Deferred Maintenance

"The Cost of Doing Nothing"

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Comprehensive Asset Management

Shared risk in design/execution/maintenance/service

CAPEX projects with return

Procurement vehicles

Rebates, tax, grants, Financing

Design build HVAC

Listening

Problem solving

Procurement vehicles

Rebates, tax, grants

Turnkey

Perform Maintenance and Service Repair

Day 2 service contracts

M&V

Pre / post T&B

Providing Pragmatic Solutions to Customer Problems

Building Automation Systems

Customer education

One point of accountability

Accelerated procurement (CO-OP Purchasing)

Nimble solutions

Focus spending

Asset management

Value engineering

Energy savings and measurement

IAQ

Data analytics

Sustainability

Continuous commissioning

Professional Engineering

“Biggest bang for your buck”

Financial Justification

Objectives

Review “Third party” Relationship between Deferred Maintenance and Energy Consumption in a standard educational building

Ideas of how/where to start A Deferred Maintenance Recovery Plan

Visual and Monetize the Impacts of Deferred Maintenance

Interactive Survey

slido

Join at slido.com
#3040736

ⓘ Start presenting to display the joining instructions on this slide.

Rank who is the Greatest NFL QB (best to worst)

ⓘ Start presenting to display the poll results on this slide.

The greatest rock band of all time?

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What is the Greatest Invention Listed, Pick One?

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What is Deferred Maintenance

30%

of energy in buildings is wasted with inefficiency

EPA

>40%

of workers are dissatisfied with comfort in their space

CBE
CENTER FOR THE BUILT ENVIRONMENT

>80%

of equipment fail for non-age related reasons, i.e. before their time

LIFETIME
LRS
RELIABILITY
SOLUTIONS

Impact Can be Hidden or Delayed

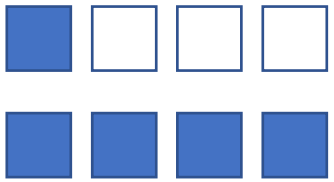
Consumes More Electricity/Water/Gas

Expensive Unplanned Repairs/Replacements

Comfort/Safety in the Space

3 Quick Deferred Maintenance Considerations

$1 deferred maintenance costs



$4 of future capital renewal needs
(American School and University Magazine)

U.S. Department of Energy analysis calculates the jump in utility bills from your building's deferred maintenance costs to be $1.16 per square foot

New schools' initial cost of construction accounts for only 10 percent of the facility's lifetime cost. The remaining 90 percent must be funded so the building can serve students and educators as intended.

Life Cycle Cost of an HVAC Chiller

Air-Cooled Chillers

The Life-Cycle Story

Item	Contractor Sell $	15-Year Op-Cost $	Total LCC $	Best Lifetime Cost of Ownership
Todays Air-Cooled Chiller	$227,487	$1,772,316	**$1,999,803**	**BASE**
CS WC Centrifugal Chiller	$266,542	$2,412,102	**$2,678,644**	**+$678,841**
VFD WC Centrifugal Chiller	$292,320	$2,200,528	**$2,492,848**	**+$493,045**
"Hybrid" VFD WC Chiller	$336,547	$1,748,226	**$2,084,773**	**+$84,970**

First Cost + Energy Cost

What is the average age (in years) of the schools you support?

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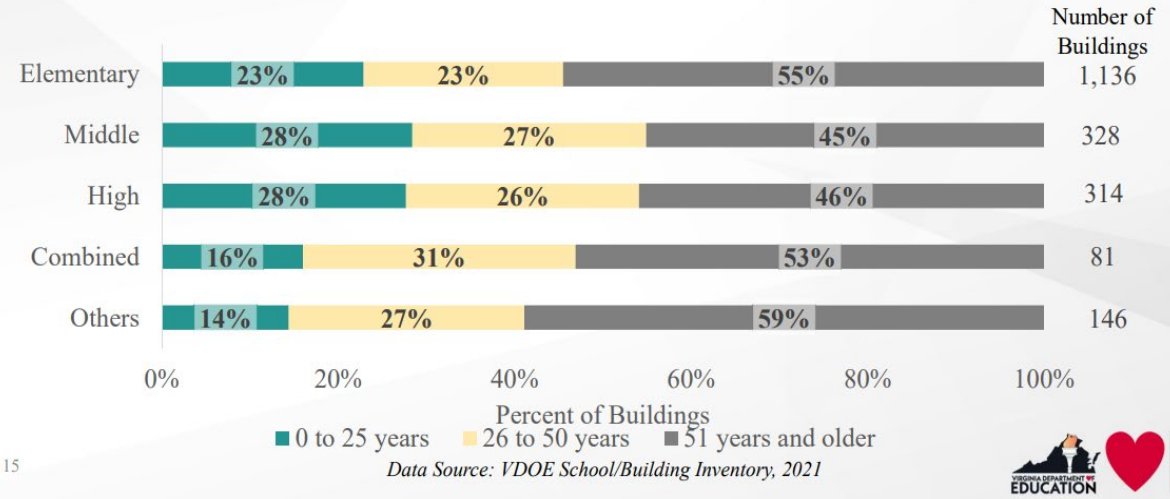
2021 Virginia State Inventory Report

Project Type	Number of Schools with Project Type	Total Costs
New Schools	81	$3,834,076,026
Renovations	566	$3,318,205,135
HVAC Repair/Replacement	463	$623,451,926
School Additions	48	$514,763,904
Roof Repair/Replacement	344	$467,944,657
Other Items*	171	$376,585,276
Technology Upgrades	132	$172,340,570
Electrical & Plumbing	226	$169,013,619
Sports & Playgrounds	287	$161,815,993
Grounds & Parking Lots	353	$127,645,348
Safety Upgrades & Lighting	191	$50,664,811

*Other most often included transportation-related costs

School Building Age by Type

- More than half of all school buildings are greater than 50 years old



Data Source: VDOE School/Building Inventory, 2021

15

In 2002 65% of VA schools construction renovations were result of Deferred Maintenance

52% of VA schools are over the age of 50 years

$623 Million planned for HVAC Repair Renovations over the next 10 years

ASHRAE Life Expectancy of Most HVAC Equipment Averages 15-20 years

What are some of the challenges you have in Facilities?

Current State of Facility Operations

Aging Equipment?

Hard to find/hire skilled techs?

No AC?

Deferred Maintenance?

No redundancy?

Limited budget?

Ventilation?

"Many buildings, what is the worst"

Energy Spend?

Explaining this project to management?

Outdated BAS?

Indoor Air Quality (Humidity concerns, M-word)?

No Asset Management Tool?

