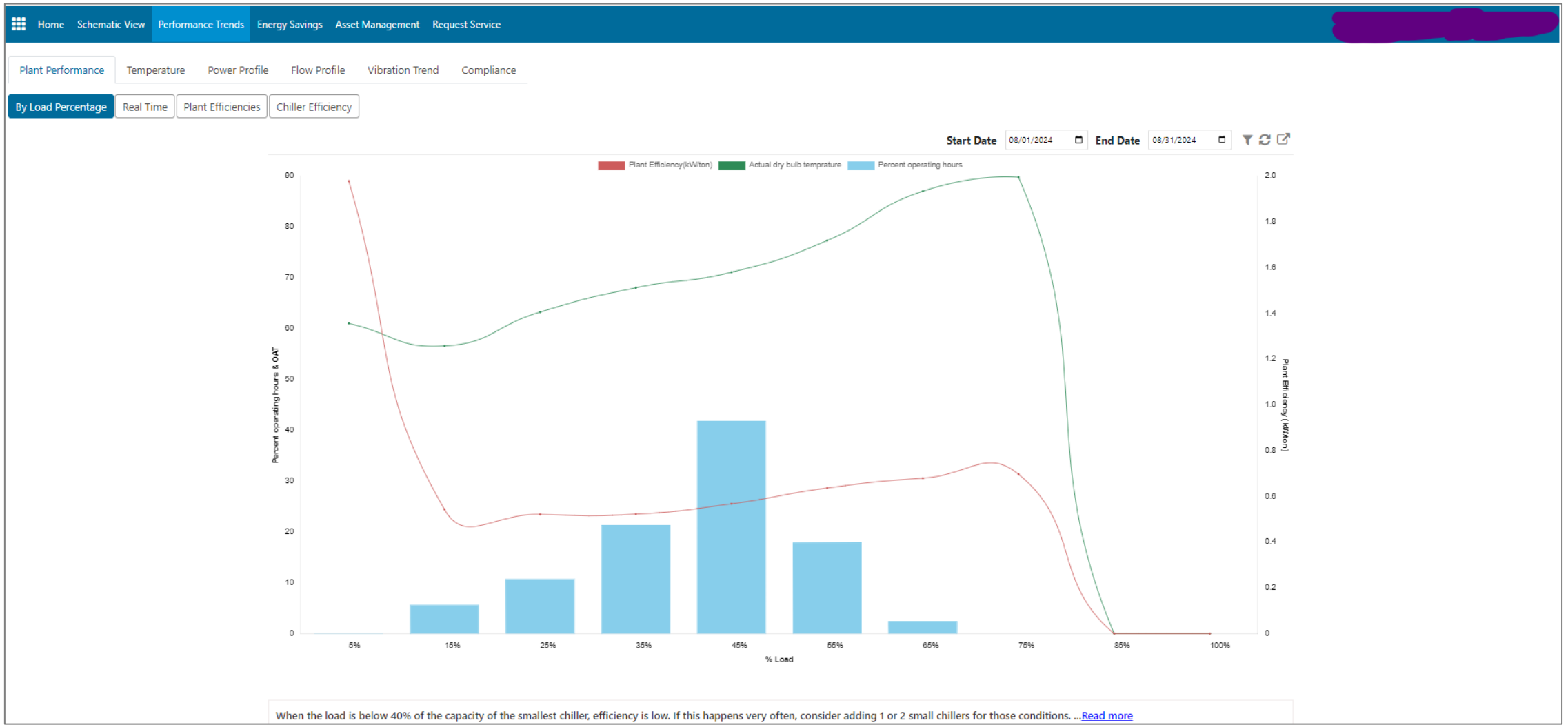
Why is it done?

What does it deliver?

