Scaling Up HVAC Fault Detection in a Portfolio: Kaiser Permanente’s Fault Detection and Diagnostic Program

Presenter: Gary Mullaney, CEM, CC-P, Kaiser Permanente
Moderator: Hannah Kramer, P.E., Lawrence Berkeley National Laboratory
March 10, 2022
Welcome!

Moderator:
Hannah Kramer,
Better Buildings’ EMIS
Tech Team
LBNL

Speaker:
Gary Mullaney,
Senior Energy
Consultant,
Kaiser Permanente
Scaling FDD from pilots to portfolios

2000
5 EMIS with FDD

2020
50 EMIS with FDD

2030?
EMIS scaled across portfolios

2016-2020: DOE’s Smart Energy Analytics Campaign
- 104 portfolio owners with EMIS implementation – 60% with FDD
- 40 software tools implemented
- 9% median annual energy savings (90M sq ft, 500+ bldgs)
- Proving the Business Case for Building Analytics 2020 (report, webinar)
Kaiser Permanente’s Fault Detection and Diagnostic Program

Gary Mullaney, CEM, CC-P
Senior Energy Consultant
Kaiser Permanente at a Glance

Recognized as one of America’s leading health care providers and not-for-profit health plans

Kaiser Foundation Health Plan

Permanente Medical Groups

Kaiser Foundation Hospitals

| 12.5+ million members | > $90 billion annual operating revenue | 23,271 physicians 63,306 nurses 219,149 employees | ~70 million square feet of occupied space 8 states and DC | 39 owned & operated hospital 730+ medical offices and other facilities |
Kaiser Fault Detection and Diagnostic Program Scope

By Square Footage:
- Live: 18.5M
- Onboarding: 7.3M

Cumulative Area Onboarded
FDD Program Journey

2014:
Regional Pilot

2014-15: Competitive RFP for FDD tool: Clockworks Analytics selected and awarded a MSA from pool of 15 vendors.

2015-16:
National Pilots
Go Live

Decision Point: Scale?

Pilot Results: Three medical centers and a medical office building resulted in identified savings that were 2 ½ times the investment

2016:
14 Buildings Live in 4 Regions
FDD Program Journey

**2014:** Regional Pilot

**2014-15:** Competitive RFP for FDD tool: Clockworks Analytics selected and awarded a MSA from pool of 15 vendors.

**2015-16:** National Pilots Go Live

**2016:** 14 Buildings Live in 4 Regions

**2017:** FDD requirement added to capital program to support Cx

**2018:** 64 Buildings Live in 5 Regions

**2018 ASHE Energy to Care Champion awarded to Zion Medical Center**

**2019:** DOE Smart Energy Award in category of Energy Performance Using FDD in a Portfolio

**2020:** 120 Buildings live in all (8) regions

**2022:** 170 Buildings (18.5M ft²) + 7M pipeline

**2023:**
How Did We Scale

• Communicated the value proposition repeatedly
  ▪ Demonstrated how FDD and MBCx can solve their pain points
  ▪ Highlighted success stories and feedback from pilots
  ▪ Quantified impact
• Established site selection criteria
• Establish funding mechanisms
Building Controls & Overrides
Case Study: When We Lose Sight of our Building Controls

50% Increase in Gas usage at peak
Cost $85,000 over period
Never Lose Sight: Monitoring Based Commission

- **Equipment Count**: 38,332
- **Count of equipment with heating related faults**: 12,411
- **Heating Related Avoidable Cost**: $302,929 USD
Sensors
Sensor Monitoring & Maintenance

**Savings/Fault:** $5,556/year, RH sensor out of range, OA damper overridden

**Persistence:** 3/12/2016 through 8/19/2020, or 4.5 years. This sensor expected life is 5 years.

**Issue:** From the start of data late 2015 through when the fault was corrected 3/12/2016 the RH sensor was not operating, and the OA was in hand/not modulating to economize.

From 3/12/2016 through 8/19/2020 this reading was maintained so the economizer could modulate accurately. Clockworks started flagging this fault 8/19/2020 that the sensor is in error again.
Enhanced Sensor Monitoring & Maintenance

Equipment: Sensor Issues

Diagnostic Date: Last 7 days
Diagnostic Analysis Interval (Daily)