Rank Facilities Management issues from (Most Important to Least)

ⓘ Start presenting to display the poll results on this slide.

“What if You Do Nothing”

Case Study Sustainable Energy Conference

Case Study

BUILDING DESCRIPTION

SAS Hall 5-story
N.C. State University 115,000 SF
New building Atrium
Constructed 2009

HVAC

Two air handling units per floor
VAV terminals with hot water reheat
Campus chilled water & hot water

Roger Woods PE, Bill Smith PE

Building Energy Consumption

BUILDING PERFORMANCE Total Energy Annual
Cost = $ 164,200 or $1.42 Sq ft

BUILDING PERFORMANCE Total Energy HVAC
54% Lighting 20% Equipment 26%

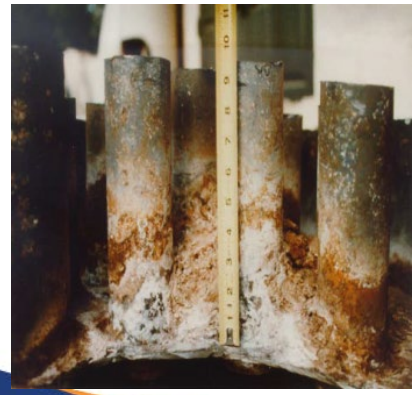
HVAC Energy
Annual Cost = $88,467

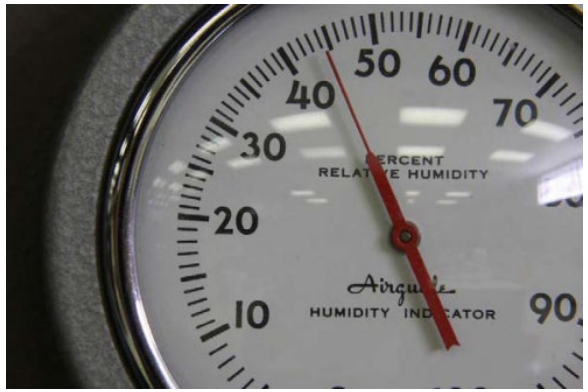
BUILDING PERFORMANCE
HVAC Energy
Chiller / Cooling Tower 45%
Boiler 13%
Pumps 30%
Fans 12%

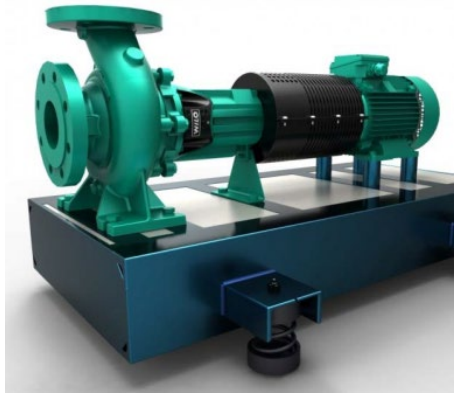
Factor Affecting Energy Performance

Maintenance Items

1. Lighting Controls
2. Filters
3. Fans
4. Pumps
5. Cooling Tower
6. Chillers
7. Boilers
8. Thermostats
9. Humidity Control
10. Night Setback
11. Outside Air Ventilation
12. Economizer Cycle
13. Schedule of Operations







Which ignored Maintenance item on the checklist do you think will impact energy the most?

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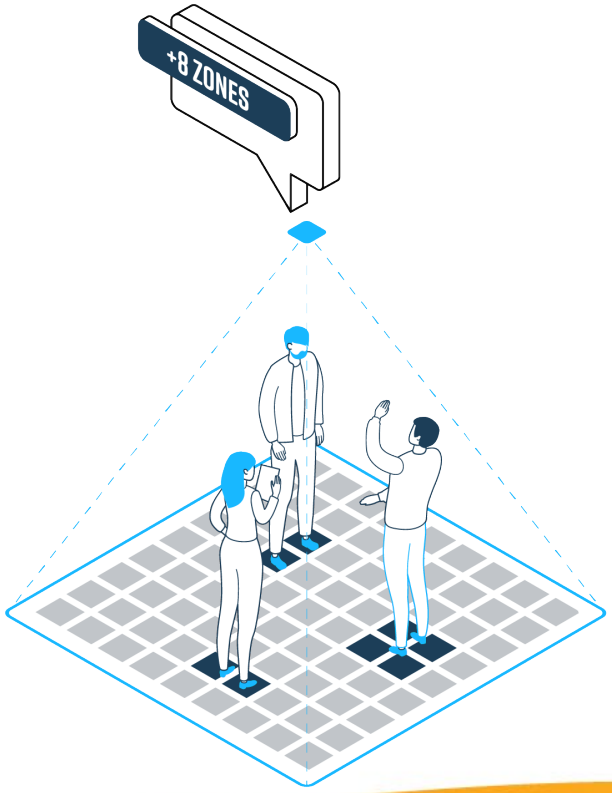
Check Points

Occupancy Sensor Light Control HVAC IMPACT
30% overage on light usage due to sensor failure

Energy Difference
+8.4%



FANS and FILTERS

HVAC Equipment	Energy Difference
Dirty filters in AHU’s (add 1” static pressure)	+4.1%
HVAC Equipment	**Energy Difference**
Variable speed fan runs constant volume	+8.4%

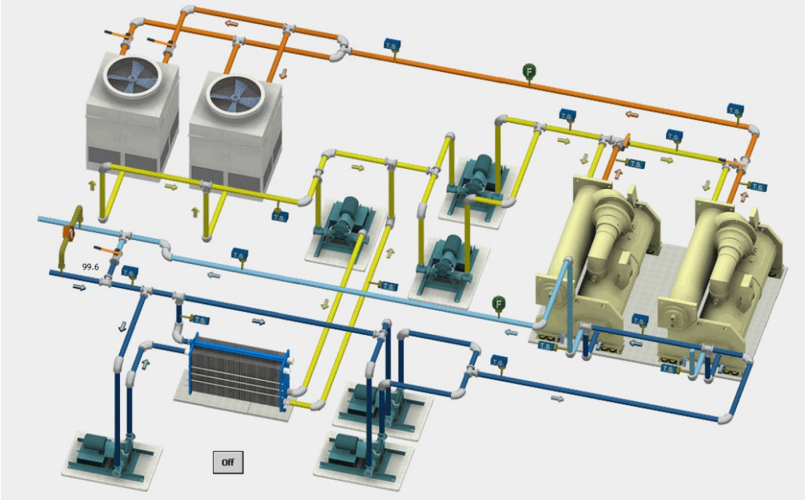
Chiller / Boiler System

Chiller Not Optimized	**Energy Difference**
Fouled tubes	+2.2%
Poor refrigerant charge	+3.7%
Plant Optimization not considered	*+4 – 8%*

HVAC Equipment	**Energy Difference**
Variable flow pumping runs full speed	+10.6%

HVAC Equipment	**Energy Difference**
Fouled cooling tower (4 degree rise in condenser water temp)	+1.3%

Problem	**Energy Difference**
93% efficient boiler acting like a 80% boiler	+4.0%



What is this?