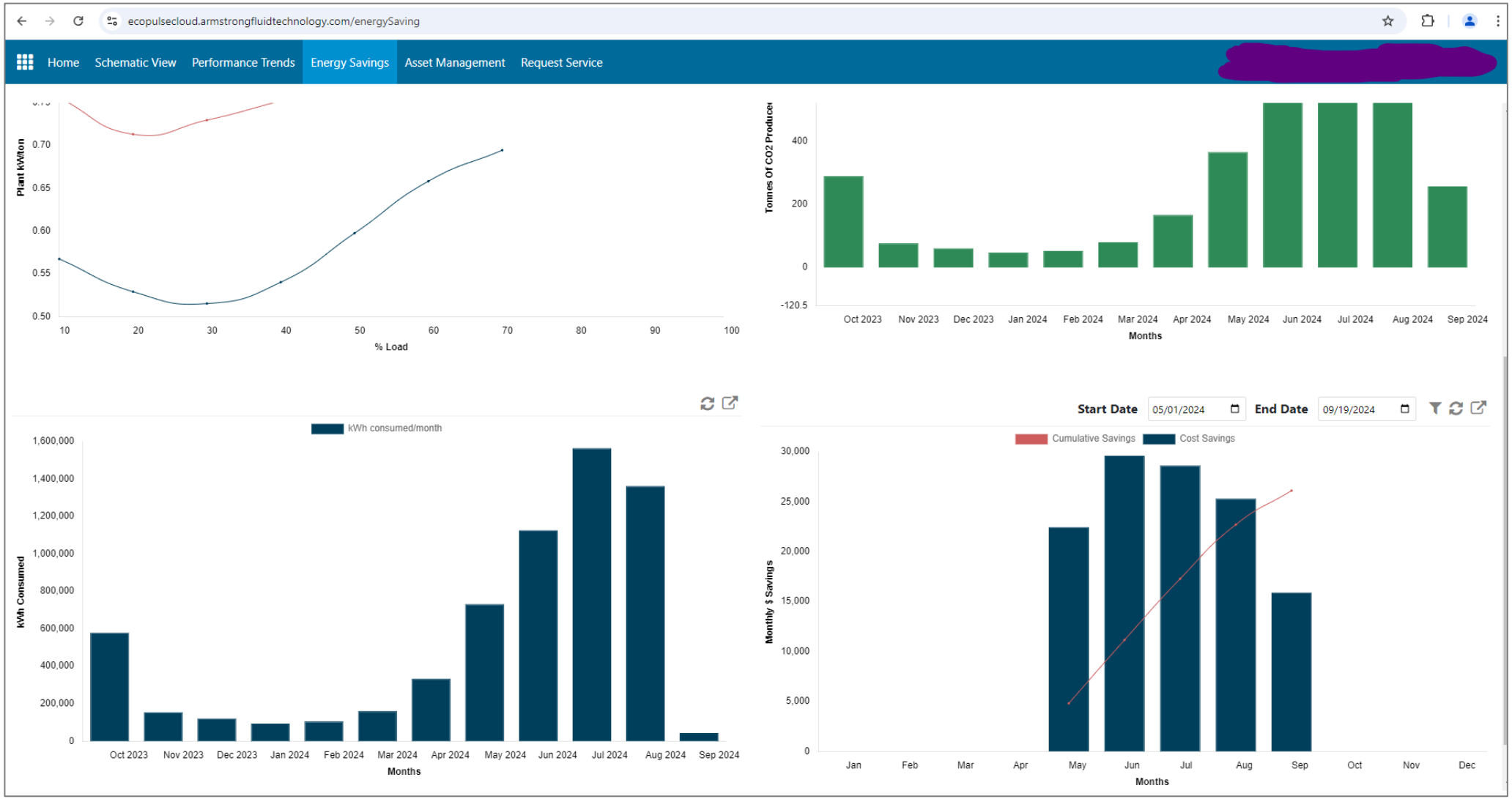
Hospital Optimized Chilled Water Plant - Cloud Dashboard – 0.6 kW/ton