Equipment Count

Count of equipment with sensor faults

38,332

4,974

Sensor faults by Building

Equipment with Sensor issues

Export to Excel Export CSV

<table>
<thead>
<tr>
<th>Building</th>
<th>Equipment</th>
<th>Notes</th>
<th>Results</th>
<th>Maintenance Score</th>
<th>Diagnostics</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Bay Carson North</td>
<td>ASU AHU 1-2</td>
<td>Filter pressure zero while fan on (IAQ). Flow sensor error. Supply air static pressure smaller than setpoint.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moanalua Ancillary Building</td>
<td>AHU-A3-1</td>
<td>Fan speed feedback lower than command. Filter alarm (IAQ). Out of range sensor error.</td>
<td>7</td>
<td>6 %</td>
<td>View</td>
</tr>
</tbody>
</table>
## Enhanced Sensor Monitoring & Maintenance

![Image of sensor monitoring interface](image)

The interface allows for detailed monitoring and maintenance of sensor data. It supports the selection of various criteria such as building groups, buildings, equipment classes, equipment types, and analysis types. The display interval can be set to half day, daily, weekly, or monthly. Filters can be applied to narrow down the results.

### Search Criteria
- **View By:**
  - Select Building Group:
  - Select Building:
  - Select Equipment Class:
  - Select Equipment Type:
  - Select Equipment:
  - Select Analysis:

- **Display Interval:**
  - Half Day
  - Daily
  - Weekly
  - Monthly

- **Date Range:**
  - Start Date: 9/1/2021
  - End Date: 9/1/2021

- **Filters:**
  - Notes Summary
  - Tracking Code

- **Generate Data**

### Data Records
3313 data records found for 9/1/2021 to 9/1/2021 in daily intervals.

<table>
<thead>
<tr>
<th>Building</th>
<th>Equipment</th>
<th>Analysis</th>
<th>Start Date</th>
<th>Notes Summary</th>
<th>Tasks</th>
<th>Cost</th>
<th>F</th>
<th>C</th>
<th>M</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHMC MOB 1_Woodland Hills M...</td>
<td>AHU S-1 (Air Handler)</td>
<td>AHU Fan</td>
<td>9/1/2021</td>
<td>Abnormal fan current. Fan status data mismatch. Flat sensor error. Flow sensor error. Return air flow higher than setpoint.</td>
<td>0</td>
<td>$112</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roseville CUP</td>
<td>OWS CT4 (Cooling System)</td>
<td>CW Loop</td>
<td>9/1/2021</td>
<td>Flat sensor error. Out of range sensor error. Supply temp higher than setpoint. Tower staging opportunity.</td>
<td>2</td>
<td>$59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baldwin Park MOB 1</td>
<td>AHU 19 (Air Handler)</td>
<td>AHU Coil</td>
<td>9/1/2021</td>
<td>Out of range sensor error. Supply temp lower than setpoint.</td>
<td>0</td>
<td>$48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WHMC MOB 1_Woodland Hills M...</td>
<td>AHU S-3 (Air Handler)</td>
<td>AHU Fan</td>
<td>9/1/2021</td>
<td>Abnormal fan current. Fan status data mismatch. Flat sensor error. Return air flow higher than setpoint.</td>
<td>0</td>
<td>$40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Santa Clara Medical Center</td>
<td>AHU 18 (Air Handler)</td>
<td>AHU Fan</td>
<td>9/1/2021</td>
<td>Flat sensor error. No static pressure reset.</td>
<td>0</td>
<td>$35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mountain Ancillary Building</td>
<td>A2-2-3-10-03 (Zone Equipment)</td>
<td>Zone Unit</td>
<td>9/1/2021</td>
<td>Leaking heating coil valve. Out of range sensor error.</td>
<td>1</td>
<td>$33</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Energy Management

Smart Building Analytics

Image credit: ENERGY STAR
Enhanced Energy Management
Terrell Estes – Modesto Medical Center (Northern California Region)

“For Kaiser Modesto I am not sure that we would be at an energy score of 97 without [our FFD platform]. It has allowed us to see things that we normally may not see. It has allowed us to operate our plant more efficiently vs just operating our plant to work. I do not view our reductions we’ve achieved as a one-time savings but as a residual income that keeps producing every year with moderate effort and I would almost fear without the technology we could easily slip backwards to where we once were. Below is 2015 the year before we implemented [our FFD platform] and where we are today. Lower energy spend with increased rates over the years, who can ask for more.”