CHECK POINTS

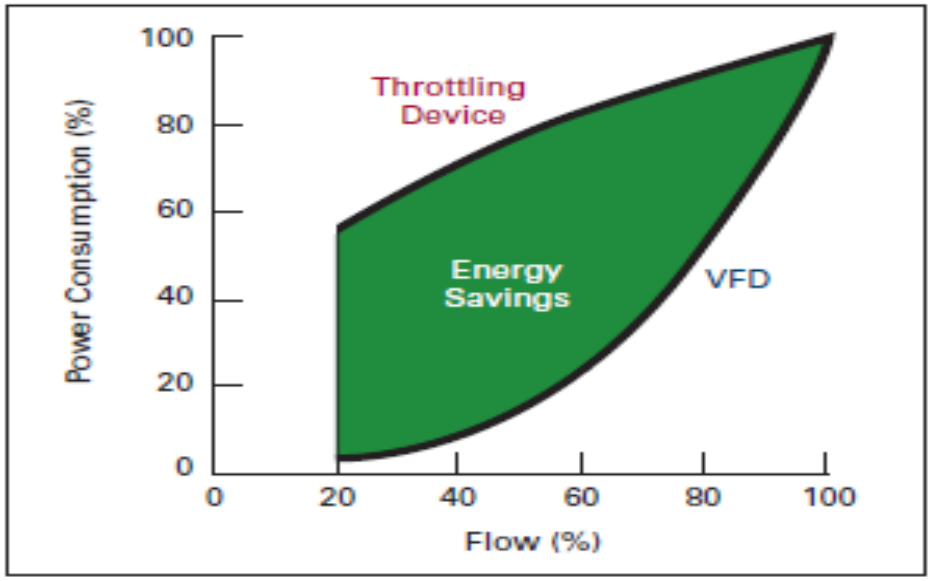
Secondary Pump or Tower Fan

(50 hp)(.746)kW/hp(4200hr)(.082$/kWh) /.92 me

= $14,048

Assume 20% reduction on flow

Current 1000 gpm with 3.5F Delta

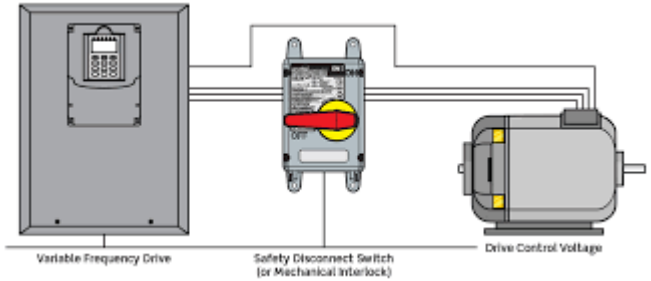


20% flow = 51.2% of bhp .8*.8*.8 = .512

(25.6)(.746)(4200)(.082)/.92 = 7,149

Current 800 gpm with 5F Delta

$14,048 – $7,149 = $6,899



Automation Related

Night Setback Temperatures	**Energy Difference**
85 F cooling / 60 F heating (system operational)	+ 6.4%
Cooling Setpoint	**Energy Difference**
75 F (base case)	0
72 F	+ 3.0%
78 F	- 2.9%
OA Quantity	**Energy Difference**
50% change from scheduled OA amount	+8.2%
Economizer Cycle	**Energy Difference**
Not operational	+1.4%
Control Setpoint	**Energy Difference**
No control	0
60% RH	+ 0.6%
50% RH	+ 2.3%
45% RH	+ 6.6%
40% RH	+17.9%

Check Point Summary

Base Case Energy

Energy $ 164,000

DOE $1.16 per SQ

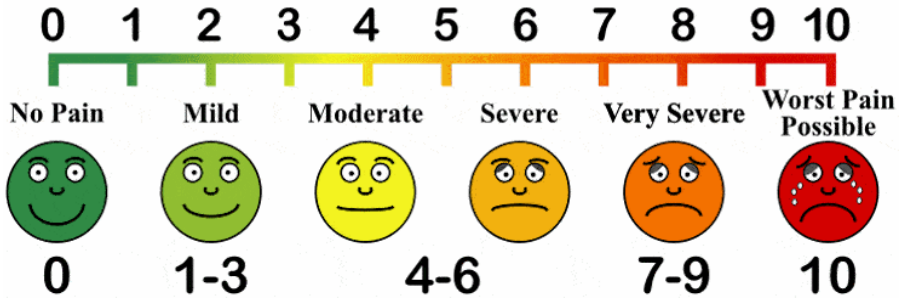
Major Repairs

Worse Case

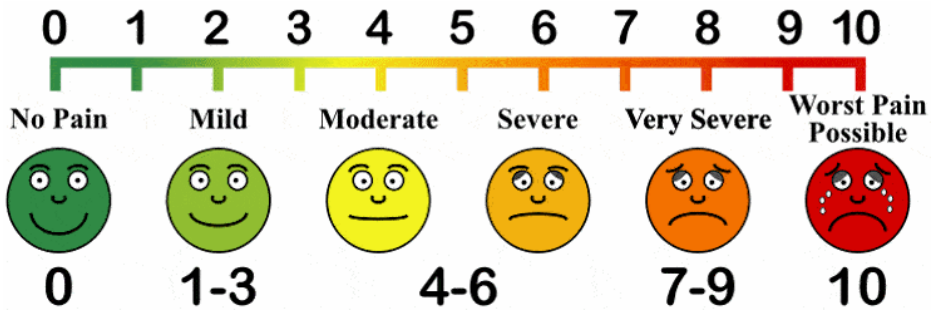
$ 297,852 81.4 % increase

$133,000 (Ventilation / Chillers / Pumps and Fans)

Premature Equipment failure impact far greater than any energy impact (5X)



On a Scale of 1 to 10 (10 being the most pain) what is your Deferred Maintenance level?