Performance Trends by Load Percentage



Energy Savings $



From Micro to Macro

Harvesting Data from Multiple Datasets to Recognize Patterns

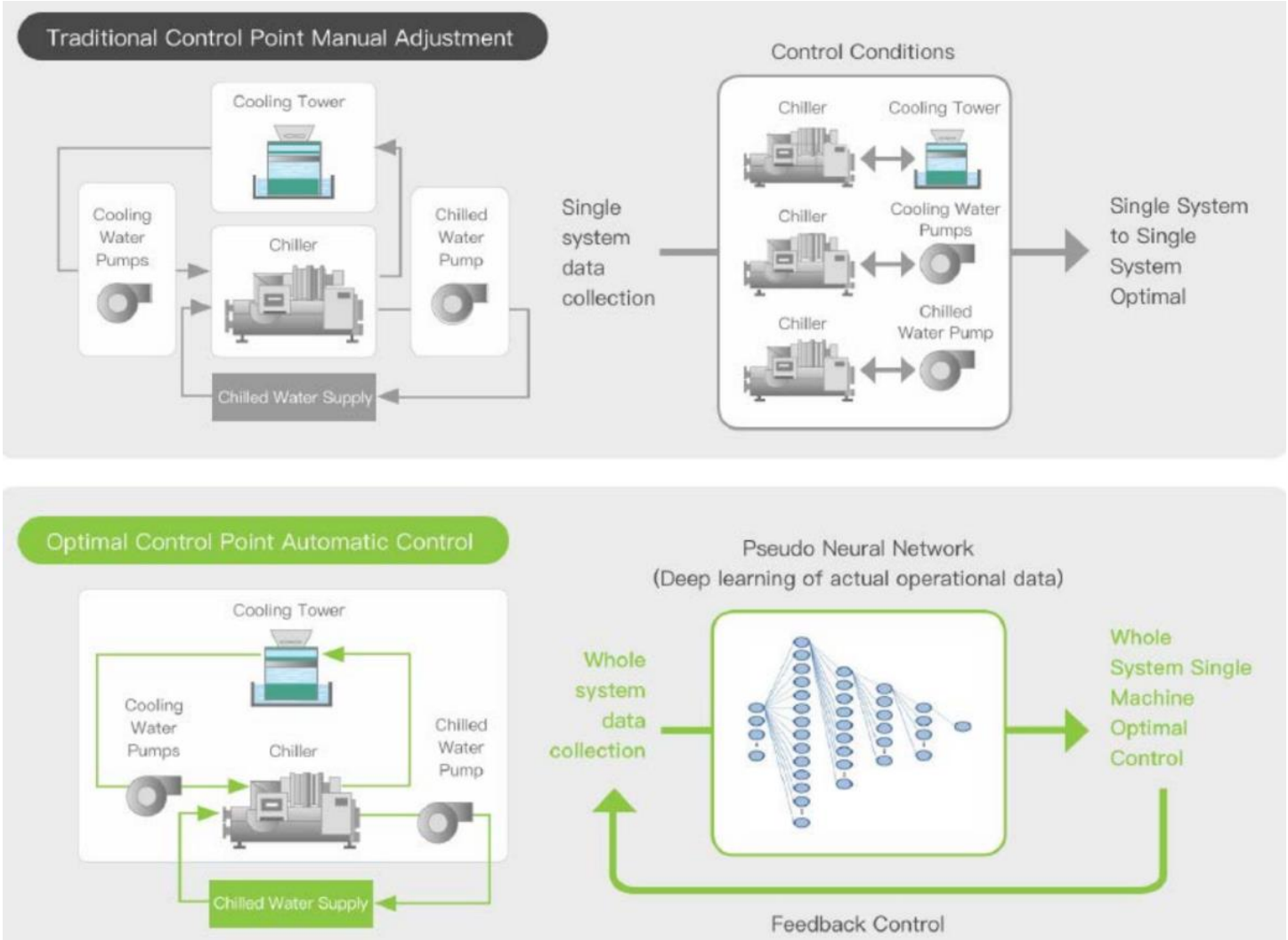
- Retail, education, multiple buildings, hospitality, healthcare chains,

- Use the mass data **aggregated** to improve outcomes.
  - Operational efficiency
  - Comfort levels
  - Grid management

- Applicable to:
  - District energy
  - Healthcare chains
  - Data centres

Adaptive Control Network → Improved Efficiency

- Bulk operational data
- Optimal energy saving program
- New model neural network algorithm of machine learning
- Explore correlations between multiple parameters



Urban Building Energy Modeling - Work in Progress

- Global shift to urban areas
- 2/3 of energy consumption, of which buildings are 40%
- Sustainable energy sources
- Aggregated data used to help modeling
- Research continues to better match power infrastructure to demand

