Notes from the Fault Detection and Diagnostics (FDD) Roundtable
June 14, 2007
University of California, Davis.

Roundtable Host: Western Cooling Efficiency Center
Roundtable Sponsors: New Buildings Institute, California Commissioning Collaborative, Architectural Energy Corporation.
Roundtable Funder: California Energy Commission Public Interest Energy Research Program

The first Roundtable exercise was to envision what the commercial buildings marketplace would look like if fault detection and diagnostics (FDD) were mainstreamed throughout the market.

- Invisible, like auto diagnostics.
- Makes the invisible visible.
- Instrument clusters are universally understood.
- Email alerts to facilities staff prior to equipment fault.
- Eliminates experts-KISS.
- FDD is already mainstream, just not universal.
- Currently, where it is mainstream for a given enterprise--model it.
- Integrated with current infrastructure.
- Buildings would be comfortable, low cost to operate with little constant tinkering needed.
- FDD benefits would be verifiable.
- Existing labor would embrace available FDD tools with full buy-in as to role and value.
- Maintenance would equal efficiency tuning.
- Staff would be stepped through diagnostics with a knowledge base on what to do.
- Open data point standards and databases would allow meta analysis.
- Deemed savings as an approach goes away with real data from FDD.
- Feedback available to designers for HVAC systems and the whole building.
- Easily incorporated into existing systems.
- Senior managers rely on the FDD system for decisionmaking and accountability. People's jobs depend on using it.
- Today's control systems morph into FDD since FDD IS the control system.
- Self-correcting.
- Works in a range of buildings including those with no on-site operators.
- Eliminates nuisance alarms and parses symptoms.
- Indicates significance of a given fault notice.
- FDD is multiple things.
- Automated operation. Is an operator required? FDD + technician is needed.
- Specialized energy service firms are successful and using FDD.
- FDD is cheaper than today.
- FDD is mandatory for all systems in the CA Title 24 2014 Standards revision.
- FDD is out of the energy efficiency 'Valley of Death.'
- Detection vs. diagnosis: get detection done well first.
- Pipeline of solutions.
- Control systems have adequate bandwidth.

- Easy installation, plug and play.
- Owner sees a profit in using FDD.
- Public sees value in buildings operating correctly.
- Limiting emissions drove FDD in cars.
- FDD is at the whole building level including energy monitoring and analysis.
- Energy rates much higher.
- Generates usable reports.
- Used in all buildings including residential, buildings with no EMS/BAS, small buildings.
- Unitary equipment communicates to service provider.
- Car FDD keeps owner going to the dealer for service.
- Salespeople can make more money selling FDD.
- When full realization that comfort is the main driver for labor productivity; when full realization of IAQ and energy impacts.
- The FDD marketer lets the owner know that they need FDD and why.
- FDD has standards capabilities.
- FDD will identify performance, not just faults.
- When owners push back to the design/construction community that they are not getting the performance expected.
- Don't let engineers define product marketability.
- Starbucks phenomenon.
- Low charge indicators in residential air conditioners is mandatory.
- FDD enables/drives other advances in controls, operations and maintenance.
- All retrocommissioning uses FDD for persistence.
- Utilities adopt use of FDD for persistence of savings and impact evaluation for large and small buildings and systems.

Overall Barriers/Challenges to FDD in the Buildings Market

The following barriers/challenges lists were summarized from a variety of published assessments of what is keeping FDD from faster market entry as well as additions from the Roundtable participants. Participants then broke into working groups to address the challenges and identify Action Items for the activities they could agree on.

A. Technical Challenges

1. Data Acquisition including Bandwidth and Storage
2. Data Sufficiency
3. Data Standards
4. Open Standards / Interoperability
5. Data Visualization
6. Data Usability including reporting of information, presentation of information
7. Data Integration
8. Sensors including number needed, accuracy, calibration, drift, cost
9. Durability
10. Performance Standard (s) --Benchmark (s)
11. Control System Variability
12. Operational Sequence

13. Point Naming Convention
14. Fundamental Approach including qualitative, quantitative, other
15. Whole Building Level, System Level, Device Level