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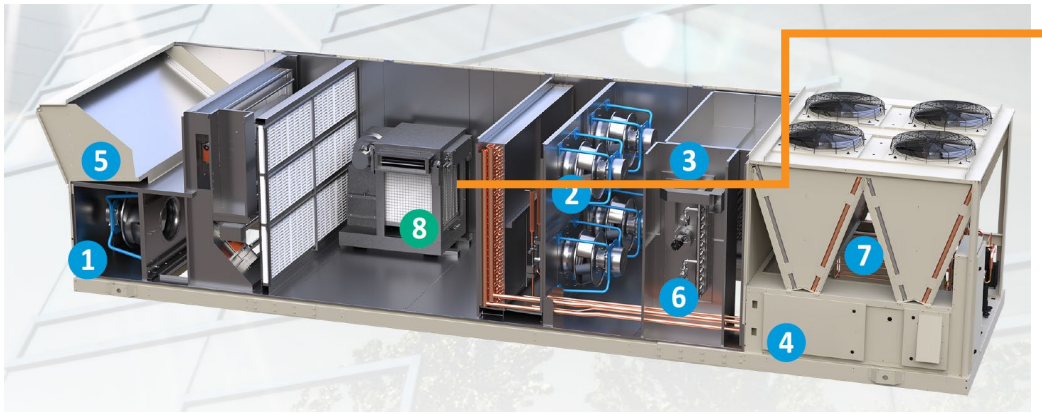
Ventilation EnVerid

- **Daikin Rebel Applied** is the industry's first packaged total-air-quality system that combines the benefits of sorbent media with a class-leading, configurable rooftop unit.
- When using ASHRAE 62.1's IAQP, SVT provides the clean air changes needed for healthy indoor spaces, allowing building operators to decrease the volume of outdoor air needed and total cooling load of their facilities.



2020 DEALER DESIGN AWARDS
the NEWS | SILVER

engineer 2020 PRODUCT OF THE YEAR Silver

VISION AWARDS 2020 WINNER
facilitiesnet

8 **SORBENT VENTILATION TECHNOLOGY (SVT)**

SVT is tested in accordance with ASHRAE 145.2 to remove CO2, VOCs and other contaminants using sorbent filtration. When applied using ASHRAE 62.1's IAQ Procedure (IAQP), SVT provides cleaner air and reduces operating expenses by up to 30%.

Better Air: Promote better IAQ by removing building and occupancy related contaminants.

Retrofit Flexibility: Increase occupancy of served spaces without requiring increases in building infrastructure.

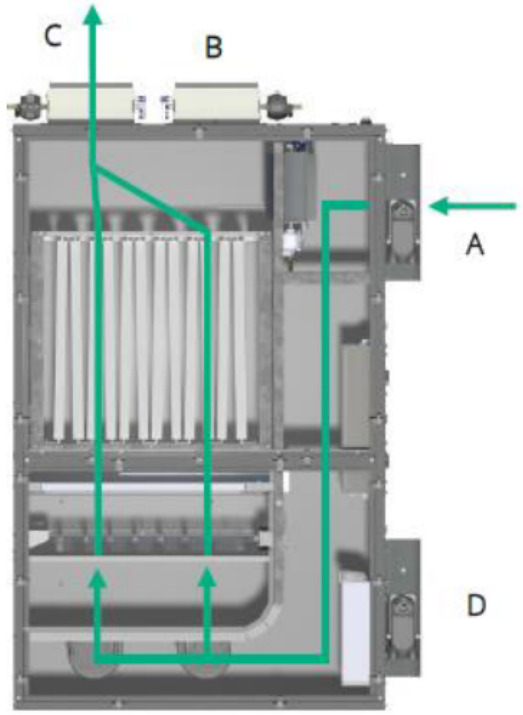
Energy Cost: Reduce outdoor air by up to 80%, and save up to 30% in annual operating expenses.

Sustainability: By reducing unit energy consumption by up 30%, SVT offers a sustainable decarbonization solution that reduces indirect carbon emissions while enhancing building air quality.

enVerid
Energy savings. Air quality.

Product Offerings: HLR 200M

enVerid
Energy savings. Air quality.



850 - 950 CFM

A	Adsorption Mode Air Inlet	Air entering this inlet is the air that is being cleaned. Inlet damper is in open position (controlled locally)
B	Exhaust Outlet	Outlet damper is in closed position (controlled locally)
C	Clean Air Outlet	Outlet damper is in open position (controlled locally)
D	Regeneration Mode Air Inlet	Inlet damper is in closed position (controlled locally)

Each HLR module typically addresses 15,000 – 25,000 ft² of occupied space

- **Captures:**
  - **Carbon Dioxide**
  - **VOCs**
  - **Formaldehyde**
  - **Ozone**
- **Zero by-products**

Thoroughgood Elementary School (VA)

PROJECT GOALS

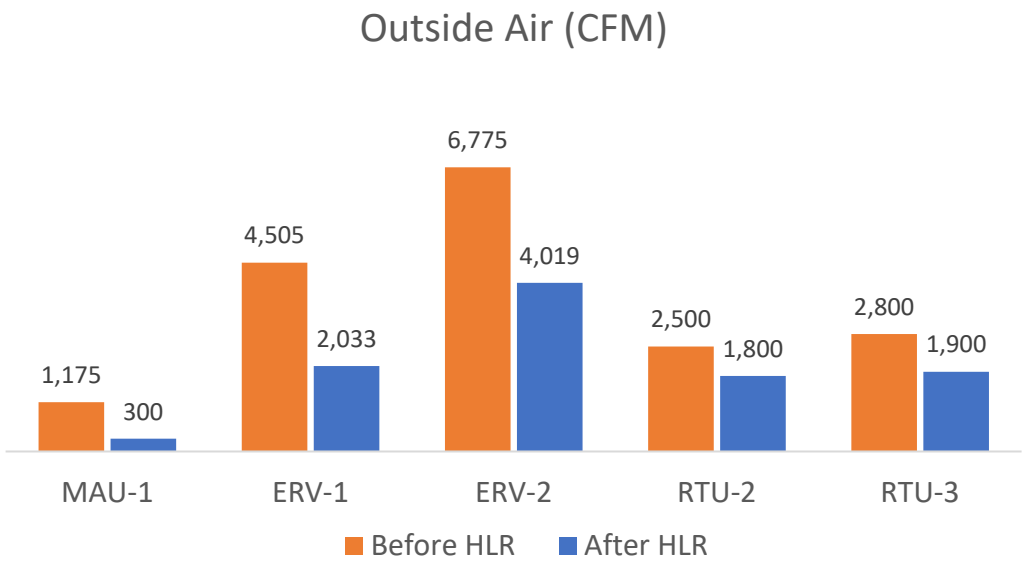
- LEED Gold certification
- Improved indoor air quality
- Peak cooling and heating load reduction

enVerid Project Details	
Location	Virginia Beach, VA
Owner	Viriginia Beach City Public Schools
Contractor	Conrad Brothers
MEP	exp.
Year Installed	2020
Project Type	New Construction
Floor Area	91,913 ft^2
HLR Modules	6 Rooftop & 1 Indoor
LEED/WELL	LEED Gold