<table>
<thead>
<tr>
<th>Metric</th>
<th>Jan 2015 (Other)</th>
<th>Jun 2018 (Other)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY STAR Score (1-100)</td>
<td>56</td>
<td>97</td>
<td>41.00 (73.20%)</td>
</tr>
<tr>
<td>Source EUI (kBtu/ft²)</td>
<td>352.1</td>
<td>303.2</td>
<td>-48.90 (-13.90%)</td>
</tr>
<tr>
<td>Site EUI (kBtu/ft²)</td>
<td>196.8</td>
<td>171.9</td>
<td>-24.90 (-12.70%)</td>
</tr>
<tr>
<td>Energy Cost ($)</td>
<td>2,526,261.66</td>
<td>2,063,569.06</td>
<td>-462,692.60 (-18.30%)</td>
</tr>
</tbody>
</table>
Ben Pfeiffer – Westside Medical Center (Northwest Region)

“Our FFD platform] was onboarded at our Westside Medical Center pilot site in 2015. As the Project Champion here, I’ve found the tool to be very useful, especially in respect to the software’s ability to detect faults within our Zone Equipment. This fault detection service has allowed us to diagnose and repair equipment failures before we ever even get a comfort complaint by the building occupants—that’s awesome!

Although there have not been a lot of Energy related cost saving faults identified at WMC (due to the facility being a newly built Gold-LEED site), there have been some; these would not have been identified and repaired so quickly without the aid of Clockworks running 24/7 in the background of our Metasys BAS.

It’s clear to me that [our FFD platform] is a huge asset to the FMS group, and, will be more so in the future, as it is onboarded to more of the older facilities throughout the region!”
Impact

### By Campus

<table>
<thead>
<tr>
<th>Region</th>
<th>Building Group/Medical Center</th>
<th>Live</th>
<th>Go Live Date</th>
<th>1st Year</th>
<th>Annual Avoided Cost</th>
<th>1st Year - Annual Avoided Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCAL</td>
<td>Roseville</td>
<td>1,274,925</td>
<td>4/24/2019</td>
<td>$101,994</td>
<td>$109,091</td>
<td>$(7,097)</td>
</tr>
<tr>
<td>SCAL</td>
<td>South Bay</td>
<td>1,686,433</td>
<td>5/14/2018</td>
<td>$134,915</td>
<td>$159,476</td>
<td>$(24,561)</td>
</tr>
<tr>
<td>SCAL</td>
<td>Regional South</td>
<td>753,634</td>
<td>9/11/2014</td>
<td>$60,291</td>
<td>$92,415</td>
<td>$(32,124)</td>
</tr>
<tr>
<td>WA</td>
<td>WA</td>
<td>750,000</td>
<td>5/3/2019</td>
<td>$60,000</td>
<td>$96,022</td>
<td>$(36,022)</td>
</tr>
<tr>
<td>NW</td>
<td>NW - Central Ambulatory</td>
<td>256,334</td>
<td>12/17/2020</td>
<td>$20,507</td>
<td>$24,079</td>
<td>$(3,572)</td>
</tr>
<tr>
<td>GA</td>
<td>GA</td>
<td>136,699</td>
<td>6/12/2019</td>
<td>$10,936</td>
<td>$36,364</td>
<td>$(25,428)</td>
</tr>
<tr>
<td>CO</td>
<td>CO</td>
<td>80,200</td>
<td>5/23/2019</td>
<td>$6,416</td>
<td>$16,814</td>
<td>$(10,400)</td>
</tr>
<tr>
<td>NCAL</td>
<td>Stockton</td>
<td>398,222</td>
<td>4/30/2021</td>
<td>$31,858</td>
<td>$44,208</td>
<td>$(12,350)</td>
</tr>
</tbody>
</table>

**Overall, by Time**

<table>
<thead>
<tr>
<th></th>
<th>All buildings live at least 2 years (Go Live through 12/31/2019)</th>
<th>All buildings live at a 1.5 year (Go Live through 6/30/2020)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Cost</td>
<td>$221,042</td>
<td>$283,544</td>
</tr>
<tr>
<td>1st Year Cost</td>
<td>$589,446</td>
<td>$740,602</td>
</tr>
<tr>
<td>Avoided Cost</td>
<td>$553,802</td>
<td>$577,356</td>
</tr>
<tr>
<td>% of 1st Year Cost</td>
<td>94%</td>
<td>78%</td>
</tr>
</tbody>
</table>

**Case Study: Impact Beyond Energy**

- **2021**
  - 500 Tasks completed
  - 286,788 USD of annual savings
  - 1,423,870 kWh electric savings
  - 353,598 TON-hrs cooling savings
  - 5,852,504 kBTU heating savings

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**Equipment Class Faults for Past 26 Weeks**

*Unique Faults, Comfort, Energy, Maintenance*
Site Selection & Funding

- Targeted Buildings
  - All medical center campuses
  - Campus ≥ 100,000 ft²

- Funding
  - Capital: required for all new buildings and projects with control system spend greater than $250,000.
  - OPEX: locally funded or split funding with regional team
Operating Model

Kaiser Permanente employees and partners are fully engaged in leveraging FDD and a continuous improvement process to deliver multifaceted value across the enterprise and facility lifecycle.