***Action Item 1*:** Develop an end-to-end Data Standard for FDD. For existing and new systems.

Work with ASHRAE through TC 1.4, 7.5, 7.9 & GPC13 + work with USGBC and BOMA toward a common Standard. A Guideline would also be useful and may take less time to get to market, but the goal is a Standard. The California-based BOMA Regional Manager and the Technical Chair of USGBC's Energy & Atmosphere TAG have indicated support for a common standard. Proposal development is underway. Will utilize existing standards where appropriate such as IEC 61850 and others as noted below. The following areas would be addressed by the Standard:

- Sensor: accuracy, frequency, drift
- Transducer: accuracy, bandwidth, storage
- Network: Noise, bandwidth, storage
- Database: organization, format, what data, availability, frequency

***Lead*:** Reinhard Seidl, Taylor Engineering, initial lead with Ice Energy, PNL, LBNL part of the action.
Status: Preparations and approaches being made to ASHRAE TC 1.4, 6.5, 7.9, GPC30. Phil Haves has made reference to the Specification Guide for Performance Monitoring Systems that was developed recently with funding from CEC and DOE: http://cbs.lbl.gov/performance-monitoring/specifications/ *"It was intended to meet the needs of automated diagnostics as well as providing better information for operators and facility managers. It addresses end-to-end sensor accuracy and data archiving; what it doesn't do is address the specific sensor requirements of different FDD methods and tools. Figuring out how to do this in the context of a formal document will require some thought and discussion to reach consensus. A variant of the Specification Guide has been submitted to GPC 13 (Specifying DDC Controls) for inclusion as an Appendix - Ken Gillespie from PG&E, a lead author of the Specification Guide and a member of GPC 13, has taken the lead on this."*

Reinhard Seidl: *"In our opinion, a code change proposal to SSPC 135 (BACnet) is the way to attack the data standardization issue through ASHRAE. Phil Haves sent a 152 page spec that LBL developed for just that purpose-I haven't read it yet, but that should cover one ASHRAE avenue. Only drawback is that code change proposals (even though they have to be acted on) run on an annual cycle for the summer meetings, and we're too late for the current summer meeting so first action will be summer 08.*

Mike Brambley was also going to try separate re-introduction as a standard through TC, 7.5. (our Taylor Engineering effort 2 years ago didn't pan out because the standards committee thought it too slim for its own standard, but things might be different now). I've sent Mike a standards proposal and cover letter, too. Expect to hear back from him soon, if

he gets positive feedback from standards, we'll take it to other TC's as discussed.

Mike Day, Ice Energy, also got positive replies from USGBC and BOMA and I think will take a proposal to them (they said they would back what we give them, that might be Phil Haves' spec) Next to that, I'm writing up an RTAR for an ASHRAE research grant on user interface efforts, which we'll introduce through TC1.4 (specifying control systems).”

Action Item 2: Small Commercial Building Rooftop Unit Diagnostics
Action Item 3: Improved interface and usability of FDD information reported to user

***Follow up*:** NBI staff were asked and have agreed to continue to provide networking support among interested participants in the Technical Challenges group as the above noted Action Items go forward.

B. Demonstrated Performance / Value Challenges

1. Case study project design: which FDD tool, research design options, modeling, M&V.
2. Building type and quantity.
3. FDD Level: whole building, system level, device/unit level.
4. kW/kWh/carbon impacts.
5. Building operating impacts: labor productivity, maintenance
6. Indoor air quality impact.
7. Costs of FDD tool: purchase, setup/commissioning, ongoing.
8. What is working and why?
9. What is not working and why?

Action Item 1: Investigation Best Practices.
Objectives: Market segment comparison
Define what constitutes demonstrated performance
Understanding organizational issues for decision makers
Key players: FDD providers, owners/users, utilities
Resources: $250,000+
Timing/Schedule: not detailed.

Action Item 2: Survey of Cost/Benefits of Existing FDD Demonstrations/Field Sites
Objectives: Develop data collection protocol, adapted from existing commissioning protocol
Encourage future additions of information to the database
Comparison of FDD buildings with control buildings
Understanding organizational issues for decision makers
Key players: FDD providers, owners/users, utilities
Resources: not detailed
Timing/Schedule: after Action Item 1 is completed.