Partners

Case Study Thoroughgood – Outside Air & Indoor Air Quality

The HLR design reduced outside air requirements by 43% from 17,755 CFM to 10,052 CFM



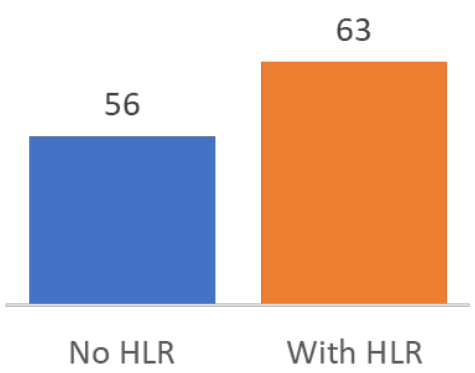
Indoor air contaminant levels were measured in 6 locations and remained well below LEED limits

Contaminant	Concentration Limit (ug/m3)	Measured Average Concentration (ug/m3)
Formaldehyde	20	**16**
Total Volatile Organic Compounds (TVOC)	500	**375**
Carbon Dioxide	800 ppm (VRP equivalent)	**569 ppm**
PM2.5	12 ug/m3	**1.19**

The project demonstrated that HLR modules can be used to provide superior indoor air quality with much less outside air.

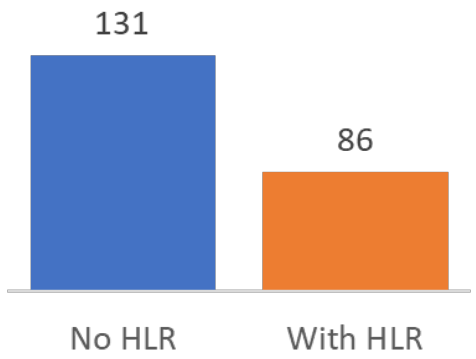
Case Study Thoroughgood – Project Outcomes

LEED Points



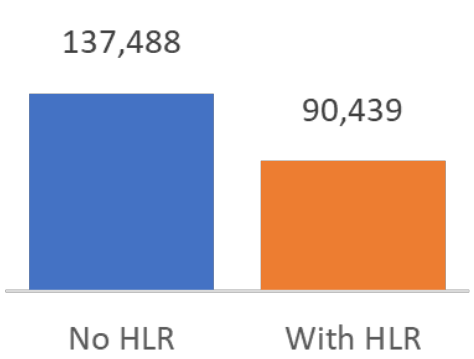
From LEED Silver to LEED Gold rating

Peak Cooling Load (tons)



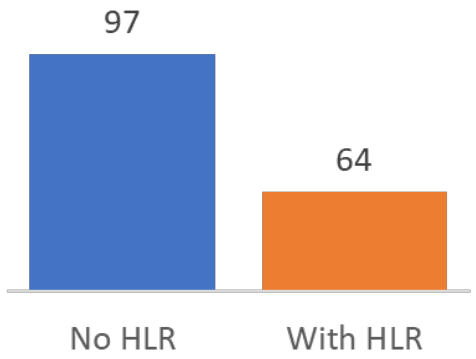
$60k first cost savings on new HVAC system

Ventilation Energy (kWh/yr)



$100k utility bill lifetime savings

Metric Tons CO_2/yr



Reduced 42 metric tons CO_2 annually

These outcomes were achieved while maintaining indoor air quality well below LEED limits

Deferred Maintenance Management

START A TEAM THAT FOCUSES AND MEETS REGULARLY TO DISCUSS

Include Facility Management, Construction Group, Finance, Master Plan

Agree on % of Budget for PM and protect it

START AN ASSET MANAGEMENT PROGRAM

AGE of School / Useful Life of Building / Renovation vs New Construction

AGE of Major Equipment / Useful ASHRAE LIFE / ROOF / SWITCHGEAR

Third Party Groups can perform this service

Energy Index / Find the Hogs

EVALUATE CURRENT MAINTENANCE PHASE

No Maintenance

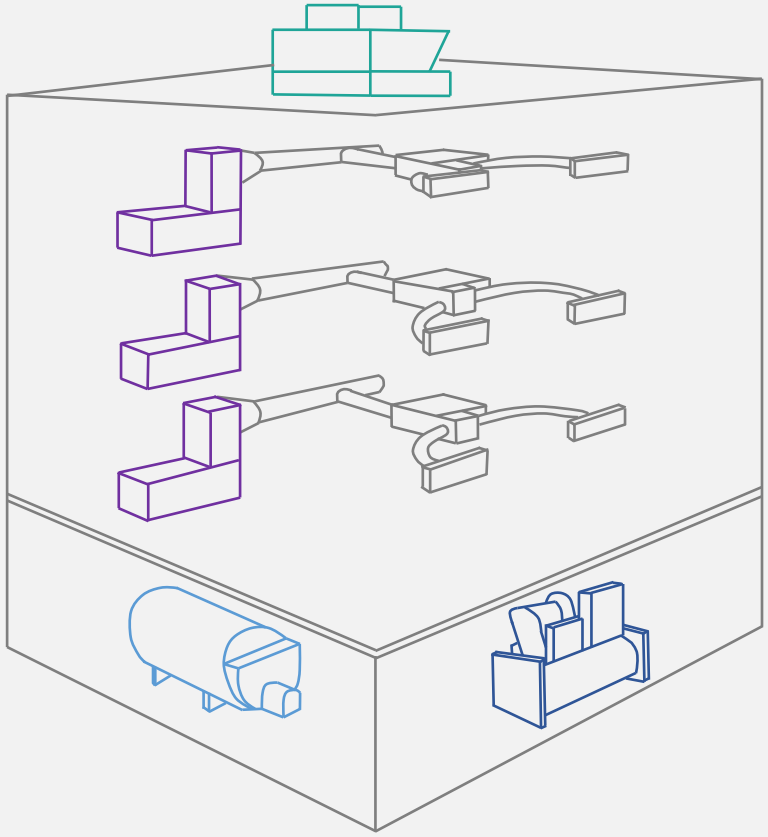
Reactive Maintenance

Proactive Maintenance

Conditional Maintenance

CLOCKWORKS ANALYTICS

What does it take to maintain a typical building?



