How Faulty are Commercial Buildings? - HVAC Fault Prevalence Study Results

Energy Technologies Area
BERKELEY LAB
U.S. DEPARTMENT OF ENERGY

Background

Lack of granular data on commercial buildings faults:

- Commercial building HVAC systems experience many sensing, mechanical, and control-related faults that increase energy consumption and impact occupant comfort
- Energy savings potential from resolving operational faults in commercial buildings is now well documented, but the exact nature and frequency of those operational faults has been less studied

Who benefits from knowing more about HVAC fault characteristics?

- **Building operators:** focus operations & maintenance (O&M) effort on the most common and lingering fault types
- **Analytics software developers:** enhance diagnostic algorithms, improve algorithms to target faults found to be most common
- **Equipment manufacturers:** alter design or selection of most faulty components
- **Researchers:** determine highest priority R&D to better identify and more quickly resolve faults

Study Approach

The HVAC fault prevalence study involved multiple steps, from obtaining fault data to analyzing results:

1. Obtain and clean HVAC fault data & associated metadata
2. Apply HVAC Fault Taxonomy and standard time resolution
3. Calculate fault reporting prevalence metrics
4. Analyze and chart results

Project Team

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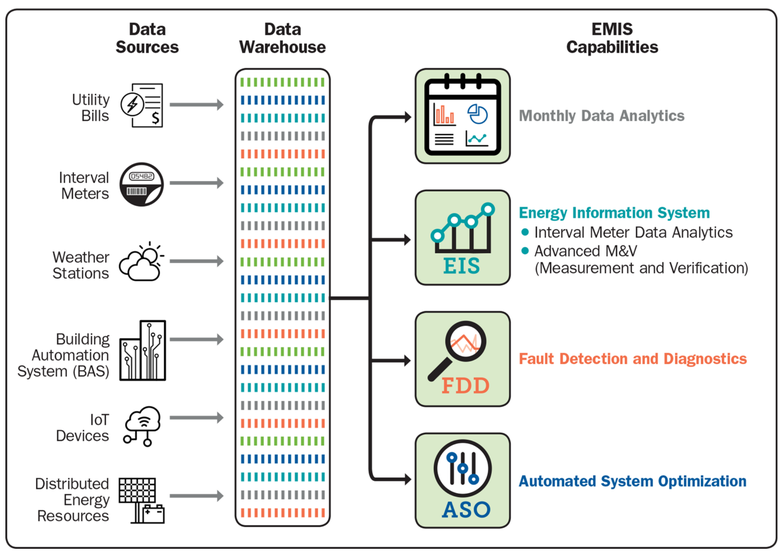
Data Source: Fault Detection & Diagnostic (FDD) Software

Fault Detection & Diagnostics (FDD) software analyzes HVAC data to identify faults. FDD tools are a class of energy management & information system (EMIS)(See figure below). Data for this study was sourced from eight commercially available FDD tools.



Study Dataset by the Numbers

- ❑ **8** data partners
- ❑ **3,660** Air Handling Units (AHUs)
- ❑ **53,865** Air Terminal Units (ATUs)
- ❑ **7,974** Rooftop HVAC Units (RTUs)
- ❑ **>365** days' worth of fault records
- ❑ **18** millions rows of fault data
- ❑ **182** defined faults

Results

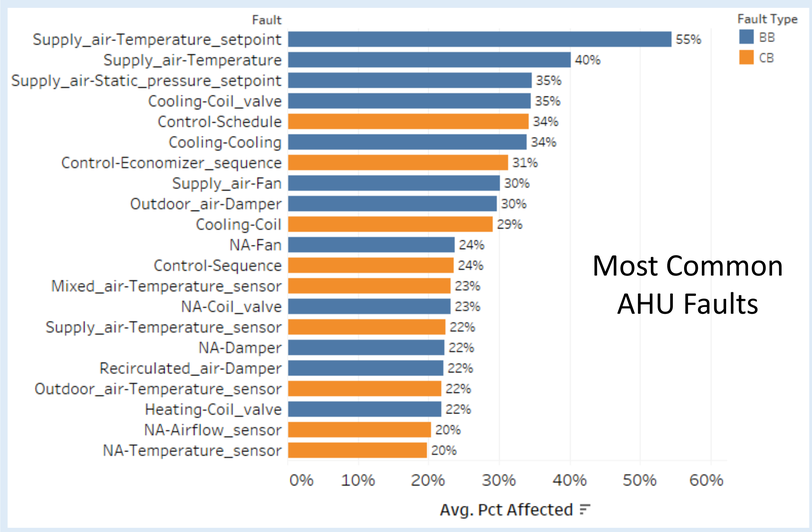
The quantity of reported faults can be overwhelming (see examples below). When rolled up to a monthly level the number of reported faults is reduced (see table), but can still be significant where buildings may have many air handlers and terminal units

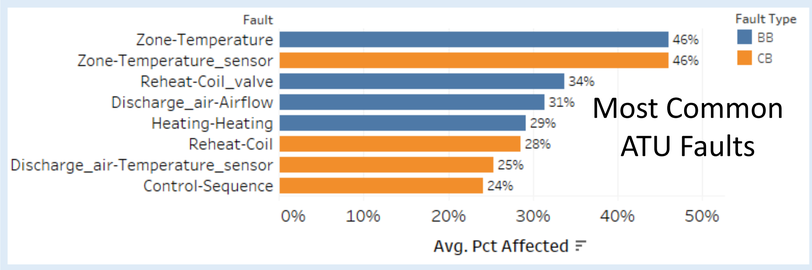
Example case 1: Office
- 8 Air Handling Units (AHUs)
- 175 Terminal units (ATUs)
- 61 unique faults reported over 365-day period
- Total 98,234 daily fault records!

Example case 2: Hospital
- 47 AHUs
- 818 ATUs
- 34 unique faults reported over 365-day period
- Total 443,308 daily fault records!

	Mean Reported Faults per Month	Sample Size
Per Building	245	317 buildings
Per AHU	3	3,660 AHUs
Per ATU	1	53,865 ATUs

Charts below show the most common faults for AHUs (top) and ATUs (bottom), including all faults appearing on 20% or more pieces of equipment in the study dataset. A wide array of sensing-related and other faults were observed, with potential to impact energy use, comfort, and equipment reliability.





What Next?

Recommended areas for further research and development include:

- Extending research on fault reporting characteristics:
  - Extension of fault prevalence study to other HVAC equipment;
  - Deeper investigation of fault persistence, intermittency, and recurrence;
  - Characterization of the intensity of faults, such as the degree of sensor bias;
  - Study of the drivers that may correlate with fault prevalence.
- FDD Algorithm development:
  - New fault self-correction algorithms for high prevalence faults;
  - Active testing or other solutions to improve diagnosis of behavior-based faults;
  - Standardized fault prioritization algorithms.