Action Item 3: FDD Model Specification. **see Action Item 3 in Market Awareness below*
Objectives: Develop a generic FDD specification that can be adapted.
Guidelines for building owners. Guidelines for utilities
Link with CA Title 24 Standards

Develop standard FDD scopes
Develop acceptance tests and related criteria

Key players: FDD providers, owners, ASHRAE, non-profits (as drivers).

Resources: not detailed.

Timing/Schedule: near term

C. Market Awareness Challenges

1. Little awareness across the market including building owners, operators, and controls vendors/specifiers.
2. Lack of cost (ROI, capital, etc) and performance information/data.
3. Varied customer needs: owners, managers, operators, design community, HVAC contractors. (Internal politics always plays a role)
4. Cultural: accountability; work expectations; workplace hierarchy
5. Fragmented market.
6. Market transformation is needed.
7. Who can you talk to about FDD? Who are the advocates? Who has the information? No national organization or point of contact or website.
8. Controls companies: why so little interest?
9. ESCO's: should be a natural ally.
10. Market perceptions of FDD are few and likely not favorable.
11. Owner interest.
12. Training/usability of the FDD tools.
13. Commissioning of FDD tools.
14. Non-energy benefits.
15. Utilities role: big demand response benefit potential
16. Current cost of energy is not a sufficient driver.
17. Predictability of results.
18. Building owner/operator response requirements when FDD finds problems.
19. Codes and Standards.
20. FDD Level: whole building, system level, device/unit level.

Action Item 1: Target and Sell FDD to Market Leaders in a Given Sector.

Objectives: Demonstration projects built on existing relationships with multi-site owners and their current maintenance providers.
FDD suppliers partner with Roundtable participants to identify Market Leaders.

Key players: FDD suppliers, O&M providers, referrals from Roundtable participants owners. NBI, AEC, CCC and WCEC could participate.

Resources: $150,000 for three demonstration projects

Timing/Schedule: Immediate, with one year to complete.

Action Item 2: Engage Industry Leaders on FDD.

Objectives: Outreach to owners associations BOMA, IFMA, PRSM, SMACNA, ACCA, NAEASCO, AIA, ASHRAE, USGBC, others…

Key players: NBI lead. Could be part of NBI's *Billion Square Foot Initiative*.

Resources: $75,000 from CEC

Timing/Schedule: 24 months

Action Item 3: FDD Model Specification.
Objectives: Develop a generic FDD specification.
Key players: FDD providers (Jay Santos-lead-Facility Dynamics, Field Diagnostics, Cimetrics, others), owners, ASHRAE, non-profits (as drivers).
Resources: *Pro bono*
Timing/Schedule: 90 days.

Action Item 4: Case Studies, 3rd Party Reviewers, Web Site and Articles
Action Item 5: Get Programs Like LEED to Embed FDD to Create Market Pull
Action Item 6: Form an FDD Industry Group
Action Item 7: Cultural Issues including: Accountability, Motivation/Incentives/Rewards, Identifying the Key Entry Points to a Given Market.
Action Item 8: Work with Industry Associations to Set Minimum Codes and Standards for FDD

D. Ideas for Collaboration

These results are from the final discussion on opportunities to collaborate in support of FDD.

- Data standards.
- Projects: sharing information to provide accountability and credibility. Input, structure and funding from the entity with the interest.
- Common workplan approaches
- EM&V requirements.
- Provide information to trade organizations—Who?
- Subcommittee on FDD within California Commissioning Collaborative.
- US DOE-what is the current or projected interest in FDD? If it's too California-centric, US DOE might be put off.
- Make contact with CA Air Resources Board and CAL EPA on FDD.
- Influence CA state environmental procurement program.
- CEC-PIER/CPUC-all with Big Bold Energy Efficiency initiatives pending.
  CEC-PIER RFP coming late July-early August—for discrete research projects; will initially solicit short proposal concepts (1-pager?) for review then proposal solicited. One model is to team with a strong Program Manager by aggregating team members to have 1 contract with PIER. Funding would not be available until Spring 2008.
- Field studies including impact on standards: BERG & BERG-ASHRAE RFP coming in September
- ACCELERATE!