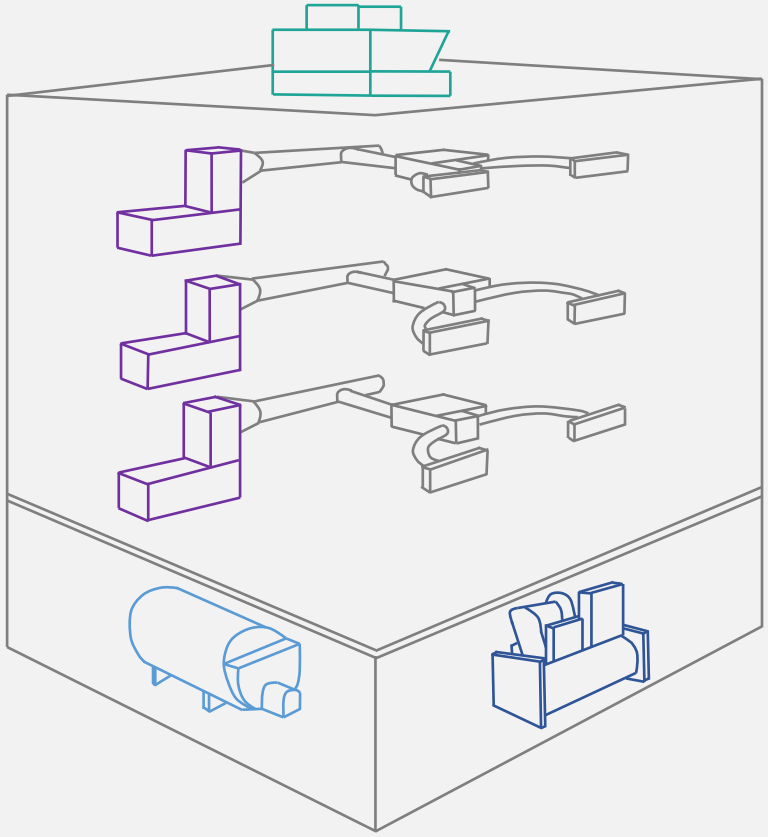
955

PM checklists per YEAR

	Equip. Count	Daily	Monthly	Quarterly	Semi-annually	Annually	Total PMs per Year
Cooling Towers	3		✓	✓	✓	✓	57
Chillers	3		✓	✓	✓	✓	57
Boilers	3		✓	✓	✓	✓	57
Air Handlers	12			✓	✓	✓	84
VAV Boxes	100			✓	✓	✓	700

CLOCKWORKS ANALYTICS

What does it take to maintain a typical building with FDD Software?



955
PM checklists per YEAR

vs.

>4,000
automated checks every DAY

	Equip. Count	Daily	Monthly	Quarterly	Semi-annually	Annually	Total PMs per Year	Automated Checks EVERY DAY
Cooling Towers	3	✓	✓	✓	✓	✓	57	20
Chillers	3	✓	✓	✓	✓	✓	57	90
Boilers	3	✓	✓	✓	✓	✓	57	45
Air Handlers	12	✓		✓	✓	✓	84	900
VAV Boxes	100	✓		✓	✓	✓	700	3,000

CLOCKWORKS ANALYTICS

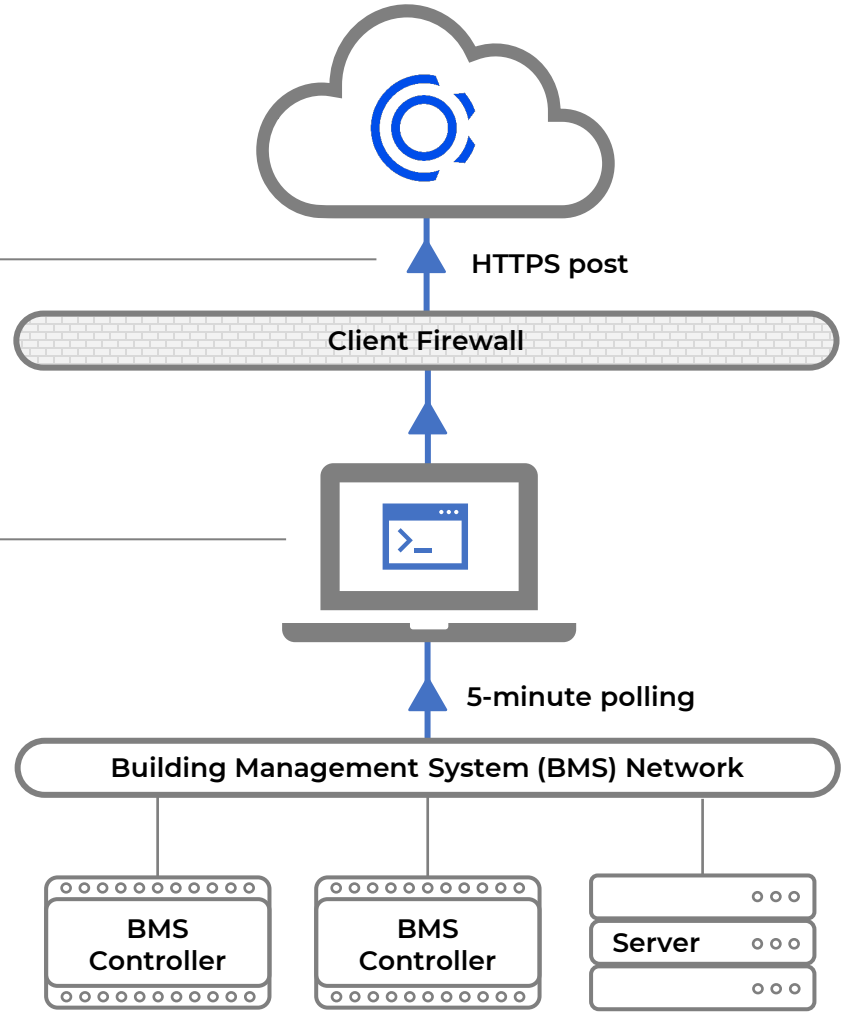
CONNECT

HTTPS outbound only data push to cloud

Software Gateway installed on existing BMS workstation, server, or virtual machine