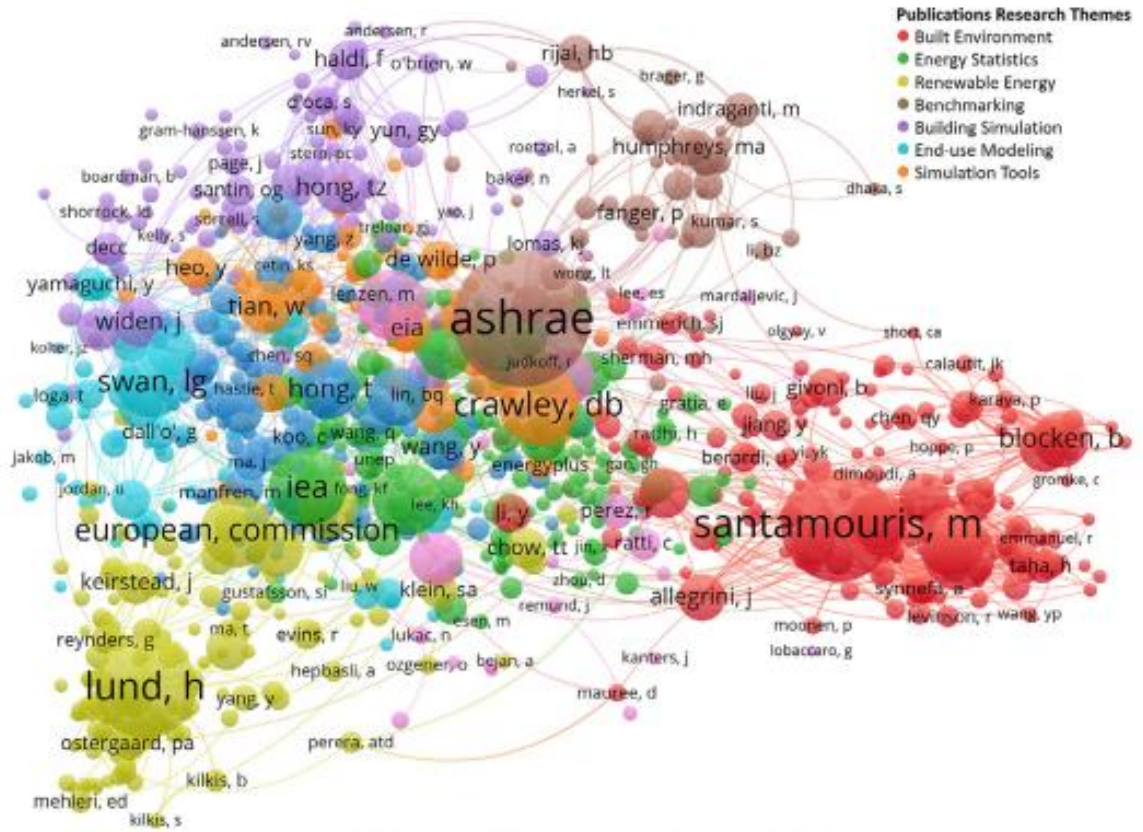


Fig. 2. UBEM publication co-citation network categorized under six clusters based on closely related research themes and obtained from World of Science academic search platform using VOSViewer tool [25].

Source: Energy & Building 246 (2021) 111073

Decarbonization and Optimization through Cloud-Based Data Harvesting

- Thank you for your attention.
- Questions:
- 1) Q:How many billion $ tax savings did the USGBC say could be saved if all existing commercial buildings were given energy efficiency upgrades in line with local energy code? A: $56B
- 2) Q: How many years did the Berkeley Labs say it took to pay back, in simple terms, the cost of FDD and EMIS? A: 2
- 3) Q: According to the US Green Building Council, what percentage of the retro-commissioning market results in 4 billion BTU saved? A: 1
- 4) Q: What was the highest 10 percent (decile) of design flow that the heating pump in the New York condo attained in any of the annual February reports? A: 30-40% - but that was when the pumps were in hand mode
- 5) Q:What percentage of total urban energy do building systems consume? A: 40%