- Decentralized approach
- Use cases MBCx and Capital Cx primarily but exploring additional uses case

Focusing on maximizing engagement to drive impact

Onboard + Analyze + Engage = Impact
Training/Governance

- Enterprise workgroup:
  - Monthly meetings updates, training, collaborate
  - MS Team’s team collaborate
- Program handbook
- Monthly regional meetings to drive engagement and provide tailored support
- Performance dashboard: track key engagement metrics

<table>
<thead>
<tr>
<th>Regional - Medical Center</th>
<th>Average Weekly CW Log ins</th>
<th>CW Task Creation</th>
<th>Annual Avoided Cost of Energy Tasks Created</th>
<th>CW Task Completion</th>
<th>Annual Avoided Cost of CW Energy Tasks Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jan’22</td>
<td>Avg. Last 3 Months</td>
<td>Avg. Last 12-Months</td>
<td>Jan’22</td>
<td>Avg. Last 3 Months</td>
</tr>
<tr>
<td>NCAL</td>
<td>0.3</td>
<td>0.2</td>
<td>0.7</td>
<td>11</td>
<td>4.3</td>
</tr>
<tr>
<td>SCAL</td>
<td>0.2</td>
<td>0.3</td>
<td>0.6</td>
<td>1</td>
<td>1.7</td>
</tr>
<tr>
<td>CO</td>
<td>0.2</td>
<td>0.3</td>
<td>0.2</td>
<td>1</td>
<td>2.3</td>
</tr>
<tr>
<td>GA</td>
<td>1.8</td>
<td>1.1</td>
<td>0.7</td>
<td>3</td>
<td>5.0</td>
</tr>
<tr>
<td>MA</td>
<td>5.0</td>
<td>3.2</td>
<td>2.3</td>
<td>12</td>
<td>5.0</td>
</tr>
<tr>
<td>NW</td>
<td>0.8</td>
<td>1.0</td>
<td>1.4</td>
<td>-</td>
<td>4.7</td>
</tr>
<tr>
<td>WA</td>
<td>3.4</td>
<td>3.3</td>
<td>2.9</td>
<td>-</td>
<td>0.7</td>
</tr>
<tr>
<td>Enterprise</td>
<td>1.66</td>
<td>1.3</td>
<td>1.25</td>
<td>28</td>
<td>23.7</td>
</tr>
</tbody>
</table>
Training/Governance

• Initial training at turnover
• Support requests
• New portal BI/Dashboarding tool
• Objective is for teams to see the Clockworks Analytics team as an extension of their team from an advisory and technical support standpoint
Lessons Learned

- Focus on engagement metrics instead of just impact since the former are leading indicators
- Get creative in funding deployment
- Widen the use cases and value proposition beyond just energy
- Onboard in waves/larger groups vs. building by building where possible
- Right size service support
- This is a “team sport”
  - Think beyond just your internal team – leverage vendors/partners
What’s Next

- **Continue to drive engagement** and impact

- **Continue to grow**

- **Integrate**, integrate, integrate!

- **Mature** program beyond energy – explore maintenance use cases
Thank you!

- Questions?
  - Hannah Kramer (hkramer@lbl.gov)

- Get involved:
  - Building owners, operators, and managers: join the Better Buildings Alliance or contact bba@ee.doe.gov with questions
  - Join the EMIS Tech Team list: send request to emis@lbl.gov

Better Building Solution Center Resources

- Low Carbon Technology Strategies Toolkit – (Link)

- Smart Energy Analytics Campaign Toolkit (Link) with:
  - Business Case Resources: Final Report | Applications Showcase | Success Stories | EMIS Infographic
  - Resources for getting started with EMIS: Crash Course | Primer | Procurement Spec

Register for our Webinar on April 5th:
- Low Carbon Technologies: Strategies For Different Building Types (Register Now)
Global Call for Engineers, Scientists & Developers

Up to $55,000 USD in Awards

Sign Up Deadline: April 15th, 2022
Data Access Provided by April 22nd, 2022

Learn more at rtemhackathon.com
DOE Launches the Better Climate Challenge

WATCH THE EXECUTIVE ROUNDTABLE

On February 28, 2022, DOE Secretary Granholm officially launched the Better Climate Challenge during an Executive Roundtable with HUD Secretary Fudge, White House National Climate Advisor Gina McCarthy, and committed partner organizations.

To learn more and join, click here.
Better Buildings, Better Plants

SUMMIT

MAY 17-19 2022

SAVE THE DATE

Learn more: betterbuildingssolutioncenter.energy.gov/summit