Reads BMS data from IP devices or server via supported protocols

BACnet Project Haystack OPC FOUNDATION



CLOCKWORKS ANALYTICS

MODEL

- Equipment Classification

AHU_03 → Air Handling Unit w/ Economizer

- Equipment Variables

Equipment Schedules → Supply Fan HP; Rated Airflow; Htg/Clg Capacity

Control Sequences → Dehumidification Type; Economizer Type; SAT Reset Schedule

- Point Types

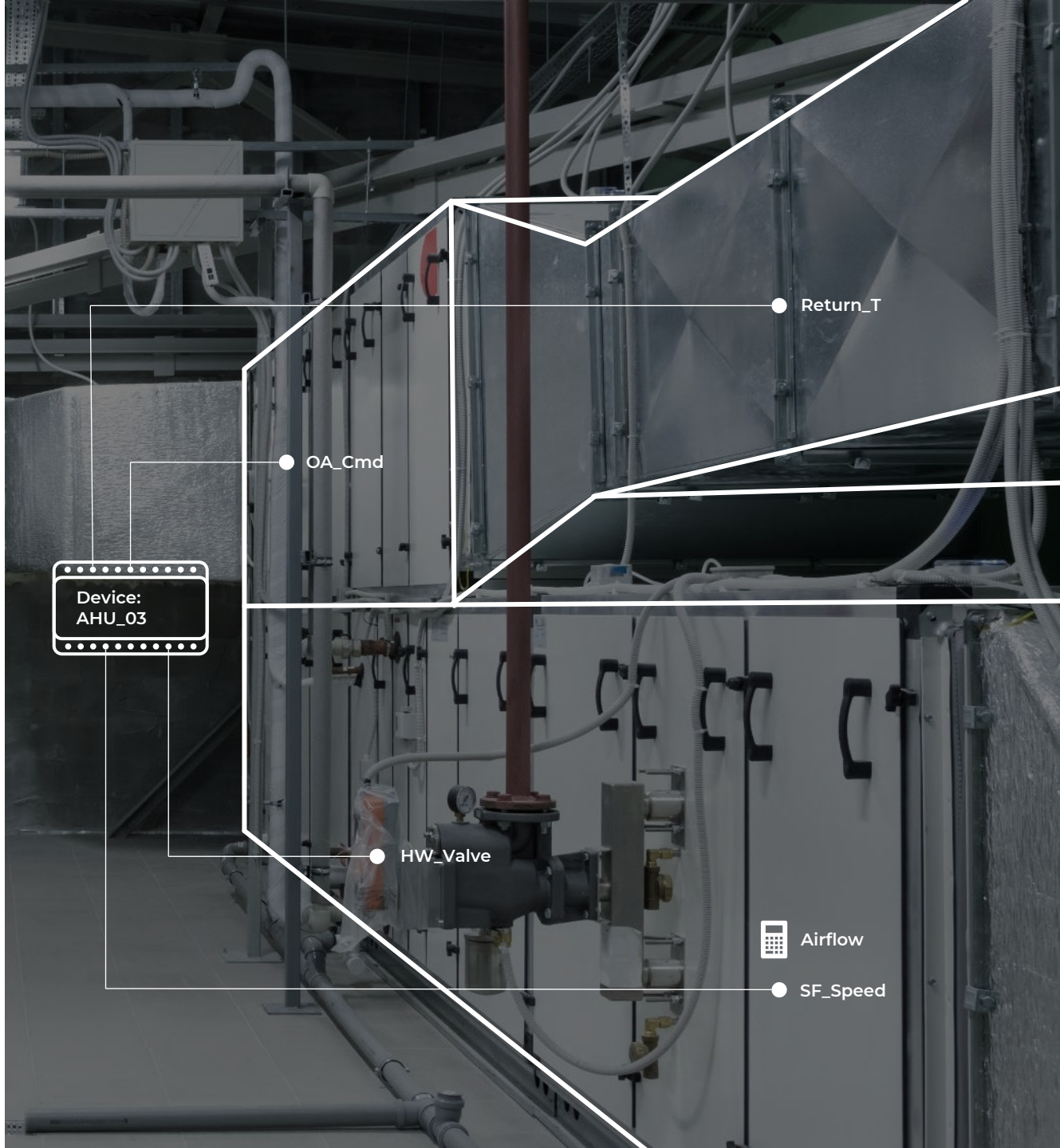
Return_T → return air temp point

OA_Cmd → outside damper cmd point

HW_Valve → hot water heat valve cmd point

SF_Speed → discharge fan drive speed point

Airflow → Rated Flow x Fan Speed

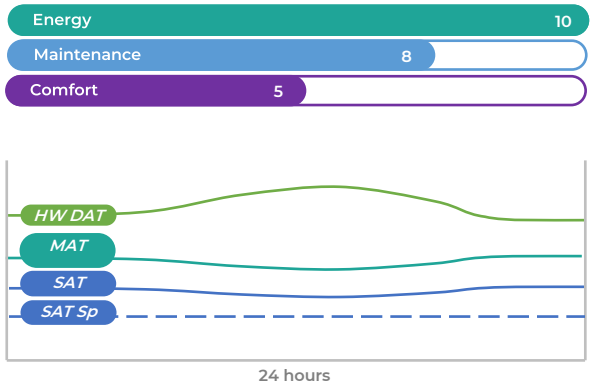


CLOCKWORKS ANALYTICS

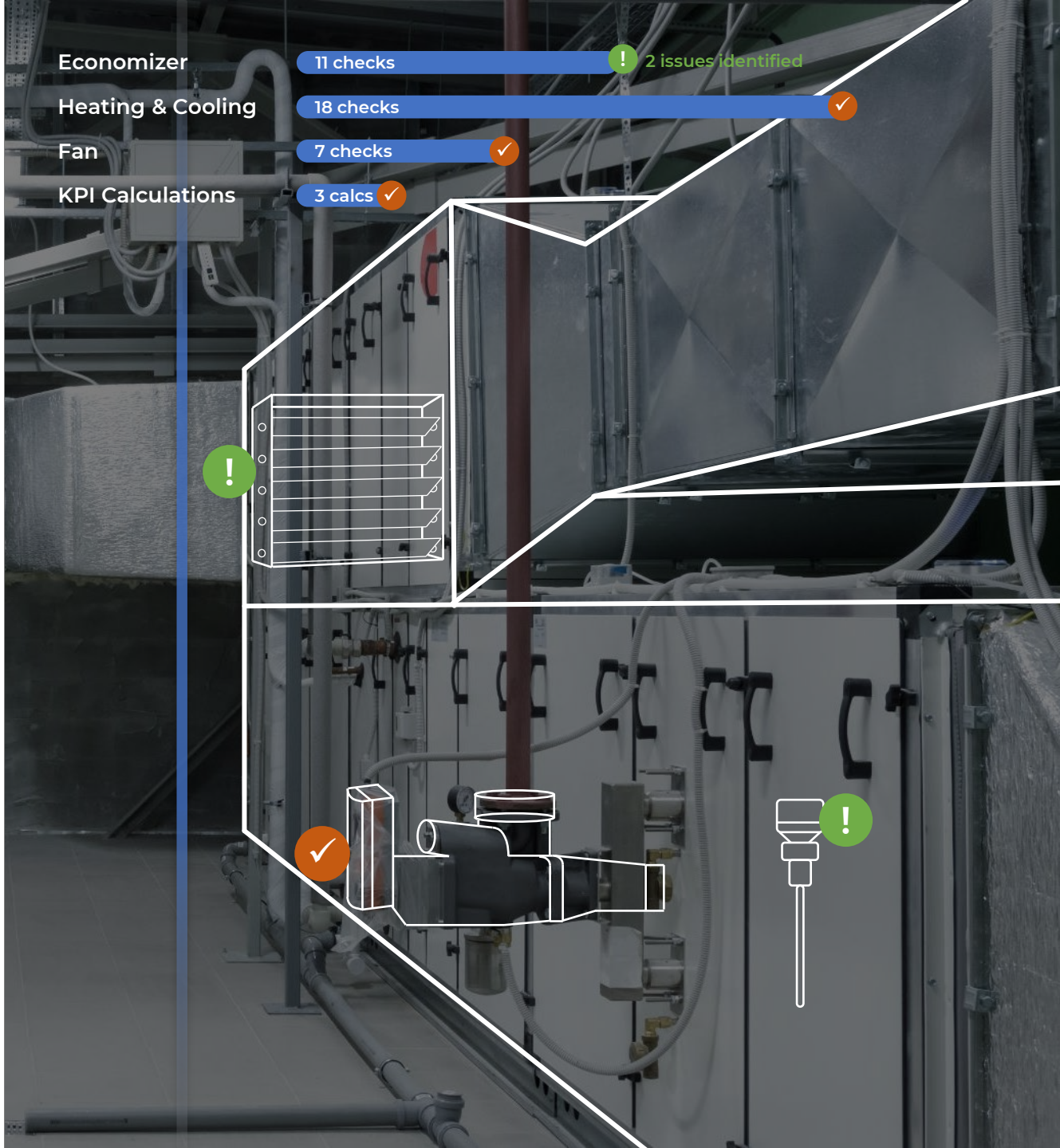
DIAGNOSE

AHU Diagnostic Report

Problems	Economizer Damper Above Minimum
Root Cause	Stuck Damper
Avoidable Cost	$350 per day



Create Task



CLOCKWORKS ANALYTICS

Using FDD during: Operations

Key Performance Indicators

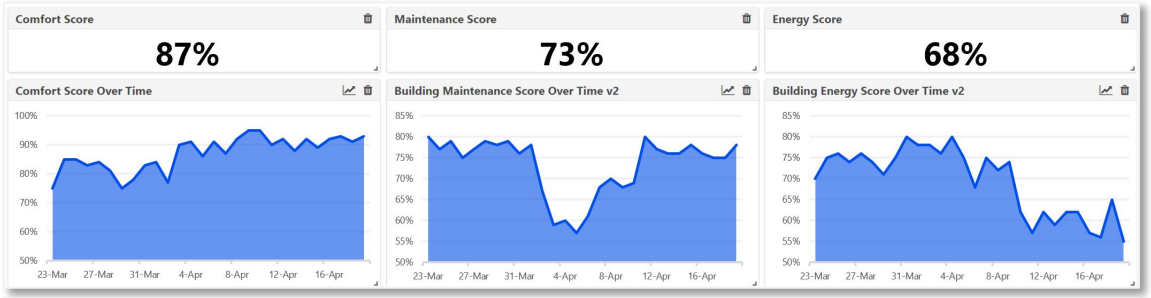
"Top-Down" view of building, system, and equipment performance, normalized for weather and operating conditions

Diagnostic Reports

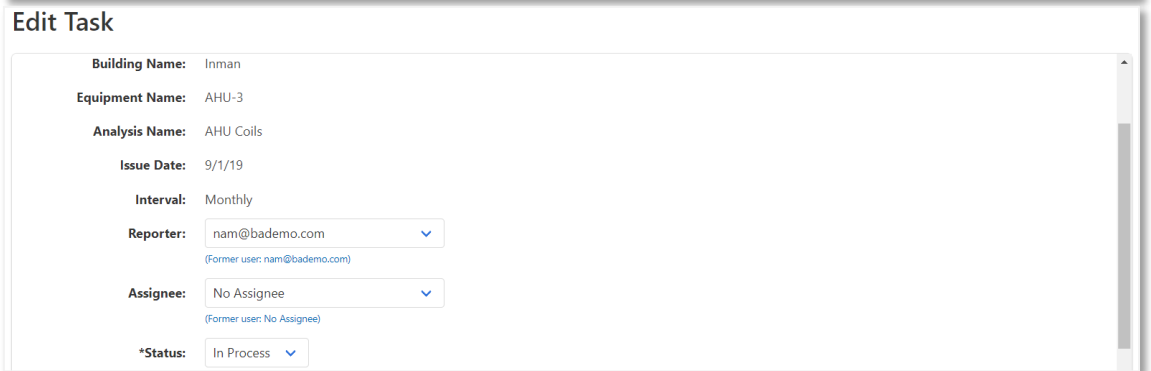
"Bottom up" view of system and equipment performance, with precise detail on identified issues and root cause

Tasks

Tasks and work orders used to manage activities across a Facilities Maintenance Team

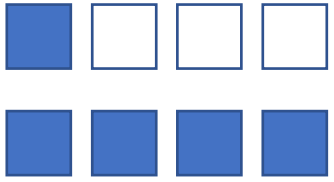


Equipment	Notes	Avoidable Cost
South Boston – Boiler Plant	Boiler efficiency is low.	$19,147
South Boston – AHU03	Leaking pre-heating coil valve. Return RH higher than setpoint. Return air RH setpoint belo w suggested min (IAQ). Simultaneous heating and cooling. Supply temp reset error.	$17,549
Inman – AHU01	Fan on longer than expected. Occupancy not compliant with schedule.	$9,995
Kendall – AHU07	Leaking pre-heating coil valve. Simultaneous heating and cooling.	$7,879
Somerville – RTU04	Leaking pre-heating coil valve. No supply temp reset. Simultaneous heating and cooling.	$4,923



Summary

$1 deferred maintenance costs



$4 of future capital renewal needs
(American School and University Magazine)

DOE $1.16 per square foot

Deferred Maintenance on Ventilation and OA could potentially have the largest energy impact